



Development of e-Courses for B.Sc.(Agriculture)
Degree Program



HORT 281
PRODUCTION TECHNOLOGY OF
VEGETABLES AND FLOWERS

Production Technology of Vegetables & Flowers

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All About Agriculture...

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IMPORTANCE OF OLERICULTURE

India is the second largest producer of vegetables in the world (surpassed only by China), accounting for about 10 per cent of the world's production. In 2002, India produced 78.2 million tons from 5.73 million ha of land. Indian farmers grow an amazing number that is 175 different vegetables but potato, tomato, onion, cabbage and cauliflower account for 60 per cent of total production.

It is projected that the domestic vegetable requirements will rise from current levels of 83-91 million tonnes to 151-193 million tonnes by 2030. Indian farmers today cannot meet the high domestic demand for vegetables, as India imports approximately \$678 million of vegetables annually.

To increase domestic vegetable production, improvements are first needed in the vegetable seed industry. There are now more than 50 seed companies developing new vegetable varieties, with increased emphasis on high-yielding hybrids. The Indian Council of Agricultural Research has three major institutes for conducting research on vegetables: Indian Institute of Horticultural Research (IIHR) in Bangalore, Indian Institute for Vegetable Research (IIVR) at Varanasi, and Indian Agriculture Research Institute (IARI) in New Delhi. Almost all agricultural universities and the State Department of Agriculture are involved in vegetable research and development. Among the 25,000 plant scientists in India, at least 1,000 are conducting research on vegetables. To increase year-round vegetable consumption, the seasonality of production must be reduced. Processing can make vegetables more accessible year-round, but less than 7 per cent of India's vegetable production is processed. Another factor that limits consumption is post-harvest damage. Currently 20-25 per cent of vegetables produced are lost due to poor post-harvest handling, and in the case of tomato and cabbage, Post-harvest losses are as high as 60 per cent. To remedy these losses, special cold storage vegetable markets and supermarkets are emerging in metropolitan areas. Specialized vegetable marketing centers are organized in strategic locations and vegetables farmers receive assistance to transport and systematically market their produce.

Vegetable exports under WTO regime

India is a major exporter of vegetables, exporting approximately \$246 million of vegetables annually. In the past, Indian vegetable exports were restricted to potatoes and fresh onions. But now the Government of India observes great opportunities for expanding exports of several more vegetables, including lettuce, fresh peppers, tomatoes, squash and gherkins. For example, the export of fresh tomatoes alone increased eight fold.

Export potential

The world trade organization (WTO) and General Agreement on Tariffs and Trade (GATT) has opened new opportunities for exporting fresh and processed vegetables. During 2001-02, Rs. 582.31 crore have been realised with the export of total fresh vegetables. In India, Agricultural and Processed Food Products Export Development Authority (APEDA) is the nodal organisation to access the market, guide and promote export of agricultural commodities. APEDA has identified traditional vegetables including okra, bitter gourd, chilli, onion, potato and non-traditional vegetables like asparagus, celery, sweet pepper, sweet corn, baby corn, green peas, french bean, cucumber, gherkins and cherry tomato having good export potential. Cultivation of new vegetable like gherkin, baby corn, sweet corn, broccoli, Brussels sprouts, Chinese cabbage, asparagus, celery and parsley is one the rise trends and provide better returns. The vegetables being exported include okra, tomato, baby corn, cucumber, gherkins, chillies, french bean, capsicum, bitter gourd, bottle gourd, onion and potato. Usually, nontraditional vegetables are exported to European countries and Australia, in addition to Gulf and South East Asian Countries. Whole pod edible garden pea is also in demand in European countries. However onion and traditional vegetables are being exported to Malaysia, Singapore, Gulf countries, Sri Lanka, Bangladesh, Pakistan and Nepal.

Export of processed vegetables

The Government of India while realising the global potential of processed fruits and vegetables, even in dried and dehydrated form. has classified the horticulture development as a thrust area. A national policy and programme has been formulated in this regard, there are a number of schemes facilitated at Centre/State Govt. levels for development of this industry. The Ministry of food Processing Industries has been offering appreciable economic incentives to promote food parks in the country, while APEDA/Ministry of Commerce encourages and supports the establishing of Agri Export Zones (AEZs). The installed capacity of food and vegetable processing industry in the country has increased from 1,108 million tonnes in 1993 to 2.328 million tonnes as on 1st April. 2004. The utilisation of fruits and vegetables for processing in the organised and unorganised sector is estimated to be around 2 per cent of the total production, over the last few years, there has been a positive growth in ready-to-serve beverages, dehydrated and frozen vegetables, tomato products, pickles, spices paste and curried vegetables. There are about 63 vegetables traded in the world market in dehydrated, canned and processed form. Dried and preserved vegetables are in demand in Egypt, Sri Lanka, UAE, USA and Turkey. The total quantity of dried and preserved vegetables exported during 2003-2004 is estimated to be 211.16 lakh tonnes valued at Rs, 520.49 crore. The export

of dehydrated vegetables from India is dominated by just five main products, which are onion flakes and powder, tamarind powder, dehydrated vegetables, garlic powder/flakes. The main product of export is dehydrated onion flakes/powder, which has been of the order of about 7224 MT valued at Rs.32.95 crores approximately in the year 2000-01.

Human body requires a wide range of nutrients like carbohydrates, protein, fat, vitamins and minerals for normal growth and sustenance of physiological activities. Protein, carbohydrates and fat, generally referred as proximate principles are required in large quantities and are oxidized in the body to yield energy. Protein is the major growth promoting or body building nutrient. Vitamins and minerals are required in small quantities for physiological processes and metabolic activities. Vegetables are rich and comparatively cheap sources of vitamins like β -carotene, folic acid, vitamin-B, vitamin-C, vitamin-E, minerals like iron, calcium, magnesium, phosphorus and dietary fibres. It also supplies fair amount of carbohydrates, protein (4%) and energy (10%).

Vitamin-A is essential for clear vision in dim light and its deficiency leads to night blindness and dry-eye or Xerophthalmia. Vitamin-A as β -carotene or pro-vitamin-A, which gets converted to vitamin-A in liver and intestine. Former is found only in foods of animal origin. The β -carotene is found in green leaf vegetables and yellow fruits / tubers like carrot, pumpkin, papaya and sweet potato. This fat-soluble vitamin is not soluble in water and is not easily lost while cutting, washing and cooking.

Prolonged deficiency of Thiamine (vitamin-B1) leads to beri beri disease Vitamin B 2 complex consisting of riboflavin and nicotinic acid (niacin), vitamin-B6 (pyridoxine), vitamin-B12 and folic acid (folacine) are all essential for metabolic activities and their deficiency lead to pellagra, anemia and other disorders. Leguminous vegetables, onion bulbs, green onion, sweet potato and cabbage contain a fair amount of vitamin-B group. Folic acid is abundant in spinach, other green leaf vegetables and beans.

Man requires about 50 mg of vitamin-C (Ascorbic acid) daily and is mainly met from fruits and vegetables. Its deficiency causes "scurvy" characterized by weakness, bleeding gums and defective bone growth. Vitamin-C is a strong reducing agent and is lost easily on exposure to air and on cooking. Vegetables like tomato, sweet pepper, chilli, immature bean seed and bean sprouts are good sources of vitamin-C.

Vitamin-E (α -tocopherol) prevents oxidation of β -carotene and vitamin-A in intestine. Green leaf vegetables are fairly good sources of this vitamin. Leaf vegetables like palak, fenugreek, drumstick etc. supply a fair amount of minerals like calcium, iron, phosphorus etc. Tender fruits of okra contain iodine, essential for prevention of goiter disease.

Root and tuber vegetables like potato, sweet potato, cassava, yams and elephant foot yam contain high amount of carbohydrates. Leguminous vegetables like peas, beans, cowpea and hyacinth bean are good sources of proteins (14%).

Vegetables are rich sources of dietary fibre consisting of cellulose, non-starch polysaccharides and lignin. Role of dietary fibre in protection against colon cancer, lowering of blood pressure and diabetes is realized now. It is recommended to include-40.0 g of dietary fibre in our daily diet. Most of leaf vegetables are rich sources of dietary fibre.

Recommended daily allowance (RDA) by the Indian Council of Medical Research in for an adult man is 300 g of vegetables. It includes 100 g roots and tubers, 125g of leaf vegetables and 75 g other vegetables. The RDA for a woman is 75 g roots and tubers, 125 g. leaf vegetables and 75 g other vegetables totaling to 275 g/day. However, it varies with age of people and nature of work.

Vegetables as protective food

Vegetables are protective foods as their consumption prevents many diseases. Almost all vegetables are finding important roles in traditional systems of medicine. Several chemicals having therapeutic value were identified from vegetables. Antioxidants and flavanoids are the most important among them.

Role of vegetables as a source of antioxidants in prevention of new generation diseases and delaying ageing is well recognized. Antioxidants like β -carotene, ascorbic acid (vitamin-C), α -tocopherol (vitamin-E), amino acids and flavanoids present in various vegetables act as scavengers of free radicals, which induce cancer development, brain disorders and arteriosclerosis. Free radicals are molecules or atoms with unpaired electrons and are unstable and highly reactive. These free radicals initiate chain reactions of destructive processes by removing electrons from stable compounds forming many unstable compounds, free radicals and reactive oxygen species (ROS). Inflammation, strenuous exercise, exposure to certain chemicals, radiation, UV light, alcohol, cigarette smoke, air pollutants and excess of free fat diets also produce free radicals. Ageing results in a decreased production of enzymes, which counter adverse effects of free radicals and ROS.

Antioxidants act as scavengers of free radicals and ROS, and prevent them from causing further damage. Actions of free radicals are prevented or inactivated by chain reaction antioxidants. Antioxidants have definite roles in prevention of certain cancer, age related eye diseases, coronary artery diseases and HIV. Certain minerals like selenium and flavanoids like quercetin, kaempferol, myricetin and luteolin have also been isolated from vegetables.

Onion and garlic contain several sulphur compounds like allicin and diallyl disulphide which are effective for control of blood cholesterol and preventing heart diseases. It also has antibacterial properties. The diphenylamine in onion is effective against diabetes.

Bitter melon contains a hypoglycemic ingredient 'cheratin' having effect against diabetes. Leguminous vegetables and brinjal also reduce blood cholesterol level indicating their role in preventing heart diseases. The 3-n-butyl pthalide isolated from celery is effective against hypertension. Certain species of yams contain diosgenin, used in manufacture of cortisone and contraceptive drugs.

Cole crops like Brussels sprouts, sprouting broccoli, knol khol and cabbage have anti-carcinogenic properties mainly due to hydrolysed glucosinolate derived products such as isothiocyanates and indoles. Presence of Indol-3 carbinol, offers protection against bowel cancer. Although, enzymatic hydrolytic products from glucosinolates are goitrogenic, some of the breakdown products induce enzymes responsible for detoxification of reactive carcinogens and eliminates carcinogens from mammalian tissue. The National Research Council Committee on Diet, Nutrition and Cancer, India and the American Cancer Society suggested inclusion of vegetables belonging to *Brassica* genus to reduce incidence of human cancer. In ancestral times, it was used against gout, diarrhea, stomach and celiac troubles. Cabbage juice is used as a remedy against poisonous mushrooms.

Toxic and anti-nutrient compounds

Plants produce toxins as a defense mechanism to protect from man and animals. During course of evolution and continuous cultivation, these undesirable qualities might have been eliminated by selection. Still a few harmful chemicals like trypsin inhibitors, phytates, oxalates and nitrates exist in cultivated vegetables.

Trypsin inhibitors are widely distributed in legumes, especially in raw soybeans. They inhibit activity of trypsin in the gut and interfere with digestibility of dietary proteins and reduce their utilization by affecting hydrolysis of proteins to amino acids.

Phytic acid (inositol hexaphosphoric acid) present in mature seeds of peas and beans binds iron, zinc, calcium and magnesium and reduces bio-availability of iron. On germination of grains, phytate content reduces due to enzymatic break down which improves iron availability.

Green leaf vegetables and legumes are rich source of oxalates and oxalic acid. Maximum oxalate concentration is noticed in amaranth (772 mg / 100 g). Oxalic acid converts calcium from the food consumed to insoluble calcium oxalates making it unavailable for absorption. Calcium oxalate crystals present in leaves and tubers of *Amorphophallus* and

Colocasia cause itching of skin, tongue and throat. Dietary oxalates contribute to increased excretion of oxalate in urine leading to urinary stones.

Vegetables are the single largest source of nitrate in human diet. Leaf vegetables have high concentration of nitrate. Nitrate accumulation results in serious deleterious effects. Within gastrointestinal tract, nitrate is reduced to nitrite, which is absorbed into blood stream where it binds with hemoglobin, oxidizing ferrous ion to ferric ion to form methaemoglobin. Methaemoglobin is incapable of oxygen transport and results in anoxia specifically referred to as “methaemoglobinaemia”. When nitrite ions combine with secondary or tertiary amines, N-nitroso compounds are formed, a few of which are potent carcinogens. On cooking, nitrate content gets reduced drastically.

Tapioca leaves contain glucosides, which liberate hydrocyanic acid by action of enzymes in stomach. *Dioscorea* species contain a toxic alkaloid, dioscorin that can be made harmless by boiling. Potato tubers when exposed to sunlight become green and produce an alkaloid called solanin, which is bitter in taste. A few brinjal varieties were also found bitter due to high solanin content.

All the brassicas contain glucosinolates (thioglucosides), which are sulphur containing compounds. Break down of glucosinolates with help of their associate enzymes produce the culinary flavour to cabbage, cauliflower and broccoli. The thioglucosides (sinigrin) are non-goitrogenic. But on enzymatic hydrolysis in the presence of an enzyme myrosinase, it produces allyl thiocynate-a goitrogen. At high intake levels, it causes enlargement of thyroid glands. Though cabbage contains goitrogen, its goitrogenic properties would be lost during cooking.

1. Vegetables rich in vitamin 'A'
2. Antinutritional compounds
 - a. oxalate
 - b. chlorophyll
 - c. lycopere
 - d. xanthophylls
3. Isothocynates presents in
 - a. cole crops
 - b. amaranthus
 - c. solanaceous vegetables
 - d. cucurbits
4. Temperate vegetables seed production done in
 - a. pusa
 - b. kullu valley
 - c. IHR
 - d. IIVR
5. RDA for adults
 - a. 250 g
 - b. 300 g
 - c. 410 g
 - d. 500 g

VEGETABLE GARDENS

Kitchen garden or nutrition garden

Kitchen garden or home garden or nutrition garden is primarily intended for continuous supply of fresh vegetables for family use. A number of vegetables are grown in available land for getting a variety of vegetables. Family members do most of works. Area of garden, lay out, crops selected etc. depend on availability and nature of land. In rural area, land will not be a limiting factor and scientifically laid out garden can be established. In urban areas, land is a limiting factor and very often crops are raised in limited available area or in terraces of buildings. Cultivation of crops in pots or in cement bags is also feasible in cities.

The unique advantages of a kitchen garden or home garden are :

- Supply fresh fruits and vegetables high in nutritive value
- Supply fruits and vegetables free from toxic chemicals
- Help to save expenditure on purchase of vegetables and economize therapy
- Induces children on awareness of dignity of labour
- Vegetables harvested from home garden taste better than those purchased from market.

Sites selection and size

Choice for selection of site for a kitchen garden is limited due to shortage of land in homestead. Usually a kitchen garden is established in backyard of house, near water source in an open area receiving plenty of sunlight.

Size and shape of vegetable garden depends on availability of land, number of persons in family and spare time available for its care. Nearly five cents of land (200 M²) is sufficient to provide vegetables throughout year for a family consisting of five members. A rectangular garden is preferred to a square plot or a long strip of land.

Layout

Layout of garden and selection of crops suited to each season depends on agro-climatic conditions prevailing in the area. Depending on climatic and seasonal changes, modifications are to be done in layout and crop allotment. General features / principles to be followed in the layout are follows :

- Perennial vegetables like drumstick, curry leaf and bilimbi should be allotted to one side of the garden so that they may neither shade remaining plants nor they interfere with intercultural operations. Shade loving vegetables like water leaf may be planted in perennial plot. One or two compost pits may be provided on one corner of kitchen garden for effective utilization of farm / kitchen waste.

- Fences on all sides should be made with barbed wire or with live stakes. Fencing on four sides may be planting chekkurmanis, ivy gourd, dolichos bean, trailing cowpea and ridge gourd. Fence may be made strong by planting agathi (*Sesbania grandiflora*) at 1.0 m. distance along the fence. An arch made of red or green Basella may be erected at entry point or gate of kitchen garden.
- After allotting areas for perennial crops, remaining portion is divided into 6-10 equal plots for raising annual vegetable crops. By following scientific crop rotation, three annual crops can be raised in the same plot. Companion cropping or accession cropping, inter cropping and mixed cropping can be followed for effective utilization of space.
- Provide walking path at centre as well as along four sides. Path can be made attractive by planting red and green amaranth or indeterminate tomato on either side.
- Utilize ridges, which separate individual plots for growing root and tuber crops.
- As intensive and continuous cropping is done in a kitchen garden, fertility and texture of soil may be maintained by applying adequate quantities of organic manure frequently. Organic farming should be given thrust for a kitchen or home garden. However, in order to harvest good crop, chemical fertilizers are also essential.
- Since fresh vegetables are directly utilized, follow clean cultivation, mechanical removal of pest / disease affected plants, planting of resistant varieties, biological control, use of bio-pesticides or bio-fungicides for pest and disease control in a kitchen garden.
- In a kitchen garden, preference should be given to long duration and steady yielding varieties than high yielding ones, which require constant care.
- Crop arrangement : While allotting or arranging crops in each sub-plot, care should be taken to plant varieties / crops at ideal time of planting or season. Principles of crop rotation also should be followed in continuous cropping.
- A bee-hive may be provided for ensuring adequate pollination of crops besides obtaining honey.
- A cropping pattern for a model kitchen garden in the warm humid tropical condition of Kerala is furnished below. However, choice of the crop depends on the likes and dislikes of family members.

Cropping pattern in a kitchen garden

Plots	May-June to September-October	September – October to December-January	December-January to May-June
Annual crops			

(a) Bitter gourd	Yard long bean	Snake gourd
(b) Brinjal and chilli	Contd.	Okra
(c) Ash gourd	Pumpkin	Amaranth
(d) Bushy / semi-trailing cowpea	Tomato	Cucumber / OP melon
(e) Okra	Ash gourd	Chilli / brinjal
(f) Pumpkin	Okra	Yard long bean
Perennial crops		
(a) Vegetables	Drumstick, curly leaf, bilimbi, culinary banana.	
(b) Fruits	Banana, acid lime, Malta lemon, papaya, West Indian cherry, guava, rose apple etc.	
Inter-crops in perennial plots		
(a) Fruits	Pineapple	
(b) Vegetables	Taro, elephant foot yam, yams, Chinese potato, tapioca water leaf.	
(c) Spices	Perennial chilli, ginger, turmeric, mango ginger	
Border of walking paths	Amaranth, bush cowpea, bush dolichos bean	
Fence		
Perennials	Chekkurmanis, Ivy gourd, agathi, giant granadilla	
Rainy season	Sword bean, clove bean	
Winter season	Ridge gourd, yard long bean	
Rainy to summer (July-February)	Dolichos bean, winged bean	

Market garden

Market gardens are established within 15-20 km of city to supply fresh vegetables to nearby local market. Cropping pattern in a market garden depends on demands of local market. Mostly high value crops, early varieties and varieties or crops which do not stand long distance transport (amaranth, yard long bean, bitter gourd etc.) are grown on an extensive manner in market garden. High cost of land and labour is compensated by high price of produce, low transport cost and availability of municipal compost. Due to increasing cost and pressure on land near big cities and fast developing transportation facilities, market vegetable gardens in big cities are on verge of extinction.

Truck garden

Truck gardens are usually established in rural areas for supplying a few vegetable crops to a distant market. Here cultivation of a few specialized crops is done on an extensive scale in large area under ideal soil and climatic conditions. Relatively cheap labour and land, mechanical cultivation and high yield result in low production cost in a truck garden. However, involvement of middlemen in marketing and cost of transportation reduce net income.

Vegetable garden for processing

Vegetables like tomato, peas, potato, sprouting broccoli, spinach, lima bean, gherkin and onion are utilized by processing industries for canning, dehydration, freezing, pickling and for making other processed products in developed countries. For regular supply of specialized varieties and crops to processing industries, vegetable gardens are established near processing factories. In India, this type of gardens is found in Punjab and a few other states for supplying tomato for processing industries. Varieties meeting processing requirements only are cultivated here and supply of seeds for sowing, cultivation practices and supply of vegetables to processing industry are mostly based on some agreement between factory owners and farmers.

Vegetable garden for seed production

Annual seed requirement of major vegetables in India is around 51,000 tonnes. Major share of requirement is met with home saved seeds of farmers. With advancement of technologies, especially development of improved varieties and hybrids, seed production has become a specialized job requiring great expertise.

Vegetables for seed production are grown in idea soil, climate and disease-free conditions. Each crop / variety is grown in specified isolation distance meeting all the field and crop standards. Timely inspection and rouging are also done to maintain seed purity. Handling of seed crop curing, threshing, cleaning, package and storage are specialized jobs requiring thorough knowledge. Since pests and diseases affect seed field more than that of vegetable field, timely crop protection measures are to be taken, especially for control of seed borne diseases.

Special Systems of Vegetable Farming

Vegetables are cultivated during specific seasons in areas where soil and climatic conditions are ideal and water is available in plenty. It is also grown as rainfed crop depending on receipt of rain. Specific regions and villages scattered throughout the country are famous for cultivation of specific vegetables. To meet increasing demand of vegetables cultivation is also undertaken in adverse climatic conditions by adjusting time of planting or creating favourable

situations for growth of plants under natural conditions or by constructing temporary or permanent structures.

Special systems of cultivation followed in India are :

1. Cultivation in protected structures like glass houses, poly houses, rain shelters etc.
2. Hydroponics
3. Floating type of cultivation
4. River bed cultivation
5. Organic farming

Cultivation in protected structures

In developed countries, vegetables are grown under protected structures like green houses to tide over unfavourable weather conditions like extremely low temperature, snow fall during winter and frequent rains during summer. Green houses are framed or inflated structures covered with transparent or translucent materials, large enough to grow crops under partial or fully controlled environmental conditions, to get optimum growth and productivity. They allow solar radiation to pass through it but traps the long wave thermal radiation emitted from inside and increases inside-temperature by 10-12°C. This “green house effect” helps for vegetable forcing in cold climate. Evaporation from soil and plants also raise humidity inside. Carbon dioxide released by plants inside increases rate of photosynthesis during daytime. Optimum CO₂ concentration in a green house atmosphere is between 700-900 ppm. CO₂ enrichment to 1200 ppm increases photosynthesis Hence, CO₂ is supplemented in green house through natural CO₂ generators kept in green house or directed through pipes or by use of liquid CO₂.

A comparison of productivity of different vegetables under open and green house conditions furnished in table 1 is self-explanatory. In addition to manifold increase in productivity, green house cultivation also results in long fruiting span, high quality and less incidence of pests and diseases.

Table 1 : Productivity of vegetables in green houses and in open field

Crops	Average vegetables yield (t/ha)	
	India (open field)	The Netherlands (Green House)
Tomato	10	200
Cucumber	20	200
Pepper	12	150

Brinjal	25	200
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Depending on cladding material used, the structures are called as glass houses or poly houses.

Glass house

Roof and all the four sides of glass houses are covered with glass sheets. Green house effect increases temperature inside glass houses. Most of the glass houses are provided with heating systems. During summer, cooling devices are also provided. Temperature, humidity, light and carbon dioxide are also controlled through computerized micro processor system for providing ideal conditions. CO₂ enrichment is done inside the glass house for increasing yield. High value and highly productive crops like tomato, capsicum, cucumber, musk melon, water melon and spinach are grown in high-tech glass houses in developed countries like USA, UK, West Germany USSR, Japan, Spain, Italy, Rumania, Bulgaria etc. Trailing cucurbits like cucumber and muskmelon are pruned to encourage vertical growth and are trained to different systems like arch way system, inclined cordon system or vertical cordon system. In tomato, mostly indeterminate F₁ hybrids are trained to vertical poles. Plants are fed with optimum amount of nutrients through drip irrigation and foliar spray. The high initial outlay for erection of glass houses and for providing glass house environment is compensated by long duration, prolonged harvesting periods, high yield and good quality.

Poly-house

Recent advancements in petrochemicals and plastics led to replacement of costly glass houses to less costlier poly-houses for growing vegetables. In developed countries like Japan, Spain, Italy, Holland, Israel and UK poly-houses are utilized for commercial production of vegetables under adverse climatic conditions. In Japan, 84% of area under poly-houses is utilized for vegetable cultivation. In India, poly-house technique has made it possible to cultivate crops like cabbage, cauliflower, knol khol, tomato, onion, spinach and fenugreek throughout the year. Due to encouragement by the Government, area under poly-houses in India was increased from a mere 5 ha in 1983 to more than 2000 ha. during 2006. Poly-houses in the country are mostly located in Bangalore, Pune, Delhi, Hyderabad and Uttaranchal. At present, poly-houses are mainly utilized for nursery raising of vegetable crops, hybrid seed production and off-season cultivation of high value vegetable crops like tomato, capsicum and cucumber in metropolitan cities.

Poly-houses are large structures made of aluminium or galvanized iron or locally available wooden materials using ultraviolet stabilized low density polythene or transparent

plastic film as cladding materials for growing plants under controlled or partially controlled environment. Based on climate control devices and materials used, poly-houses are classified into low cost, medium cost and high cost poly-houses.

Low cost poly-house

Low cost poly-houses are not provided with any climate control device. This is a zero-energy chamber made of 700 gauge polythene sheet supported on bamboo or locally available materials. During winter of mild sub-tropics poly-houses are completely closed at night and as a result temperature inside would be 5-10°C more than outside. During daytime, poly-houses are kept open to allow natural ventilation. During summer, temperature inside the poly-houses are reduced by providing shade nets, frequent watering and by opening the walls.

Medium cost poly-house

In medium cost poly-houses, all four sides are completely covered and temperature inside is controlled by providing. “Fan and pad cooling system”, shade nets and micro-sprinklers. During winter, hot air blowers are necessary to maintain higher temperature. It has a single layer covering of ultraviolet stabilized polythene of 800 gauge thickness on G1 pipes of 15 mm bore.

High cost poly-houses

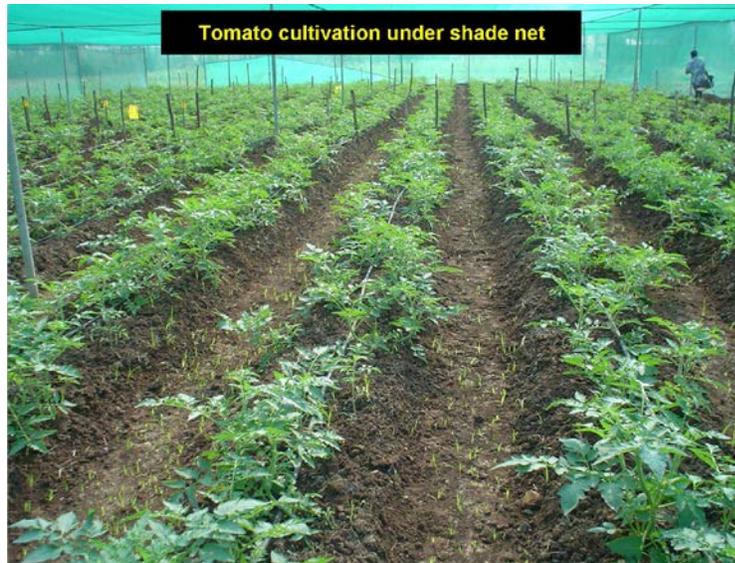
It is provided with fibreglass covering with full climate control devices. Temperature, humidity, light, day length and winds are automatically controlled using computers. Sensors and data loggers are provided in glass house to detect variation and to record climatic factors. High-tech structures are also provided with fully automatic fertigation system, sprinklers, misting system and fumigation devices.

Approximate cost estimated for one square meter in low, medium and high cost structures were Rs.125-500, Rs.500-1,000 and Rs.1,000 and above respectively. However, due to escalation in prices of component parts cost of various structures were increased considerably.

Depending on shape of roof, poly houses are of Lean type, Even-span or Gable type, Uneven span type, Ridges and furrows type, Saw-tooth type or Quonset type.

Poly-houses are mostly of Quonset types in which roof is semi-round. Pipe arches or trusses are supported by pipe pure lines running along green houses and are covered by UV stabilized polyethylene sheets. The ideal size of a structure is 30-37.5 m in length, 9.0 m width, 2.5 m and 3.5-4.5 m height at the sides and centre

Even-span type is with roof slopes of equal width slanting uniformly to either side. This is mostly constructed at level lands and its height is 2.5-2.75 m at sides and 3.75-4.25 m at centre. Ideal size with fibre glass covering is 9 m width and 30-37.5 length.



Rain Shelters

This is naturally ventilated low cost green house to protect plants from direct rain. Rain shelters are the most suited protection structures in high rainfall states like Assam and Kerala. It is provided with roof claddings of UV stabilized low density poly-ethylene film and sides are fully open. Mostly even span structure is used for construction of rain shelters.

Major bottle-neck of protected cultivation in glass / poly houses is the high initial investment. Nearly 50% of cost in protected cultivation is for structure alone. Maintenance cost of fully automatic structures also will be very high. Continuous cultivation of crops in one and same site depletes the soil and needs replenishment frequently. Sufficient care also should be taken to avoid incidence of pests and diseases in protected structures.

Trench cultivation

Vegetable cultivation is impossible at sub-zero winter temperature of high altitude places. Trench cultivation, otherwise called as underground green house technology, is a simple and economically viable technology for growing vegetables during winter. This technology is being utilized by farmers of Ladak and Leh regions of Himachal Pradesh and Jammu and Kashmir for extending vegetable production from three to eight months.

For making underground green house, a trench of 10 m length, 3.3 m width and 1.25 m depth is made. After digging, it should be filled by fertile surface soil up to a height of 30 cm. To avoid crumbling of walls, the trench can be constructed with help of stone masonry. Wooden

poles are used to hold polythene sheets over trench. Vegetables like beet leaf, spinach, vegetable mustard, fenugreek, Swiss chard, Chinese cabbage, celery, parsley, coriander and mint are the most suited crop for cultivation. Crops utilize subsoil temperature, which is higher than prevailing atmospheric temperature.

Tunnels

Tunnel is used for initiating early germination of different summer crops like cucurbits. During rainy season also, a plastic tunnel can be provided to protect mid-season varieties of cucumber raised in nursery against rains. Plastic tunnels are extensively used in cold desert of Ladakh for raising vegetable nursery and to obtain early crops. In tunnels, environment is made congenial for growth of plants when atmosphere is unfavourable. Plastic tunnels are made using UV stabilized corrugated or plain fibre reinforced plastic sheets using metallic wire or frames to provide support to film in tunnel shape.

Hot beds and Cold frames

Structures like hot beds and cold frames are used for growing vegetables in winter. These beds provide an early start for crops like tomato, cucumber, okra, pepper, cabbage, muskmelon and watermelon. Hot frame can be made of wood, cement or brick stone and is prepared above ground. The pit is filled with a mixture of well rotten farmyard manure, ash and soil. Artificial heating is employed.

Cold frames are similar to hot beds except for absence of any form of artificial heat. Cold frames are wooden or concrete structures with plastic on top, which trap heat from sun, making temperature several degrees higher.

Hydroponics

Hydroponics is the technique of growing crops in soil-less media using nutrient solutions. It provides a method of growing plants in areas where soil is lacking or soil is present but contaminated with disease causing organisms or toxic substances. This technology is suited for growing high value vegetables like tomato, capsicum, lettuce, water melon, musk melon etc. Here roots of plants are floated in nutrient solution provided with circulating air or bubbling air. The plants are kept in proper position with supports.

The Defense Research Laboratory, Haldwani in Uttaranchal made extensive works on hydroponics and has suggested the following model for a hydroponics system.

The basic components of hydroponics are :

- Shallow fibre glass trays / plastic trays (60 cm length x 40 cm width x 12.5 cm depth) in which plants are grown.
- A collection tank / nutrient solution storage tank.

- A pump which circulates the nutrient solution from reservoir to growing trays through polyethylene tubes.
- A sequential timer to control operation of pump.
- An aerator connected to reservoir through polyethylene tube, to aerate nutrient solution to maintain oxygen level in nutrient solution.

Seedlings are planted on trays covered with thermocol sheets which provide support to young plants and keep roots of plants and nutrient solution in darkness. A uniform slope is maintained in trays for free flow of nutrient solutions and to avoid water stagnation in trays. For proper growth, plants must be supplied with all nutrients. To prepare nutrient solution, various fertilizers are mixed in a particular proportion and dissolved in water as per the following table.

Table : Nutrient / Salt their concentration in a hydroponics system :

Salt to be used	Element	Form in which they are available to plants	Concentration (ppm)
$\text{Ca}(\text{NO}_3)_2$	Nitrate N and Calcium (Ca)	NO_3 Ca^{2+}	900-930 180-200
KH_2PO_4	Phosphorus (P) Potassium (K)	HPO_4	90-97
KNO_3	Potassium (K) & N	K	234-250
MgSO_4	Magnesium(Mg)&(S)	Mg^{++} SO_4	49-52 185-195
MnCl_2	Manganese (Mn)	Mn^+	0.02
CuSO_4	Copper (Cu)	Cu^{++}	0.03
ZnSO_4	Zinc (Zn)	Zn^{++}	0.06
H_3BO_3	Boron (B)	B	0.60
$\text{H}_3(\text{MO}_3)_2\text{O}_3$	Molybdenum (Mo)	Mo	0.02
Ferric citrate	Iron (Fe)	Fe^{+++}	8.00

- Notes**
1. The micronutrient stock solution be made separately
 2. The ferric citrate solution to be made separately
 3. The $\text{Ca}(\text{NO}_3)_2$, KH_2PO_4 , KNO_3 and MgSO_4 to be dissolved separately and added one by one.

Cultivation of vegetables in floating bases in lakes

In Dal lakes of Kashmir, vegetables are cultivated in floating bases made up of roots of Typha grass growing wild in the lakes. The base is first prepared by weaving of roots of Typha

grass. Then fertile soil rich in humus is placed on the grass base and seeds are sown. All the intercultural operations including watering are done with the help of boats. The floating garden can be dragged to different places for specific purposes. Most of the summer vegetables supplied to Srinagar are from these floating gardens.

Cultivation of vegetables in river bed

Growing of cucurbits in river beds or river basins constitute a distinct type of farming. These areas are called “diara lands” in UP and Bihar. In river beds of Jamuna, Ganga, Goamti, Sarayu and other tributaries in Haryana, UP and Bihar and other rivers in the remaining states, cucurbits like bottle gourd, ash gourd, parval, pumpkin and melona are commonly grown. It is a type of vegetable forcing during winter from November-February in North India. In Kerala, fertile basins of rivers Pamba and Manimala are utilized for growing crops like yard long bean, bitter gourd and snake gourd. Cucurbits like ash gourd, pumpkin, bottle gourd and water melon are cultivated during summer season in river beds of Bharathapuzha in Kerala.

River beds are formed by alluvian and diluvian action of rivers and due to inundation caused by swollen river during South West monsoon. Fresh silt and clay deposited every year during monsoon months make the land suitable, for growing vegetables literally on sand. Even though upper layer of sand seems unsuitable for cultivation, subterranean moisture seeped from adjacent river streams, makes it possible to grow early crops. Cucurbits are adapted to this situation due to long tap root system.

The system consists of identification of areas where there is silt deposit and water level is around 2.0 m below. After identifying the areas, trenches at 2.0-3.0 m spacing or pits at 4.0 m distance are dug after cessation of South West monsoon, late in October. Making pits in sand is a skilled work. Individual pits of 1.0 m diameter are taken to a depth of 1.0-1.5 m. After removing top layer of sand, lower silt is dug and raised almost $\frac{3}{4}$ height of the pit. Finally it takes the shape of a pillar inside the pit surrounded by sand on all sides. A handful of assorted seeds are sown on this silt. Most cucurbits are grown in November-December. Before sowing, trenches are manured with farmyard manure / cakes or other decomposed wastes. Since winter temperature in North India falls down to 1-20C, protection is done by planting grass stubbles (*Saccharum* spp.). It has the following uses :

- Checks sand drifting on the dug up trenches and covering the hills sown with seeds.
- Provides partial protection from chilling winds.
- The grass is available for spreading over the sand when the vines grow and cover the sand.

- Prevent the sand being blown off with vines, especially when too hot summer winds sweep the areas in May.

Due to prevalent low temperature, sprouted seeds are sown in trenches / pits during November – December and mixed cropping of several cucurbits like musk melon, water melon, pumpkin, bottle gourd, ridge and smooth gourds are practiced. Sometimes seedlings get covered with drifting sand due to wind. This has to be exposed from sand in all days. In Bihar pointed gourd (parval) is also grown wherein the rooted cuttings are planted. Plants are pot watered initially until the roots touch the water regime down below.

Channel irrigation starts when plant start vining. Small ponds or wells are dug in river and water is drawn using picota or by using kerosene or diesel engines. For preventing seepage of water, mud is mixed with water in main channel. This mud plasters the channel through which water flows to pits without much seepage loss. Irrigation is done once in 2 or 4 days. In some parts, young seedlings are also transplanted. Since the silt soil is rich in humus, carried from the forests, fertilizer application was not essential during earlier periods. Due to depletion of soil fertility, fertilizer application has become necessary in several sites and the top dressing is done twice, 20-25 days after sowing and alter. Fertilizers are applied away from the plants in shallow side trenches. When it starts vining, trenches are leveled, stubbles are spread in the inter-spaces for spreading plants on sand. In years of un-seasonal rainfall or floods in river, the crops may get lost and re-sowing has to be done. River bed system is developed through native ingenuity of farmers. The home saved seeds are used for cultivation. Yield is variable, depending on location. Since only a single crop is taken in a year, pest and disease incidence is comparatively less in river bed system of cultivation.

Organic farming

The basic principles to be followed in organic farming are:

- Cultivate crops in the ideal cropping season: The ideal time of sowing for each vegetable crop is standardized for different agro-climatic zones. However, minor alterations are to be made to suit to specific localities.
- Avoid off-season cultivation of vegetables in traditional growing areas since it may result in heavy incidence of pests and diseases.
- Cultivate varieties already acclimatized in the locality. Priority should be given to medium yielding varieties tolerant to pests and diseases rather than high yielding varieties.
- Select pest and diseases resistant varieties in areas and seasons when severe incidence of pests or diseases are expected.

- Follow scientific crop rotation practices regularly in vegetable cultivation.
- Raise a leguminous crop and plough back to soil at its pre flowering stage before cultivating a heavy feeding vegetable crop in particular site.
- Practice shifting type of cultivation and keep land fallow at least one season in a year.
- Plough back all the crop residues to the soil whenever a crop is over.
- Practice composting regularly for converting biodegradable wastes to organic manures. Fungi like *Pleurotus* sp., and earthworms (*Eudrillus eugineae*) can be effectively utilized for making compost at a faster rate and for making it nutrient rich.
- Locally available organic materials like farmyard manure, poultry manure, goat manure, green leaves, organic cakes, fish meal, bone meal, etc. may be given priority for use in the organic farming. Apply farmyard manure or compost as basal dose and organic concentrates like organic cakes, poultry manure, vermin-compost etc. as top dressing.
- Use weeds as mulches or cover it with soil for converting to organic matter.
- In organic farming, native strains of bio-fertilizers like *Rhizobium*, *Azotobacter*, blue green algae, azolla, phosphate solubilizing bacteria and fungi, mycorrhizal fungi, etc. may be utilized for fixing nitrogen and increasing availability of phosphorus to plants. The enzymes and hormones produced by microorganisms also impart favourable effects on growth and productivity of crops.
- Burning pits before sowing or practice solarisation to control soil borne pests and diseases.
- Remove alternate hosts of pests and diseases and follow eco-friendly pests and disease control measures like cutting and removal of pests and diseased plants or plant parts, trap cropping, use of colour, sticky and other traps for attracting and killing insects.
- Promote biological control of pests and diseases by promoting parasites and predators.
- Home made insecticides like neem oil – garlic mixture, neem kernel suspension, tobacco decoction, etc. have wide use for control of pests and diseases in organic farming of vegetables. Plants like *Andrographis* sp., *Clerodendron*, *Eucalyptus* etc. also have values in pest control.
- Micro organisms like viruses, fungi, bacteria etc. Are currently utilized in pest control under organic farming. Nuclear polyhedrosis viruses (NPV) for control of *Heliothis armigera*, bacteria like *Pseudomonas fluorescens* against diseases incited by *Phytophthora*, *Pythium*, *Rhizoctonia*, *Fusarium*, *Colletotrichum*, *Rolstonia*, and *Xanthomonas*; *Bacillus thuringiensis* for control of insect pests *Plutella* sp., *Helicoverpa*

sp., *Earias* sp. etc.; fungi like *Fusarium pallidoroseum* for control of aphids are useful in organic farming. Fungal antagonists like *Trichoderma* sp. For control of soil borne diseases caused by *Pythium* and *Phytophthora*, and *Pseudomonas fluorescens* for control of specific fungal, bacterial and viral diseases are also effective.

- Insects like *Trichogramma brasiliensis*, *T. chelonis* and *Chrysoperla carnea* can also be utilized in eco-friendly pest control in vegetables.

Cultivators also should lead a life in tune with nature to produce pesticide free vegetables and to practice a farming system, which is eco-friendly and sustainable.

1. Nutrition garden is otherwise called as

- a. market garden
- b. vegetable forcing
- c. kitchen garden
- d. Protected structure

2. River bed cultivation is related

- a. solanaceous vegetables
- b. cucurbits
- c. cole crops
- d. bhendi

3. Floating garden

- a. Punjab
- b. Kashmir
- c. Delhi
- d. Bangalore

4. Soil less culture

- a. poly house
- b. rain shelters
- c. low tunnels
- d. hydroponics

5. Underground green house technology

- a. rain shelters
- b. trench cultivation
- c. floating garden
- d. hot beds

VEGETABLE CLASSIFICATION

Quite a large number of vegetable crops are grown in the country either on a commercial scale or limited to backyards of homesteads. A few crops have similarity while others have dissimilarity in their climatic and soil requirements, parts, used, method of cultivation etc. While describing individual vegetables, there is possibility of repetition in many aspects. In order to avoid repetition, it is essential to classify or group into different classes/groups. Different methods of classification followed in vegetables are described below:

Botanical classification

Botanical classification is based on taxonomical relationship among different vegetables. Plant kingdom is divided into four viz. Thallophyta, Bryophyta, Pteridophyta and Spermatophyte. All vegetables belong to division Angiospermae of Spermatophyta. It is further divided into two classes viz., Monocotyledoneae and dicotyledoneae.

The family wise distribution of vegetables under the classes is as follows:

Monocotyledoneae

Family -	Alliaceae	
	<i>Allium cepa</i>	Onion
	<i>Allium cepa</i> var. <i>Aggregatum</i>	Multiplier onion
	<i>Allium cepa</i> var. <i>Viviparum</i>	Top onion
	<i>Allium porrum</i>	Leek
	<i>Allium sativum</i>	Garlic
	<i>Allium fistulosum</i>	Welsh onion
	<i>Allium ascalonicum</i>	Shallot
	<i>Allium schoenoprasum</i>	Chive
Family -	Liliaceae	
	<i>Asparagus officinalis</i>	Asparagus
Family -	Araceae	
	<i>Dioscorea alata</i>	Larger yam
	<i>Dioscorea esculenta</i>	Lesser yam
	<i>Colocasia esculenta</i>	Taro
Family -	Poaceae (Graminae)	
	<i>Zea mays</i>	Sweet corn

Dicotyledoneae

Family -	Aizoaceae	
	<i>Tetragonia expansa</i>	New Zealand spinach

Family -	Chenopodiaceae	
	<i>Beta vulgaris</i>	Beetroot and Palak
	<i>Beta vulgaris</i> var. <i>cicla</i>	Swiss chard
	<i>Spinacia oleracea</i>	Spinach
	<i>Artiplex hortensis</i>	Chakwat / orach
	<i>Chenopodium album</i>	Bathua
Family -	Asteraceae (Compositae)	
	<i>Cichorium intybus</i>	Chicory
	<i>Cichorium endivia</i>	Endive
	<i>Lactuca sativa</i>	Lettuce
	<i>Cynara scolimus</i>	Artichoke
Family -	Convolvulaceae	
	<i>Ipomoea batatas</i>	Sweet potato
Family -	Brassicaceae (Cruciferae)	
	<i>Brassica oleracea</i> var. <i>acephala</i>	Kale
	<i>Brassica oleracea</i> var. <i>gemmifera</i>	Brussels sprouts
	<i>Brassica oleracea</i> var. <i>capitata</i>	Cabbage
	<i>Brassica oleracea</i> var. <i>botrytis</i>	Cauliflower
	<i>Brassica oleracea</i> var. <i>italica</i>	Sprouting broccoli
	<i>Brassica caulorapa</i>	Kohlrabi or knol khol
	<i>Brassica napus</i> var. <i>napobrassica</i>	Rutabaga
	<i>Brassica campestris</i> var. <i>rapa</i>	Turnip
	<i>Brassica juncea</i>	Leaf mustard
	<i>Brassica chinensis</i> , <i>B. pekinensis</i>	Chinese cabbage
	<i>Armoracia rusticana</i>	Horse-radish
	<i>Raphanus sativus</i>	Radish
Family -	Cucurbitaceae	
	<i>Cucurbita pepo</i>	Summer squash
	<i>Cucurbita moschata</i>	Pumpkin
	<i>Cucurbita maxima</i>	Winter squash
	<i>Cucurbita lanatus</i>	Water melon
	<i>Cucumis melo</i>	Musk melon
	<i>Cucumis melo</i> var. <i>momordica</i>	Snap melon
	<i>Cucumis melo</i> var. <i>utilissimus</i>	Long melon

	<i>Cucumis melo</i> var. <i>conomon</i>	Oriental picking melon
	<i>Cucumis sativus</i>	Cucumber
	<i>Praecitrullus fistulosus</i>	Tinda
	<i>Sechium edule</i>	Chow-Chow
	<i>Luffa acutangula</i>	Ridge gourd
	<i>Luffa cylindrica</i>	Sponge gourd
	<i>Lagenaria siceraria</i>	Bottle gourd
	<i>Trichosanthes dioica</i>	Pointed gourd / Parwal
	<i>Trichosanthes anguina</i>	Snake gourd
	<i>Momordica charantia</i>	Bitter gourd
	<i>Benincasa hispida</i>	Ash gourd
Family -	Euphorbiaceae	
	<i>Manihot esculenta</i>	Tapioca
Family -	Fabaceae (Leguminosae)	
	<i>Pisum sativum</i>	Peas
	<i>Phaseolus vulgaris</i>	French bean
	<i>Phaseolus lunatus</i>	Lima bean
	<i>Vicia faba</i>	Broad bean
	<i>Vigna unguiculata</i>	Cowpea
	<i>Cyamopsis tetragonoloba</i>	Cluster bean
	<i>Vigna unguiculta</i> var. <i>sesquipedalis</i>	Asparagus bean
	<i>Lablab purpureas</i>	Lablab bean
	<i>Glycine max</i>	Soybean
	<i>Psophocarpus tetragonolobus</i>	Winged bean
	<i>Tigonella foenum graecum</i>	Methi / fenugreek
	<i>Tigonella corniculata</i>	Kasuri methi
Family -	Malvaceae	
	<i>Abelmoschus esculentus</i>	Okra / Bhendi
Family -	Solanaceae	
	<i>Solanum tuberosum</i>	Potato
	<i>Solanum melongena</i>	Brinjal
	<i>Solanum lycopersicum</i>	Tomato
	<i>Capsicum annuum</i>	Chilli
Family -	Apiaceae (Umbelliferae)	

<i>Daucus carota</i>	Carrot
<i>Petroselinum crispum</i>	Parsley
<i>Apium graveolens</i>	Celery
<i>Pastinaca sativa</i>	Parsnip

Cultural and climatic requirements of crops belonging to a family are not always similar. Cultural requirement of radish is entirely different from that of cabbage. Similarly climatic requirement of peas are different from that of cowpea.

Classification based on hardiness

This classification is based on ability to withstand frost and low temperature and it will be useful to know season of cultivation of a crop. Here the vegetable crops are classified into hardy, semi hardy and tender. Hardy vegetables tolerate frost and low temperature and are basically winter or cool season or temperate vegetables. Warm season or subtropical or tropical vegetables are considered as tender since they cannot withstand frost. Temperate vegetables, in general, can be stored for long periods under low temperature. Tropical vegetables are bulky and more perishable compared to temperate vegetables.

Hardy	Semi hardy	Tender
Asparagus	Carrot	Amaranth
Crucifers	Celery	Okra
Garlic	Beet root	Brinjal
Leek	Globe artichoke	Chilli
Onion	Lettuce	Cluster bean
Parsley	Palak	Cucurbits
Peas	Parsnip	Tomato
Radish	Potato	Colocasia
Rhubarb		Amorphophallus
Spinach		Yams
		Sweet potato

Classification based on parts used

In this system, crops are classified based on their parts used for vegetable purpose.

- Tender stem and leaves : Cabbage, Chinese cabbage, knolkhol.
Amaranth, palak etc.
- Fruits : Tomato, brinjal, chilli, cowpea etc.
- Flower parts : Sprouting broccoli

Under ground portion : Carrot, radish, beet root, potato etc.

The cultural requirements of crops in each group may not be same. For eg., cultural requirement of cowpea is different for that of tomato. Same is that of cabbage and palak.

Classification based on cultural requirement

This is the most convenient and widely used system of classification of vegetables. Vegetables having similar cultural requirements are grouped together and placed in one group. For eg., crops belonging to group Cucurbits are seed propagated, direct sown, trailing and vigorous growing, cross pollinated and the cultural practice are almost same.

1. Solanaceous fruit vegetables
2. Cucurbits
3. Peas and beans
4. Cole crops
5. Bulb crops
6. Root crops
7. Potato
8. Tuber crops
9. Okra
10. Pot herbs / greens
11. Salad crops
12. Perennial vegetables

Classification based on season of cultivation

This is one of the most important classifications from the grower's point of view since majority of vegetables are season bound and specific to particular seasons. Vegetables are classified into summer season crops, rainy season crops and winter season crops based on growth and production during particular seasons.

Spring / summer season prevails from February to June / July under North Indian plains and from January to May / June in South Indian plains. October to January is winter season, experiencing chilling temperature, in most parts of the country. However, in high rain warm humid climatic condition of Kerala, a distinct winter season is lacking and rainy season starts from June and extents up to September. Here vegetable crops can be grouped as rainy season, mild winter season, and summer season crops.

A few typical vegetables suited to each group are :

Winter season crops - Cruciferous vegetables, carrot, radish, beetroot, onion, garlic, peas etc.

- Mild winter - Hyacinth bean, winged bean, tomato
- Summer season - All gourds, amaranth
- Rainy season crops - Bhendi, chilli, brinjal, cluster bean, cowpea etc.

However, depending on receipts of rain, slight variation is noticed in different parts of country. Usually early rains are received in Kerala where monsoon starts during last week of May or first week of June.

Vegetable crops can also be classified based on duration of crop growth and flowering (annual / biennial / perennial), ability to grow and set seeds under a particular climate (temperate / tropical / sub tropical), mode of pollination (Self pollinated (<5% cross pollination) / cross pollinated (>12% cross pollination) / often pollinated (5-12% cross pollination). pH requirement of soil etc.

None of above classifications, except botanical classification, is hard and fast since one and the same crop fall in different groups or can be accommodated in more than one class. For example, crops like brinjal and chilli are treated as rainy season crops and bitter gourd, snake gourd and cucumber as summer season crops. These vegetables can be successfully cultivated in other seasons as well, by taking adequate care. Varieties within a crop also exhibit variations in their response to season of cultivation, temperature requirement etc. In crops like cowpea, there are specific varieties suited to rainy season, summer season and winter season.

Each method of classification has its own relevance under specific situations and will be helpful to know the crop requirements by professionals, farmers and students.

1. Scientific method of classification
2. Hardy vegetables can tolerate
 - a. low temperature
 - b. high temperature
 - c. drought
 - d. high rainfall
3. Flowers as economical part in
 - a. sprouting broccoli
 - b. cabbage
 - c. palak
 - d. knol khol
4. Vegetables classification based on cultural requirement
5. Taro is
 - a. *Colocasia*
 - b. *Dioscorea*
 - c. *Amarphophallus*
 - d. *Xanthosoma*

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR FRUIT VEGETABLES –TOMATO

Origin

Tomato is originated in Peru of South America and name of crop came from the Aztec word “Tomato”. The crop is of recent origin and first report of tomato was from Italy in 1544. Later spread was fast and the crop is grown throughout the length and breadth of world.

Area and production

It is amazing to note the quantum jump in the spread of tomato during the last four decades. In India, crop was grown in an area of 36000 ha. during 1960 and present area and production in the country is 4.58 lakh ha. and 74.62 lakh tones respectively with a productivity of 16.29 t/ha. Leading producing states are UP, Karnataka, Maharashtra, Haryana, Punjab and Bihar.

Nutritive value and medicinal use

Tomato occupies a prime position in list of protective foods since it is a rich source of minerals like calcium (48 mg / 100g), sodium (12.9 mg), trace elements, copper (0.19 mg), vitamins like vitamin A (900 IU), vitamin C (27 mg), vitamin B complex (thiamine), essential amino acids and healthy organic acids like citric, formic and acetic acids. The attractive red colour of fruit is due to lycopene and yellow colour is due to carotenes. Peculiar flavour of tomato is due to presence of ethanol, acetaldehyde and a number of volatile flavour components found in fruit. Different forms of tomatine, a steroidal glycoalkaloid, are identified from various parts of plant. Tomato is a good appetizer and its soup is a good remedy for preventing constipation.

Taxonomy

Botanical name of tomato is *Solanum lycopersicum* (lycos = wolf and persicon = peach).

Genus *Lycopersicon* is divided into two subgenera

- a. *Eulycopersicon* (Red fruited and self compatible)
- b. *Eriolycopersicon* (Green fruited and self incompatible)

Eulycopersicon includes two species, *L. esculentum* (*Solanum lycopersicum*) with large fruits and *L. pimpinellifolium* (New name *Solanum pimpinellifolium*) with small fruits born in clusters. *Eriopersicon* mainly consists of wild sp like *L. hirsutum* (*S.habrochaites*), *L. peruvianum*, (*S. peruvianum*) *L. pissisi*, *L. glandulosum*, *L. cheesmani* (*S. cheesmani*) etc.

Rick (1976) divided genus *Lycopersicon* into following two groups based on their ability to cross with cultivated tomato:

Esculentum complex (crossable with cultivated tomato)

- *L. esculentum*, *L. pimpinellifolium*, *L. cheesemani* and *L. hirsutum*

Peruvianum complex (Not crossable with cultivated tomato)

- *L. peruvianum*, *L. chinense*.

Solanum lycopersicum



S. pimpinellifolium



L. chessmanii



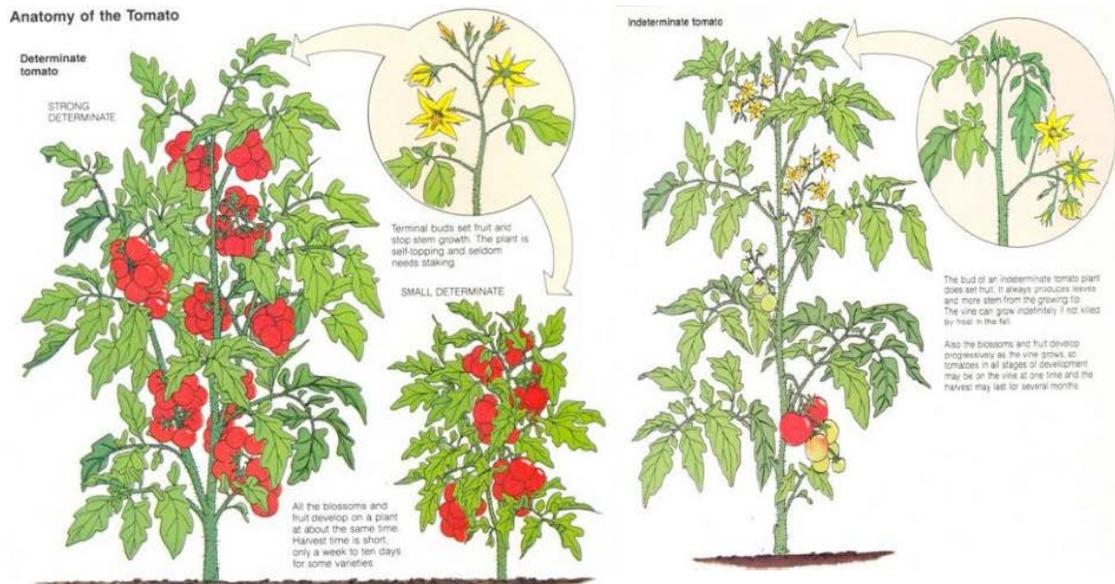
L. hirsutum

Based on growth habit and fruit characters, five forms of *L. esculentum* are identified.

- | | | |
|--------------|---|-----------------------------|
| Communae | - | Common tomato |
| Cerasiformae | - | Small fruited cherry tomato |
| Pyriformae | - | Pear shaped tomato |
| Grandifolium | - | potato leaved tomato |
| Validum | - | Erect and upright tomato |

Botany

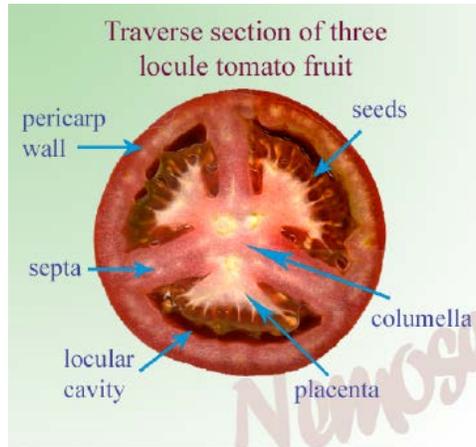
Tomato is a true diploid with $2n=24$. Plant is annual with herbaceous prostrate stem having determinate or indeterminate growth habit. In the determinate growth, terminal bud ends in a floral bud and further growth is arrested resulting in dwarf and bushy stature. In indeterminate growth, terminal bud is a leafy bud and terminal and lateral buds continue to grow and there are less production of flowers and fruits on main stem.

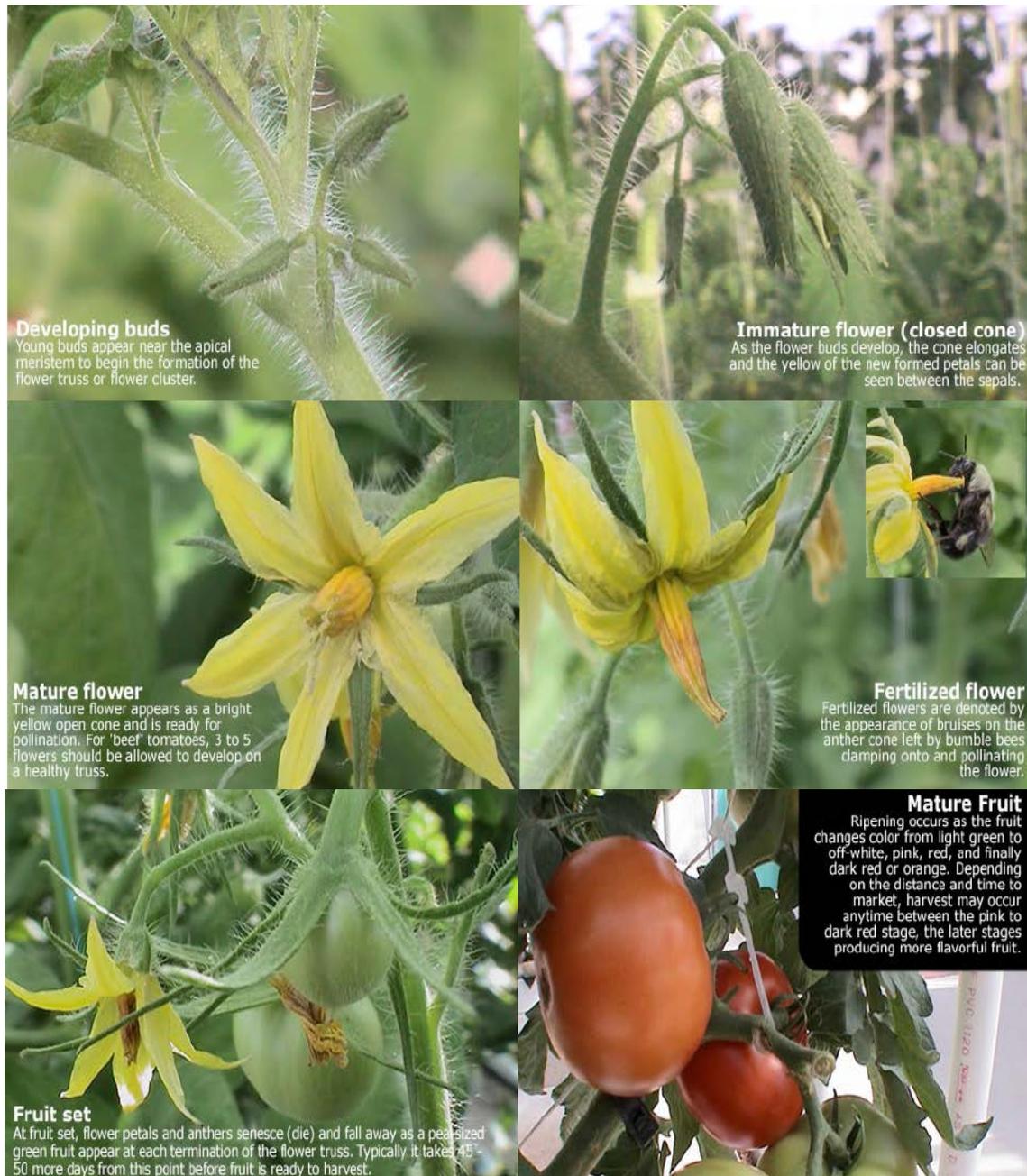


Flowers are borne in racemose cyme and flower cluster is known as 'truss' and its position is extra axillary. Flowers are hermaphrodite, pendulous, pentamerous and hypogynous. Stamens are six in number and inserted on throat of corolla tube and anthers are concentric around style.



Tomato is a self pollinated crop due to hermaphrodite flowers, introvert stigma, internal and synchronized anther dehiscence, and stigma receptivity. Self fertilization occurs when pollen grains are shedding during growth of style through anther corn. In warm regions of the country, some amount of crossing was observed when stigma protrudes out the level of anthers.





Varieties

Quite a large number of varieties differing in their climatic requirements, growth habit, fruit quality, resistance to pest and diseases are developed for specific purposes like fresh

market, processing, long distance transport etc. A brief description of important varieties are given below:

Developing institution	Variety	Special features
IIHR, Bangalore	Arka Saurabh *	Semi determinate. Fruits firm, round and nipple tipped.
	Arka Vikas *	Indeterminate, tolerant to moisture stress condition.
	Arka Alok (BWR 5) *	Bacterial wilt resistant, determinate. Fruits square and oblong.
	Arka Vikas (Sel 22) *	Determinate Fruits medium large, oblate Tolerant to mosaic.
	Arka Saurabh (Sel.4) *	Semi-determinate, resistant to fruit cracking, good transport quality. Fruits round firm with nipple tipped.
	Arka Ahuti (Sel.11)	Semi-determinate.
	Arka Ashish	Tolerant to powdery mildew.
	Arka Abha (BWR 1)	Resistant to bacterial wilt, semi-determinate.
	Arka Meghali	Suitable for rain fed cultivation.
IARI, New Delhi.	SL 120*	Resistant to nematode, determinate. Fruits flat round.
	Pusa Early Dwarf*	Determinate. Fruits flat oblate.
	Pusa Uphar (DT 10) *	Determinate. Fruits round with thick pericarp, suitable for processing.
	Sioux*	Indeterminate. Fruits small and round.
	Pusa Ruby*	Indeterminate. Fruits flat round and suitable for processing.
	Pusa Sadhabahar	Suitable for high and low temperature regimes.
	Pusa Sheetal	Cold set variety (8°C or below). Fruits flat round.

	Roma	Suitable for long distance transport, determinate growth.
	Pusa Gaurav	Suitable for processing.
	Pusa Rohini	Longer shelf life. Fruits round.
IIVR, Varanasi.	H 24*	Determinate, resistant to TLCV Fruits flat round. Developed from cross between <i>L. esculentum</i> and <i>L. hirsutum</i> <i>L.glabratum</i> .
	DVRT 2*	Determinate. Developed from cross between <i>Lesciulentum</i> and <i>L. hirsutum</i> <i>f. glabratum</i> . Fruits large and spherical.
	Kashi Amrit (DVRT 1)	<i>Lesculentum</i> (Sel.7) and <i>L. hirsutum</i> <i>f. glabratum</i> through backcross pedigree selection. Fruits spherical with 108 g weight. Suitable for cultivation in TLCV infested period.
NBPGR, New Delhi	La Bonita	Determinate. Fruits oblong with thick pericarp, suitable for long distance transport.
Kerala Agricultural University, Thrissur	Mukthi (LE 79.5) *	Bacterial wilt resistant, semi determinate. Fruits round to flat round without green shoulder.
	Sakthi (LE 79) *	Bacterial wilt resistant, semi determinate. Fruits green shouldered and flat round.
	Anagha	Resistant to bacterial wilt and fruit cracking. Semi determinate, round medium sized fruits.
TamilNadu Agricultural University, Coimbatore	Marutham (CO.3) *	Developed by mutation breeding (EMS) from CO.1 determinate. Fruits round and cluttered.

	CO.1	Semi determinate. Fruits round.
	CO.2	Indeterminate. Fruits flat round and deep orange red.
	PKM 1	Induced mutant suitable for long distance transport.
	Paiyur 1	Suitable for rain fed cultivation. Less incidence of fruit borer. Fruits round, medium sized and slightly ribbing. Suitable for long distance transportation.
GBPUA&T, Pant Nagar.	Pant T 3*	Determinate. Fruits round, suitable for processing.
	Pant Bahar*	Resistant to Verticillium wilt and Fusarium wilt. Indeterminate. Fruits flat round and suitable for processing and storage.
Haryana Agricultural University, Hisar.	Sel.32*	Determinate. Fruits flat round and large.
	HS 101*	Determinate and dwarf. Fruits round.
	Hisar Arun (Sel.7) *	Determinate and dwarf. Fruits round.
	HS 110	Potato leaved variety.
	Hissar Lalima	Determinate. Fruits round and large.
	Hisar Anmol	Resistant of leaf curl, determinate. Fruits flat round, medium size. Developed by crossing Hisar Aruna nd <i>L. hirsutum f. glabratum</i> .
	Hisar Lalit	Resistant to root knot nematode. Determinate. Fruits medium large and round.
Punjab Agricultural	Punjab Chuhara*	Determinate. Fruits pear shaped and suitable for long distance transport,

University, Ludhiana		susceptible to TLCV.
	Punjab Kesari *	Determinate. Fruits pear shaped and suitable for long distance transport, susceptible to TLCV.
	Punjab Kesari * Sel.1-6.1-4*	Determinate, dwarf, fruits oval round. Root knot nematode resistant, determinate, fruits pear shaped.
CASU&T, Kanpur.	Azad T2 (KS-2) *	Determinate, early, fruits small round, moderately resistant to leaf curl virus.
QUA&T, Bhubaneswar	Uskal Kumar*	Bacterial wilt resistant, fruits round and medium sized.
	Urkal Urbashi (BT12) *	Bacterial wilt resistant, indeterminate, fruits pear shaped and clustered.
	BT 18	Bacterial will resistant.
	BT 21	Bacterial wilt resistant.
Narendra Dev. Agricultural University, Faizabad, Uttar Pradesh.	Narendra Tomato 1	Indeterminate, fruits large.
	Narendra Tomato 2	Determinate, suitable for transport and processing. Resistant to nematode
Assam Agricultural University, Jorhat.	VC 48-1	Bacterial wilt resistant, determinate fruits pear shaped and clustered.
YS Parmer Univ. of Horticulture	Solan Gola	Round fruits

and Forestry, Solan.		
HARP, Ranchi	Swarna Naveen	Resistant to bacterial wilt. Fruits are of medium size (60 g), oblong, dark red with 5.0% TSS. Yield 60 t/ha in 120-140 days. Resistant to bacterial wilt. Fruits are of medium size (125 g), dark red with 4.0% TSS. Yield 50.5 t/ha.

* Varieties released / identified by AICRP (Vegetables).

Hybrid Vigour

Tomato is a classical example for exploitation of hybrid vigour in vegetables. Increasing consumer demand, better emasculation and pollination processes, more seeds per fruit, diversified use and scope for combining large number of favourable genes in F_1 coupled with easiness in cultivation makes the crop ideal for heterosis, breeding. Quite a large number of F_1 hybrids with specific attributes like yield, earliness, uniformity, high quality, suitability to long distance transport, storage and processing, adaptability to adverse conditions, resistance to biotic and abiotic stresses have been developed by public sector research organizations as well as private sector seed companies. With the adoption of new seed policy by the Government of India in 1988, a large number of private seed companies entered in vegetable research and F_1 seed trade. F_1 hybrids developed and marketed by the private seed industry are now ruling in many states like Maharashtra, Karnataka, Haryana, Punjab etc. Features of some public sector tomato hybrids are given Table.

In addition, hybrids like Sun 496* (Sungrow seeds, Delhi), HOE 303*, Avinash 2* (Syngeta), BSS 20*, Meenakshi, Tolstoi (Beejo Sheetal), NA 501*, NA 601* (Nath Seeds), Sadabahar, Gulmohar, Sonali, MTH 6* (Mahyco, Jalna), ARTH 3*, ARTH 4* (Ankur Seeds), Rashmi, Vaishali, Rupali, Naveen (IAHS, Bangalore), Swaraksha, Uttam (Namdhari Seeds, Bangalore), Kt 4* (IARI, Katrain) etc. are a few hybrids popular among farmers.

Developing institution	Variety	Special features
Tamil Nadu Agril. University	COTh.1	Determinate. Fruits round to oblong, slightly acidic, 96 t/ha in 115 days.

	COTH 2	Semi determinate, fruits are borne in clusters of 4-5, high yield (90.2 t/ha) and resistance to leaf curl virus disease
IIHR, Bangalore.	Arka Vardhan*	Indeterminate, resistant to root knot, nematode, oblate fruits, 75 t/ha in 160 days.
	Arka Vishal (FMH 1)*	Indeterminate. Fruit weight 140 g. round, green shouldered, resistant to cracking, good shelf life. 75 t/ha in 160 days.
	Arka Abhijit (BRH 1)	Determinate. Resistant to bacterial wilt, 63.7 t/ha.
	Arka Shresta (BRH 2)	Determinate. Resistant to bacterial wilt, 68.5 t/ha.
IARI, New Delhi.	Pusa Hybrid 1*	Determinate, tolerant to high temperature (upto 23o night temperature)
	Pusa Hybrid 2*	Semi-detrminate, tolerant to nematode, 55 t/ha.
HARP, Ranchi	Swarna Baibhav	Fruits round, deep red, suitable for long distance transportation, average yield 70-80 t/ha.

Most of commercial F1 hybrids were developed by hand emasculatation and pollination by planting female and male parents in the ratio of 12:1. Usually flowers are emasculated in afternoon and pollinated during next day morning with freshly collected pollen. Pollen grains can also be stored for 2-3 days under normal condition for pollination purpose.

Male sterile lines can be utilized for minimizing cost of production of hybrid seeds. Male sterile plants in a population can be identified by their small sized flowers, poorly developed anthers, no anthers, anthers with sterile pollen grains etc. Once a male sterile plant is identified, it has to be stabilized for utilizing it as female parent in commercial production of F₁ seeds. Since male sterility is governed by recessive genes (msms), its maintenance is done by crossing with a heterozygous (Msms) fertile parent. The progeny segregates as male sterile

(ms ms) and male fertile (Ms ms) plants in the ratio of 1:1. From this, male sterile plants are detected and used in hybrid seed production programme.

Climate

Tomato is a day neutral warm season crop, which cannot tolerate frost. Cool and dry weather is preferred by the crop and optimum temperature is 21-28°C during day and 15-20°C during night. Night temperature is more critical than day temperature. High temperature results in exerted stigma, dryness of stigma, burning of anther tip, poor pollen dehiscence, low pollen viability and slow pollen tube growth leading to low pollination and fruit set. Incidence of viral diseases also will be more at high temperature. Optimum temperature for colour development of fruit is 21-24°C. Development of colouring pigment, lycopene will be hampered above 27°C. Seed germination and pollen germination are adversely effected below 10°C.

Based on night temperature requirement for fruit set, tomato varieties are classified into three.

- a) Normal set varieties: Set fruits at 15-20°C.
- b) Hot set varieties: Set fruits above 20°C – eg : Philippine, Punjab Tropic, Pusa hybrid 1.
- c) Cold set varieties: Set fruits below 15°C – eg : Pusa Sheetal, Avilanche.

Tomato cannot withstand water logging. Hence well drained fairly fertile soil rich in organic matter is preferred. It is moderately tolerant to acid soil having pH 5.5 and ideal pH requirement is 6-7°C.

Sowing time and seed rate

Under mild climatic conditions, where there is no danger of frost, three crops can be raised in a year. In the hills, seeds are usually sown in March-April. In plains is grown during June to November. Under Kerala condition, seeds are sown in September and transplanted in October.

Seed rate

Open pollinated variety: 400-500 g / ha

Indeterminate F₂ hybrid: 125-175 g / ha.

Seeds sown in an area of 4-5 cents (200-240 m²) will be sufficient to plant one hectare. Four to five weeks old seedlings are used for transplanting. Hardening of seedling is essential for their establishment in main field and is done by withholding irrigation for one week before transplanting, adding NaC1 (400 ppm) to irrigation water or by spray of cycocel (200 ppm) and Zinc Sulphate (0.25%) + 25 ppm proline at time of transplanting.

Main field preparation and transplanting

Seedlings are transplanted on raised beds or on sides of ridges. Field is ploughed 4-5 times and raised beds of 80-90 cm width or ridges and furrows are prepared. Spacing depends on the growth habit (determinate, indeterminate or semi determinate) of variety and various spacing followed are 60 x 30-45cm, 75 x 60cm and 75 x 75 cm. Usually closer spacing results in early and higher yield, but it may effect size of fruits.

Manures and fertilizers

Manure and fertilizer recommendation for tomato depends on the growth habit and productivity of variety and it varies from state to state. In most of states, in addition to 15-20 tonnes of FYM, 100-125 kg, N, 50-60 kg P₂O₅ and 50-60 kg K₂O are recommended for one hectare. Recommendation for F₁ hybrid is 250:250:250 kg NPK/ha.

FYM should be incorporated in soil at the time of final ploughing. 1/3 N, Full P and K may be applied as basal dose either just before transplanting or 5-10 days after transplanting. Remaining 2/3 N is applied 20 and 45 days there after. In Tamil Nadu, additional dose of 10 kg borax and 5 kg Zinc Sulphate, as basal dose, are also recommended for correcting fruit cracking and to increase yield and fruit quality.

Application of fertilizer in Tamil Nadu:

Apply FYM 25 t/ha, N 75 kg, P 100 kg, K 50 kg, Borax 10 kg and Zinc sulphate 50 kg/ha as basal dose and 75 kg N/ha on 30th day of planting during earthing up. Spray 1 ppm (1 mg in one lit) Triaccontanol, 15 days after transplanting and at full bloom stage to increase the yield.

Irrigation

Furrow irrigation is the most common method in tomato and the crop require adequate moisture throughout growth period. Frequency of irrigation depends on the climatic and soil conditions. During summer, crop should be irrigated at 3-4 days interval. Water stress at flowering stage will adversely effect fruiting and productivity. A long spell of drought followed by heavy irrigation leads to cracking of fruits. Similarly a dry spell after regular irrigation causes blossom end rot. Drip irrigation and sprinkler irrigation are becoming more common in areas of water shortage.

Inter-cultivation

Field should be kept weed free by frequent weeding, hoeing and earthing up. Application of pendimethalin (1.0 kg a.i. / ha) as pre emergence spray along with one hand weeding at 45 DT is ideal for tomato variety Pusa Ruby. Oxyfluorfen (0.25 kg a.i. / ha) Goal (0.25 kg a.i./ha) and Basalin (1.0 kg a.i. / ha) were also ideal as pre emergence application. Post emergence spray of Sencor (0.5 kg a.i./ha) was also effective at the All India Coordinated

trials. Mulching with straw or plastic is also effective for weed control and for regulating soil temperature.

Training and pruning

All indeterminate varieties are trained with wires, strings or stacks to prevent lodging and loss of fruits by coming in contact with soil. It is done by providing individual stack or by erecting 2-2.5 m long poles on either side of ridges for stretching G1 wire. Branches of plants are supported on poles or strings with twine.

Pruning is also generally followed in indeterminate varieties to improve size, shape and quality of fruits. It is removal of unwanted shoots to enhance vigor of plants.



Training

Plant growth regulators

Plant growth regulators are beneficial for early yield, increased fruit set at extreme temperatures and to impart resistance to viral diseases. However, their effect is not seen consistent and varied with genotype, climate, location etc. Some of the growth regulators found useful in tomato production are :

Purpose	Growth regulator	Mode and time of application
High yield	GA ₁ (5-25 ppm)	Seed treatment
	PCPA (10-20ppm)	-
	DNOA (25-50ppm)	-
	GA (10 ppm)	Foliar spray
	NAA (1000 ppm)	-
	PCPA (50 ppm)	-

	24 D (5 ppm)	-
	Cytocyme (0.25%)	-
Increased fruit set	NAA (0.1 ppm)	Seedling soaking for 24 hours
Increased fruit set	IAA (50 ppm)	-
In summer	Borax (1.0%)	-
For increasing fruit set at low temperature	PCPA 50-100 ppm	Foliar spray at flower cluster
Ripening of fruits	Ethrel 1000 ppm	Whole plant spray at the initiation of ripening.

Harvesting

Crop starts yielding by 70 days after planting. Usually fruits are harvested with hand by a gentle twist so that the stalk is retained on plant. Intervals of harvests depend on season and it is twice in a week during summer and weekly during winter and rainy days. Harvesting maturity depends on the purpose whether for fresh market, processing, long distance transport etc. Following maturity standards are recognized in tomato:

- **Mature green:** Fruits fully grown, fruit colour changes from green to yellowish and cavity filled with seeds surrounded by gelly like substance. Harvested for long distance market.
- **Turning or breaker stage:** Fruits firm, 1/4th portion of fruit changes to pink in colour, but the shoulder still yellowish green. Harvested for long distance market.
- **Pink stage:** 3/4th of whole fruit surface turns pink colour. Harvested for local market.
- **Light red:** Entire fruit surface is red or pink but the flesh is firm. Harvested for local market.
- **Red ripe or hand ripe:** Fully ripened and coloured. Flesh becomes soft. Harvested for processing and for seed extraction.

Breaker stage



Yield

Open pollinated varieties :	20-25 t/ha.
F1 hybrids :	50 t/ha.

Grading storage and marketing

Fruits after harvesting are graded and packed in bamboo baskets or wooden boxes. Four grades specified by Bureau of Indian Standards are Super A, Super, Fancy and Commercial. Since tomato is a climatic fruit, good care should be taken to remove bruised, cracked and damaged fruits before packing in baskets. Though tomato can be stored at low temperature, commercially it is not stored in cold storages in the country due to practical reasons. Fruits can be stored for-two weeks and four weeks at 10-13°C when harvested at red stage and green stage respectively. Pre-cooling of fruits before storage and transportation enhances storage life.

Processing tomatoes

Use of tomato for processing is increasing day by day and a variety of products like puree, paste, syrup, juice, ketchup etc are made. Varieties for processing should have following qualities.

- Deep red colour which retains even after processing.
- Low pH – The acidity of fruits affect-heating time required for sterilization of processed product. Longer time is required if pH is high and hence a pH below 4-5 is required for processing.
- High TSS – Fruits with high TSS yield more finished products / tonne of raw fruits and hence minimum TSS should be 4.5°B
- High viscosity and consistency
- Firm and easy peeling
- Pericarp thickness-should be more than 0.5 cm.
- Crack resistance
- Fruits size should be above 50 g and oblong in shape

Varieties like Pusa Gaurav, Roma, Punjab Chuhara, Pusa Uphar, Arka Saurabh are specially suited for processing.

Physiological disorders

Fruit cracking

Fruit cracking is caused both by genetic and environmental factors. Following four types of cracking are noticed tomato.

- Radial Cracking: Usually seen at ripe stage and crack radiate from pedicel end to stylar end.
- Concentric cracking: Seen around shoulder of fruit even at green stage.
- Cuticular: Seen on outer skin of fruit.
- Burst: Burst occurs at certain points on shoulder of fruit.

Radial and concentric cracking are more common of which, former is more damaging. A long spell of drought followed by sudden heavy irrigation may cause cracking. Wide variation in day and night temperatures and high humidity also cause fruit cracking.

Many crack resistant varieties like Crack Proof, Ohio 832, Sioux, Manulucie, Anagha etc. were developed at various research organizations. Fruits of crack resistant varieties have thick pericarp or cuticle and fruit skin with high elasticity and less acidity. Pectin content in resistant varieties ranges from 0.8 to 1.6% compared to 0.54% in susceptible ones. High pectin concentration makes fruit less rigid and more pliable.



**Blossom
red rot**

Water soaked spots of one cm or more appear at point of attachment of petals and effected portion becomes sunken, leathery and dark coloured. This is mainly due to reduced soil moisture supply and high rate of respiration at the time of fruit development. Deficiency of calcium also causes this disorder. Balanced irrigation, cultural practices to conserve soil moisture and spraying of 0.5% calcium chloride at fruit development stage are recommended for control of blossom end rot.



Sun scald

Due to extreme heat, tissues on exposed fruit develop a blistered appearance leading to sunken areas, which have a light or grey colour on green fruit and yellow colour on red fruit. In varieties with heavy foliage, fruits are shaded and incidence of sun scald is less.



1. New botanical nomenclature for tomato
2. _____ is the stage of harvest for long distance transport
3. Temperature tolerance for hot set varieties
4. Processing tomato should contain _____ T.S.S.
5. Calcium deficiency leads to _____

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR BRINJAL

BRINJAL - (Syn: Egg plant) (*Solanum melongena* L.) (2n = 24) Hindi: Banigan)

Brinjal is one of the most common tropical vegetables grown in India. It is known by different names like aubergine (French), begun (Bengali), ringna (Gujarathi), baingan (Hindi) badane (Kannada), waangum (Kashmiri), vange (Marathi), baigan (Hindi) badane (Kannada), waangum (Kashmiri), vange (Marathi), baigan (Oriya), Vashuthana (Malayalam), Kathiri (Tamil), venkaya (Telugu) and Peethabhala (Sanskrit). A large number of cultivars differing in size, shape and colour of fruits are grown in India. Immature fruits are used in curries and a variety of dishes are prepared out of brinjal. Fruits are moderate sources of vitamins and minerals like phosphorous, calcium and iron and nutritive value varies from variety to variety.

Brinjal is also valued for its medicinal properties and has got decholesterolizing property primarily due to presence of poly-unsaturated fatty acids (linoleic and lenolenic) present in flesh and seeds of fruit in higher amount (65.1%). Presence of magnesium and potassium salt in fruits also impart de-cholesterolizing action. In native medicines, role of brinjal in treatment of liver diseases, cough due to allergy, rheumatism, colilithiasis, leucorrhoea and intestinal worms has been mentioned.

Origin and distribution

Brinjal is originated in Indo- Burma region (Vavliov, 1926). Crop is distributed in south and south East Asia, southern Europe, China and Japan. India is the second largest producer of brinjal in the world next to China and produces 83.47 lakh tonnes from an area of 5.02 lakh ha. Cultivation of brinjal is maximum in Orissa, West Bengal, Bihar and is also distributed in almost all states.

Taxonomy Genus *Solanum* comprises approximately 2000 species, which include both tuber bearing and non-tuber bearing forms. Important edible species under non-tuber bearing forms are *S. melongena*, *S. torvum*, *S. nigrum*, *S. macrocarpom*, *S. ferox* and *S. aethiopicum*

S. torvum – used for its small clustered fruits for curry purpose and for drying. It is grown as a wild plant in backyards and roadsides. Due to its resistance to *Fusarium* wilt and bacterial wilt, *S. torvum* can be a resistant root stock for grafting cultivated *S. melongena*

S. macrocarpom* and *S.aethiopicum – grown for edible fruits and leaves.



Solanum macrocarpum



Solanum aethiopicum

Solanum nigrum – Small clustered acidic fruits are also edible and are harvested ripening stage when it turns purple in colour. In Tamil Nadu this species is cultivated and for frying. Leaves and flowers of *S. nigrum* have more resemblance to that of chilli.



S. nigrum

Several species of Solanum are used in native medicines through out tropics. *S. melongena* var. *insanum*, *S. incanum*, *S. indicum*, *S. viarum* are a few among them.

Studies on inter-specific hybridization revealed incompatibility between cultivated *S. melongena* with other species, except with *S. incanum*. Further taxonomic studies revealed that *S. incanum* is only a variety under *S. melongena* and can be treated as *S. melongena* var. *incanum*.

Based on growth habit and fruit shape, four botanical varieties are reported under *S. melongena*.

S. melongena var. *melongena* (Syn: *S. melongena* var. *Esculenta* Nees) includes cultivars with round and egg shaped fruits

S. melongena var. *serpentinum* Desf. Includes long and slender fruited cultivars

S. melongena var. *depressum* includes early and dwarf cultivars

S. melongena var. *incanum* includes wild and prickly plants with small fruits.

Botany

Brinjal is a diploid with $2n=2x=24$. Plant is erect, semi erect or prostrate, herbaceous and branched with around 1.0m height. Stem is spiny or non spiny with or without purple pigmentation which is due to anthocyanin. Flowers are bisexual, pentamerous and are solitary or in 2-7 flowered cyme. Calyx is persistent and spiny or non spiny. Corolla is lobed with different shapes and purple, light pink or white coloured. Stamens are free and form a loose cone surroundings the style. Dehiscence is poricidal. Ovary is bilocular with many ovules. Heterostyly is very common. Fruit is a berry with wide variation in shape, colour and size. Fruit

shape may be long, oval, round, ovoid, cylindrical or elongated. Fruit colour may be nearly black, different shapes of purple, white, green or variegated.



Flower biology and pollination

Though reported as a self pollinated crop, cross pollination to varying degree has been reported in brinjal. Cross pollination is due to its heteromorphic flower structure and is mainly by honey bees and bumble bees.

Depending on length of style in relation to position of anthers, four types of flowers – heterostyly are available.

Long styled – stigma well above the anthers

Medium styled – stigma and anthers at same level

Short styled – style short

Pseudoshort styled – style rudimentary

Fruit set in long styled flowers ranges from 60 to 70% whereas in medium styled flowers it is 12.5 to 55.6%. Short styled and pseudoshort styled flowers act as male flowers and there is no fruit.

Opening of flower and dehiscence of anthers are almost simultaneous and it takes place at 6-7.30 am during summer and is delayed up to 11 am during winter. Flowering depends on climatic factors and high temperature and humidity in the morning hasten flower opening and dehiscence of anthers. In addition to climatic factors, fertility level of the soil also influences flower initiation and development.

Climate

Brinjal is warm season day neutral plant and is susceptible to severe frost. A long and warm growing season with a temperature range of 21-27°C is ideal for its production. Crop is adversely affected by chilling temperature of winter in North India. Generally late cultivars can

withstand low temperature than early ones. Plants grown luxuriantly and yield heavily during rainy season under warm humid climatic condition of Kerala.

Soil

Brinjal is a hardy crop and is cultivated under a wide range of soils. Since a long duration crop with high yield, well-drained and fertile soil is preferred for the crop. Crops grown in sandy soils yield early and those grown in clayey soils yield more. Ideal pH for cultivation of crop is 5.5-6.6

Varieties

A large number of cultivars and improved varieties differing in size, shape and colour of fruits are grown in India. Since consumer preference varies from region to region and from district to district, judicious selection of varieties plays an important role in success of brinjal cultivation. Quite a large numbers of local cultivars like Banaras Giant, Wayanad Giant, Mukthakeshi and Manjiri Gota are grown in specific areas.

Fruits of some local cultivars exhibit bitterness due to presence of glycolalkaloids like solanin. Generally glycol-alkaloid content varies from 0.37 to 4.83 mg/ 100g in most of cultivars. High glycol –alkaloids (20 mg/100g fresh weight) produces bitter taste and off flavour. Varieties also vary for content of polyphenol oxidase which imparts brown discoloration when the fruits are cut open.

Pest and disease resistant/ tolerant varieties with upright and sturdy growth habit, high yield, fruits with soft flesh, low seediness, low solanin content and attractive glossy skin are generally preferred for commercial cultivation.

The important features of improved brinjal varieties developed in India are furnished below:

Developing institution	Variety	Special features
IIHR, Bangalore	Arka Kusumakar	Small green fruits borne in clusters of 5-7
	Arka Sheel	Medium long deep shining purple fruits.
	Arka Nidhi (BWR 12)	Resistant to bacterial wilt, medium long blue black glossy fruits.
	Arka Shirish	Extra long fruits with green colour
	Arka Neelkanth	Resistant to bacterial wilt, short

		purple fruits borne in clusters of two
	Arka Keshav	Resistant to bacterial wilt, Fruits long red purple and glossy.
IARI, New Delhi	Pusa Kranti	Oblong, 15-20 cm long dark purple fruits
	Pusa Purple Cluster	10-12 cm long deep purple fruits borne in clusters tolerant to bacterial wilt
	Pusa purple long	Long purple glossy fruits
	Pusa Anupam (KT4)	Cylindrical purple fruits borne in clusters
	DBR 8	Round dark purple fruits of 295g
	Pusa purple round	Fruits round and purple
	Pusa Bairav	Resistant to phomopsis blight. Fruits long and purple
	Pusa Uttam	Early variety with oval dark purple fruits
	Pusa Utkar	Early variety with round dark purple fruits
	Pusa Bindu	Early. Small oval-round violet-purple fruits
	Pusa Ankur	Fruits oval round, dark purple and glossy
Kerala Agrl. University, Thrissur	Surya (SM 6-7)	Resistant to bacterial wilt, small purple oval fruits
	Swetha (SM 6-6)	Resistant to bacterial wilt, small white elongated fruits
	Haritha	Resistant to bacterial wilt, long light green elongated fruits, Long duration
Tamil Nadu Agricultural University, Coimbatore	CO 1	Oblong, pale green fruits

	CO 2	Oblong fruits having dark purple streaks under pale back ground
	PKM 1	Small ovate fruits with green stripes, developed through mutation breedings
	PLR 1	Small to medium sized egg shaped fruits with purple colour
	MDU 1	Large, round and purple fruits
	KKM 1	Small, white coloured and egg shaped fruits borne in clusters of 2-4
Annamalai University, Tamil Nadu	Annamalai	Aphid resistant. Fruits oblong, purple, few thorns on the calyx
GBPUA&T, Pantnagar	Pant Rituraj	Large purple round fruits
	Pant Samrat	Resistant to bacterial wilt and phomopsis blight, less infestation of shoot and fruit borer and jassids. Fruits long and purple.
Haryana Agrl. University, Hisar	Hisar Pragati (H 7)	Fruits dark bright purple, tolerant to little leaf round, dark and bright purple fruits oblong dark purple fruits.
	Hisar Shyamal (H8)	Round, dark and bright purple fruits.
	Hisar Jamuni	Oblong dark purple fruits
Punjab Agrl. University, Ludhiana	Jamuni GOI (S 16)	Long plummy and shining purple fruits
	Punjab Barsati	Tolerant to fruit borer, fruits medium long and shining purple
	Punjab Neelam	Long purple fruits
	Punjab Sadabahr	Long black purple fruits
	PH 4	Fruits medium to long, thin and dark purple
CSAUA&T, Kanpur	T-3	Round light purple frits with white

		styler end
	KS 331	Long purple fruits of 218 g weight
	Azad Kranti	Medium thick and long purple fruits tapering to distal end
	Azad B 2(KS 224)	Solitary round purple fruits of 135 g
MPKV, Akola	Aruna	Fruits round to oval with light purple rind
DARL, Pithoragarh	ARU 1	Long light purple fruits borne single or double
	ARU 2 C	Resistant to bacterial wilt, cylindrical and violet fruits borne in clusters of 4-6
CHES, Ranchi	CHBR -1	Round dark violet fruits
JNKV, Jabalpur	JB 15	Long violet purple fruits of 270 g weight
	JB 64-1-2	Small round purple fruits of 95 g weight
OUA &T Bhubaneswar	Utkal Tarini (BB 77)	Resistant to bacterial wilt, medium sized oblong deep purple fruits
	Utkal Madhurai (BB 44)	Resistant to bacterial wilt, medium long green fruits with white striped distal end
	UTkal Jyothi (BB 13)	Tolerant to bacterial wilt, small to medium long purple fruits
	Utkal Kesari (BB 26)	Tolerant to bacterial wilt, small to medium long purple fruits Tolerant to bacterial wilt. Fruits deep purple, medium large, cylindrical with slightly thick basal portion.
RAU, Sabour	Green long	Long green fruits of 135 g
APAU, Hyderabad	Gulabi (Sel 4)	Light purple, medium long fruits

		borne in clusters of 3-5 suitable for long distance transport. Very small purple round fruits
	Shyamala Bhagyamathi	Oblong and deep purple fruits
PRVV, Akola	Aruna	Small round deep purple fruits
MPKV, Rahuri, Maharashtra	Vaishali	Fruits oblong, purple with white stripes
	Pragati	Fruits oval, purple with white stripes and spines on peduncle

Exploitation of Heterosis

Brinjal continues to be a choice of breeders for exploitation of heterosis due to hardy nature of crop, comparatively large size of flowers and large number of seeds in a single fruit enabling production of a large number of F1 seeds with a single act of pollination. Highly varied consumer acceptance from region to region also demands for development of a large number of high yielding F1 hybrids. Hand emasculation and pollination are still followed in the hybrid seed production of brinjal. Quite a large number of heterotic hybrids are developed in ICAR institutes and State Agricultural universities and details are furnished below:

Developing institution	Hybrid	Parents	Special features
IARI, New Delhi	Pusa Anmol	Pusa Purple long x Hyderpur	Produce 80% more than Pusa Purple Long, yield 62t/ha
	Pusa Hybrid 5	-	Long glossy dark purple fruits. Yield 51.6t/ha
	Pusa Hybrid 6	-	Early. Round glossy purple fruits. Yield 45.0t/ha
	Pusa hybrid 9	-	Early dark purple round fruits. Yield 56.0t/ha
IIHR, Bangalore	Arka Navneeth	IIHR 221 x	Large dark purple round to slightly

		Supreme	oval fruits. Yield 65-75 t/ha
	Arka Anand	IIHR -3 x SM 6-6	Resistant to bacterial wilt, fruits green long & medium sized (50-55g). yield 65t/ha
Tamil Nadu Agricultural University, Coimbatore	COBH 1	Cross between EP 45 x CO 2	Fruits are purple in colour. High yield 56.40 t/ha
Haryana Agrl. University, Hisar	Hisar Shyamal (H8)	Aushey x BR 112	Resistant to bacterial wilt, tolerant to little leaf, rufts round bright purple
Kerala Agrl. University, Thrissur	Neelima	Surya x SM 116	Resistant to bacterial wilt, protracted fruiting. Round to oval purple fruits. Yield 62 t/ha
GAU, Anad	ABH 1	M2 x M 35	Early variety with purple oval fruits, yield 37.0t/ha
CSAUA&T, Kanpur	Azad Kranti	Pusa purple Loong x BGL	Long dark purple fruits
GBPUA &T, Pantnagar	Pant Brinjal Hybrid 1	PB 121 x PB225	To learnt to bacterial wilt. Fruit long and borne in clusters

In addition, a large number of F1 hybrids are marketed by private seed companies. Supriya, Suphal (IAHS), Kalpatharu, Ravaiya (Mahyco), Kanhaiya, Novkiran, Pragati (Sungro Seeds), Apsara, Nisha (Namdhari) etc are a few commercial hybrids popular among farmers.

Season

In hills, brinjal is sown during March and transplanted during April. In plains there are three seasons for growing brinjal.

Autumn-winter crop

Crop is sown in June and transplanted in July Spring -summer crop: Crop is sown in early November and transplanted in January-February. Due to low temperature, seedlings take

6 to 8 weeks for attaining normal size for transplanting and nursery beds are to be protected from frost.

Rainy season crop

Seeds are sown in March-April and transplanted during April-May. Being a low priced vegetable, rainy season crop is the most economical in many parts.

Sowing

Seeds are sown in nursery bed and transplanted to main field after four weeks during summer and after 7 to 8 weeks during winter, when it is 8 - 10 cm tall. Depending on growth of varieties and seasons of cultivation, 300 to 3:500 g seeds are required for one hectare. Since brinjal seedlings grow fast, sufficient care must be taken to sow seeds as thin or loose as possible. Hardened seedlings withstand transplanting shock better and establish well in main field.

Main field preparation and transplanting

Proper drainage is essential for growth of brinjal. Soil should be prepared to a fine tilth by 4 to 6 ploughings. FYM should be incorporated in soil at the time of final ploughing. Seedlings are transplanted in levelled land in plots of convenient size for irrigation. It may be grown on raised beds/ ridges during rainy season. In undulating land, in order to avoid soil erosion, small pits are dug at the point of planting and seedlings are planted.

Spacing depends on variety, season and fertility of soil. For long duration spreading varieties, a spacing of 75-90cm x 60-75 cm and for bushy and non-spreading varieties a distance of 45-60cm on either side are given. For early and less spreading varieties, paired row planting is advantages due to, easiness in harvesting and other cultural operations.

Manures and fertilizers

Brinjal is a long duration crop with high yield potential. Flower and fruit production will be adversely affected when crop is grown under low fertility conditions. Depending on availability, 25 tonnes of FYM/ha may be incorporated in soil at the time of final ploughing. Application of wet cow dung as a band, 10 -12 cm away from the plant, followed by earthing up at fortnightly interval during rainy season is a common practice for high productivity in Kerala.

Fertilizer requirement of crop varies with variety, season and type of soil. Fertilizer requirement for targeted production in Co-2 under Tamil Nadu condition is estimated and 7.6 kg N, 1.4 kg P and 17.3 kg K/ha are required to produce one tonnes of fruits. Fertilizer studies at various centres of AICRP (Vegetables) indicated varying results. Under Bangalore condition, 150 kg N and 100 Kg P₂₀S were optimum while at Hisar it was 100 kg N and 60 kg P₂₀S/ha. For a balanced nutrition, 30 to 60 kg ~O is included in fertilizer package of brinjal in most of the

states. 1/3 N, full P and full K should be applied as basal dose and remaining N in 2 split doses, 1/3 at 25 days after planting and remaining 1/3 N 45 days after.

Application of fertilizers in Tamil Nadu : Apply FYM 25 t/ha. N 50 kg, P 50 kg and K 30 kg/ha as basal dose, N 50 kg/ha 30 days after transplanting during earthing up. Apply 2 kg of Azospirillum and Phosphobacteria in the mainfield at planting. Spray 2 ppm (1 ml in 500 lit.) Triaccontanol plus Sodium borate or Borax 35 mg/lit. of water 15 days after transplanting and at the time of full bloom to increase the yield.

Irrigation

Though brinjal cannot tolerate water logging, timely irrigation is essential especially for fruit set and development. In plains, irrigation is required at every third or 4th day during summer while in winter it should be at 10-15 days interval. During winter, care should be taken to keep soil moist to avoid crop loss due to frost injury. Being a row planted crop, drip irrigation is advantageous and water used in drip irrigation is only 24.47 cm compared to 69.18 cm under furrow method.

Brinjal is mainly grown as a rainfed crop in high rainfall states like Kerala by transplanting seedlings just before onset of South West monsoon. Here also transplanted seedlings should be given one or two life irrigations for initial establishment.

Intercultivation

It is essential to keep the field free of weeds especially at initial stages of crop growth and is usually done by 2-3 light hoeing or earthing up. This facilitates better aeration to root system and gives support to plants. Application of fluchloralin @ 1.5 kg a.i./ha as a pre-emergent weedicide, applied one week after transplanting seedlings, followed by one hand weeding at 30 days after planting controls a broad spectrum of weeds. Use of black polythene mulches is also efficient for suppression of weeds and for better growth of plants.

Application of growth regulators

Whole plant spray of 2-4, D (2 ppm) at an interval of one week from 60 -70 days after planting from commencement of flowering increase fruit set, early yield and total yield in brinjal. Spray Mixtalool (long chain C24-C34 aliphatic alcohol) at 4 ppm, 4-6 weeks after transplanting, is also effective and gave additional yield of 7.1% in F1 hybrid Arka Navneet.

Harvesting

Brinjal fruits are harvested at immature stage after attaining full size, but before losing its glossy appearance. Dullness of fruit indicates over maturity. Usually fruits are harvested along with its stalk with a slight twist by hand. In some varieties, a sharp knife is also used for harvesting fruits along with fleshy calyx and a portion of fruit stalk. The harvested fruits are

graded and packed in baskets or in loose gunny bags. Care should be taken to remove the fruits affected by Phomopsis blight.

Yield

Early short duration varieties: 20-30 t/ha

Long duration varieties: 35-40 t/ha

FI hybrids: 55-80 t/ha

Storage

Fruits can be stored for 7-10 days in a fairly good condition at 7.2-10°C with 85-90% RH. Keeping quality of fruits varies with variety. It is better to store at 20°C than at 6°C and in perforated polythene bags than under open condition.

Seed production

Though brinjal is considered a self pollinated crop, varying amount of cross pollination takes place because of heterostyly. Cross pollination is mainly through honey bees and bumble bees. To encourage pollination, it is advisable to plant *Mimosa pudica* in the vicinity of brinjal plot. Isolation distance recommended for brinjal is 200 m for foundation seed and 100 m for certified seed.

To maintain genetic purity, rouging should be conducted at pre flowering, flowering and initial fruiting stages. Leaving initial one or two harvests for vegetable purpose is advisable for detection and removal of off types and to avoid chances of contamination from off types.

Fruits are harvested at full ripe stage and crushed with help of a wooden hammer or stone. Crushed fruits are soaked overnight in buckets for softening. This results in easy separation of seeds from pulp when pulp is stirred next day morning. Seeds are then washed with running water and dried under open sun light for half to one hour and later under partial shade till 8% moisture is reached. Depending on variety used and agronomic packages followed, yield varies from 100-350 kg/ha.

Pests

Pests Fruit and shoot borer, jassids ,epilachna beetle and mites are the major pests.

Fruit and shoot borer (*Leucinodes orbonalis*)



The larvae bore into tender parts causing drooping of young shoots and rotting of fruits. Affected plant parts should be removed along with larvae and destroyed by crushing or by immersing in insecticide solution.

Jassids (*Empoasca* spp.)



Adults and nymphs suck sap by feeding from under surface of leaf resulting in typical yellowing and drying up of leaves. Varieties . Punjab Barsati and Pusa Kranti have tolerance to jassid attack.

Epilachna beetle

Yellow coloured nymphs seen on under surface leaves feed on foliage resulting in skeletonization of leaves. Since nymph are seen in large numbers on a single leaf plucking infested leaves along with nymph is an effective way control of pest.

Five sprays of cipermethrin @ 30 g a.i./ha or ethofenprox @ 75 g a.i/ at 15 days interval starting from 30 DAT is effective for control of jassi and fruit and shoot borer. Four sprays of carbaryl (800 g a.i/ha) at days interval starting from 30 DAT is also equally effective for control-pest.

Mites

Red spider mites and other mites seen on under surface of leaf suck sap and cause characteristic yellowing. Spray of neem oil garlic solution in initial stage of attack is effective for control of mites. Under severe infestation spray Kelthane (0.03%) or metasystox (0.03%).

Diseases

Diseases Bacterial wilt Fusarian wilt, phomopsis blight, little leaf, mosaic and damping off are the major diseases.

Bacterial wilt (*Ralstonia solanacearum*)

Disease results in sudden wilting and drying up of plants. Plants are more affected during flowering and early fruiting stages. Grow resistant varieties like Swetha, Haritha, Arka Nidhi, Arka Neelkant, Pant Samrat, Utkal Tarini, Utkal Madhuri and F1 hybrid Neelima in wilt prone areas.

Fungal wilt

Fungi like *Fusarium* and *Verticillium* cause wilting of plants. Lower leaves turn yellow and progress slowly leading to browning and complete death of plants. *Pythium* and *Phytophthora* also cause collar rot and wilting of plants. Crop rotation burning with dry leaves prior to planting and drenching the soil with copper oxychloride are effective for control of wilt.

Phomopsis blight

This is a major disease particularly when crop is raised for seed production. Soft and water soaked brown lesions of fruits which turn black and mummified in appearance are the common symptoms. Leaves and stem may also develop dark brown spots. Seed treatment with Bavistin (1 g a.i./kg) and seedling dip in Bavistin (0.05%) for 30 minutes before transplanting, followed by two sprays of Bavistin are recommended for control of disease.

Little leaf:



Diseased plants produce small sized leaves and result in bushy and stunted growth and will not produce fruits.

Mosaic

Uproot and destroy mosaic and little leaf affected plants as soon as symptoms are noticed. Avoiding ratooning and raising seedlings in seed beds treated with Phorate (1.25 kg a.i./ha), treating seedlings with systemic insecticides for eight hours followed by application of Phorate (1.25 kg a.i./ha) at 21 DAT control both little leaf and mosaic.

Damping off

This is a major nursery disease. Affected seedlings topple over and die in patches. For reducing disease incidence sow seeds as loose/ thin as possible on raised beds. Adequate drainage are drenching nursery bed with Bavistin (0.1 %) control disease effectively.

1. Origin of brinjal
 - a. India
 - b. China
 - c. Sri Lanka
 - d. America
2. Fruit set is high in
 - a. Long style
 - b. Medium style
 - c. Short style
 - d. Pseudoshort style
3. Cross pollination is due to -----
4. Annamalai brinjal is resistant to
 - a. Aphid
 - b. Jassid
 - c. Fruit borer
 - d. Bacterial wilt
5. *Solanum* species used for fruit and leaves -----

**ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR
BHENDI**

(Syn: Lady's finger, Bhindi)

(*Abelmoschus esculentus* (L.) Moench) (2n = 130)

(Hindi: Bhendi)

Okra is predominantly a crop of tropics and subtropics. It occupies fifth position, next to tomato, in area under vegetables in the country with a production of 33.24 lakh metric tonnes from an area of 3.47 lakh hectares. The crop is cultivated for its young tender fruits, used in curry and soups after cooking. It is a good source of vitamins A and B, protein and minerals. It is also an excellent source of iodine and is useful for the treatment of goiter. Fruit is useful against genitor-urinary disorders, spermetorrhoea and chronic dysentery. Fruits are also dried or frozen for use during off-season. Dried fruit contain 13-22% edible oil and 20-24% protein and is used for refined edible oil. Dry fruit skin and fibres are used in manufacture of paper, card board and fibres. Root and stem are used for clearing cane juice for preparation of jaggery.

Origin and distribution

Okra originated in tropical and subtropical Africa. Existence of a large number of related species with wide variability and dominant characters suggest possible role of India as a secondary centre of origin.

India is the largest producer of okra in the world. It is also used as a vegetable in Brazil, West Africa and many other countries. In India, major okra growing states are Uttar Pradesh, Bihar and West Bengal.

Taxonomy and botany

Cultivated bhendi belonging to Malvaceae was earlier placed under *Hibiscus esculentus* L. Since its calyx, corolla and staminal column are fused together and fall down at anthesis (caduceus), it was renamed as *Abelmoschus esculentus* L. in *Hibiscus*, calyx is persistent. Cultivated bhendi is an annual herb with duration of 90-100 days. Flowers are bisexual and often cross-pollinated. Time of anthesis is 8.00-10.00 a.m. Dehiscence of anthers occurs 15-20 minutes after anthesis and is completed in 5-10 minutes. Pollen fertility is maximum in the period between one hour before and after opening of flower. It takes 2 to 6



hours for fertilization after pollination. Stigma is receptive at opening of flower and hence, bud pollination is not effective in okra. Fruit is a capsule. Usually fibre development starts from fifth to sixth day.

Most of cultivated varieties are amphidiploids with $2n=130$. *A. esculentus* is noted for its chromosome polymorphism and $2n$ ranges from 72 to 144. It tolerates addition or deletion of one or a few chromosomes. The chromosome number of *A. esculentus* is $2n=130$ which is evolved by crossing *A. tuberculatus* ($2n=58$) with *A. ficulneus* ($2n=72$). The F₁ developed was subjected to colchicines treatment to make it an amphidiploid. *A. esculentus* ($2n=130$).

Similarly, *A. caillei*, a complex polyploidy, can be evolved by colchicines treatment of F₁ of cross between *A. manihot* and *A. esculentus*.

Four species viz., *A. esculentus*, *A. manihot*, *A. caillei* and *A. moschatus* include both cultivated and wild forms.

Crop improvement

Yellow vein mosaic virus disease being a serious problem in okra cultivation, concerted effort was made to develop high yielding as well as YVMV resistant varieties in the country. With development of YVMV resistant variety, Pusa Sawani, most of the primitive low yielding local cultivars has become less significant. After break down of resistance of Pusa Sawani, research on virus resistance was intensified at various research centres in India and it resulted in development of a number of YVMV resistant varieties.

Various methods like plant introduction (Perkin's Long Green), single plant selection and pure line selection from local collections (Pusa Makhmali, Salkeerthi), selection from bi-parental crosses (Pusa Sawani from IC 1542 x Pusa Makhmali) and selection from complex crosses (sel 2 from (Pusa Sawani x Best 1) x (Pusa Sawani x IC 7194) were used. YVMV resistant variety Susthira developed at the Kerala Agricultural University is *A. caillei*. Pedigree selection in the segregating populations of resistant YVMV varieties resulted in Hisar Unnat (Sel 2-2 x Parbhani Kranthi) and Varsha Uphar (Lam selection 1 x Parbhani Kranthi). Related wild species were also utilized in development of YVMV varieties like Parbhani Kranti (*A. esculentus* cv. Pusa Sawani x *A. manihot* ssp. *Manihot*), Punjab 7 (*A. esculentus* cv. Pusa Sawani x *A. manihot* ssp. *Manihot* cv. Ghana) and Arka Abhay (*A. esculentus* x *A. manihot* ssp. *Tetraphyllus*). MDU 1 and Punjab 8 (EMS 8) were developed through mutation breeding using gamma rays and EMS respectively.

Varieties

Bhendi varieties and cultivars differ in growth habit, height of plants, presence of purple pigmentation on plant parts, length, colour and number of ridges of fruit etc. A brief description of improved varieties developed in the country is given below:

Developing institution	Variety	Special features
IIHR, Bangalore	Arka Abhay	Developed through hybridization, back crossing and selection from
	(Sel.4)*	<i>A. esculentus</i> x <i>A. tetraphyllus</i> ssp. <i>tetraphyllus</i> . Resistant to YVMV. Tolerant to fruit borer. Fruits 5-ridged, dark green, medium long. Productivity 10.5 t/ha.
	Arka Anamika	Developed through hybridization back crossing and selection from <i>A. esculentus</i> x <i>A. tetraphyllus</i> ssp. <i>tetraphyllus</i>
	(Sel 10)*	Resistant to YVMV. Fruits 5-ridged, green medium long. Productivity 11.5 t/ha.
IARI, New Delhi	Pusa Makhmali	Fruits medium long. Productivity 8-10 t/ha. Susceptible to YVMV.
	Pusa Sawani	Fruits 5-ridged, green medium long. Productivity 8-10 t/ha. Initially resistant and later became susceptible to YVMV.
	Pusa A 4	Plants with short internodes. Fruits 5-ridged, dark green and medium long with excellent shelf life. Productivity 10-12 t/ha. Resistant to YVMV, Jassids and fruit borer.
	Selection 2-2	Fruits green, tender and long (16-20 cm) and 5 ridged.
IIVR, Varanasi	VRO 3*	Resistant to ELCV. Fruits 5-ridged, green, medium long. Productivity 11.2-16.5 t/ha.
	VRO 4*	Resistant to YVMV and ELCV. Fruits 5 ridged, green, medium long. Productivity 16.0 t/ha.
Kerala	Kiran	Shy branching plant with light green and long

Agricultural University.		fruits; Fruit length 2-30 cm; Fruit weight 25-30 g; Productivity 11.21 t/ha.
	Salkerthi	Attractive and long light green fruits; Fruit length 24-30 cm; No of ridges on fruit 5; Days to first harvest 44; Productivity 16.2 t/ha.
	Aruna	Attractive red coloured long fruits; Fruit length; 25-30 cm; No. of ridges on fruit 7; Productivity 15.8 t/ha.
	Susthira (<i>A.caillei</i>).	Mosaic tolerant, late and long duration variety suitable for homesteads during kharif season. Fruits green coloured; Fruit length: 22 cm; No. of ridges on fruit 5; Productivity 18 t/ha.
Tamil Nadu Agricultural University	MDU 1	Developed through gamma irradiation of seeds of Pusa Sawani. Plants compact with close arrangement of nodes. Fruits 5-ridged, light green, medium long. Productivity 10-11 t/ha. Susceptible to YVMV.
	CO.1	Fruits pinkish red in colour. Productivity 12.0 t/ha. Susceptible to YVMV.
Haryana Agricultural University, Hisar	Varsha Uphar (HRB-9-2)*	Derived from Lam selection x Parbhani Kranti. Resistant to YVMV. Fruits 5-ridged, dark green, medium long; Productivity 9.8 t/ha.
	Hisar Unnat (HRB 55)*	Plants 3-4 branched, early and high yielding (12-13t/ha).
Punjab Agricultural University, Ludhiana.	Punjab 7 (P 7)*	Developed through back cross method form <i>A. esculentus</i> cv. Pusa Sawani x <i>A. manihot</i> ssp. <i>manihot</i> cv. Ghana. Resistant to YVMV. Jassids and cotton boll worm. Fruits 5-ridged, dark green, medium long. Petiole base is deeply pigmented. Productivity 9.5 t/ha.
	Punjab Padmini	Selection made at F ₈ generation of cross between F ₁ of <i>A. esculentus</i> cv. Rashmi x <i>A. manihot</i> ssp. <i>manihot</i> with F ₂ of <i>A. esculentus</i>

		cv. Pusa Sawani x <i>A. manihot</i> ssp. <i>manihot</i> . Fruits dark green, 15-20 cm long and five ridged. Pigmentation on stem, petiole and lower basal veins of leaves. Resistant to YVMV, Jassids and cotton boll worm. Yield 10-12 t/ha.
	Punjab 8 (EMS 8)	Induced mutant from Pusa Sawani using EMS (1%). Fruits 5-ridged, dark green, medium long. Field tolerance to YVMV and resistance to fruit borer. Fruits 5-ridged, green and 15-16 cm long.
MAU, Parbhani	Parbhani Kranti*	Developed through back cross method from <i>A. esculentus</i> cv. Pusa Sawani x <i>A. manihot</i> ssp. <i>manihot</i> . Fruits 5-ridged, dark green, medium long. Productivity 9.0 – 11.5 t/ha.
CSAUA&T, Kanpur	Azad Kranthi	Fruits 5-ridged, shining green with long beak. Productivity 12.5 t/ha.
YSPUH&F, Solan, H.P.	Harbhajan Bhindi	Perkins Long Green was released as Harbhajan Bhendi. Fruits long tapered green and 8 ridged.

* Varieties released / identified by AICRP (Vegetables).

Exploitation of hybrid vigour

A large number of seeds in a fruit and large size of flowers are favourable factors for exploitation of heterosis in bhendi. A number of hybrids resistant / tolerant to YVMV were developed in public and private sectors. Most of the hybrids were developed by hand emasculation and hand pollination. Two F1 hybrids developed by TNAU are CO.2 and CO.3.

CO.2: AE 180 x Pusa Sawani. Fruits very long (22-25 cm), thick, 7-8 ridged and light green in colour. Productivity 15-16 t/ha. Susceptible to YVMV.

CO.3: Parbhani Kranti x MDU.1. Fruits very long (22-25 cm), thick, 7-8 ridged light Green in colour. Productivity 16-18 t/ha. Moderately resistant to YVMV.

COBhH 1: Varsha Uphar x Pusa A4 (T). Fruits are dark green, long, slender with five ridges. High yield – 22.1 t/ha. Resistance to yellow vein mosaic virus

Climate

Bhendi is a typical tropical or sub-tropical crop and cannot tolerate frost. Performance is also adversely affected by drought, low night temperature and shade. Even though fertilization and seed set are affected during high rainfall, growth of plant and subsequent productivity is

exceptionally good rainfall areas. Under high temperature and low humidity, plant growth is stunted and will be shorter in stature. Similarly flowers drop when day temperature exceeds 42°C.

Soil

Okra prefers loose, well drained and rich soil. The ideal pH for growth of plants is 6-8.

Season

In areas where winter is mild, bhendi is grown throughout the year. Since it cannot tolerate frost and low temperature, only two crops are taken in plains of North India. As kharif crop, seeds are sown from May to July and as a spring summer crop, sowing is done during February-March. In hills of North India bhendi is sown during March-April.

Seed rate and spacing

During summer, vegetative growth is relatively less and seeds are sown at a closer spacing of 45 x 20 cm or even less. Seed rate required is 18-20 kg / ha. During kharif, plant grows vigorously with more branching and seeds are sown at wider spacing of 60 x 30 cm for branching types and 45 x 30 cm for non-branching types. Seed rate recommended for kharif crop is 8-10 kg/ha. For harvesting smaller fruits for export, three rows planting with a spacing of 20-30 cm between rows and 20 cm within a row is advantageous. Distance between two sets is kept as 60 cm. This system has the unique advantage of easiness in inter cultural operations, harvesting, application of plant protection chemicals, etc.

Land preparation and sowing

Field is ploughed thoroughly for 2-3 times for making soil to a fine tilth. Ridges and furrows or raised beds are prepared and dibbling on sides of ridges or on raised beds sows seeds. Soak seeds for 6-12 hours before sowing to enhance germination during summer.

Manuring and fertilizer application

Apply 20-25 t of farmyard manure as basal dose at the time of final ploughing. A dose of 150 kg each of N, P₂O₅ and K₂O is recommended for Pusa Sawani in the coordinated trials. NPK recommendation varies from state to state and a lower dose of 50:8:30 kg N is recommended under Kerala condition. One third dose of N, full P and K are to be applied as basal dose. Remaining N has to be applied in two split doses, 4 weeks after sowing and at flowering and fruiting stages. Split application of N in soil at every 3rd picking is advantageous for getting high yield, for increasing number of harvests and to maintain size of fruits towards last harvests.

Application of Fertilizers in Tamil Nadu

Apply FYM 25 t/ha, N 20 kg, P 50 kg and K 30 kg/ha as basal and 20 kg N/ha 30 days after sowing. Apply *Azospirillum* and *Phosphobacteria* each at 2 kg/ha mixed in 100 kg of FYM before sowing.

Irrigation

Water stress at flowering and fruiting stages will drastically influence growth of plants, size of fruits and yield. Immediately after sowing, field is irrigated. Subsequent irrigation is given at fixed intervals depending on texture of soil and climate. In black soils, irrigation is done at 5-6 days interval.

Interculture

Weed growth should be under control till crop canopy covers fully. This is achieved by frequent hoeing, weeding and earthing up. Used of weedicides like Lasso (2 kg a.i./ha) or fluchloralin (1.5 kg/ha) or Metolachlor (1.0 kg a.i./ha) and one hand weeding at 45 days after sowing was very effective and financially viable under the All India Co-coordinated trials.

Harvesting and yield

Harvest fruits when they attain maximum size but still tender. Fruits of 6-8 cm long are preferred for export purposes. This is usually attained by 5-6 days after opening of flower. Harvesting is done in alternate days with a knife or by bending pedicel with a jerk. For harvesting, cotton cloth hand gloves should be used to protect fingers from stinging effect. It is advisable to harvest in morning hours since fruit hairs will be soft. Sprinkling water on pods during night will keep them cool and fresh for market.

Post-harvest management

Fruits after harvesting are graded and filled in jute bags or baskets or perforated paper cartons and sprinkled with water. Pre-cooling of fruits before packing maintains turgidity of fruits and will save it from bruises, blemishes and blackening. This is usually done before packing fruits in perforated cartons of 5-8 kg before transporting to refrigerated van for export.

Yield 6.0 – 8.0 t / ha for spring-summer crop
 10 – 12.5 t / ha for kharif crop.

Pests and Diseases

Diseases

Yellow Vein Mosaic Virus Disease

This is the most serious disease of bhendi. Characteristic vein clearing is the typical symptom and yield loss may be up to 100% depending on stage of occurrence of the disease. Fruits of virus affected plants turn to cream or white in colour. Virus is transmitted through a

whitefly *Bemisia tabaci*. Removal of weeds susceptible to mosaic from nearby fields, control of white fly, uprooting and burying of affected plants, adjusting time of sowing and cultivation of resistant varieties like Arka Anamika, Arka Abhay, Susthira etc. are recommended for raising a disease free crop. Recently, a hybrid COBH 1 has been released from HC & RI, TNAU Coimbatore which is resistant to YVMV.

Cercospora leaf spot

This disease is serious when there is high humidity in atmosphere and is common in a seed crop. Sooty, black mouldy growth of pathogen appear as under surface of leaves and finally leaves dry off and fall down. Mature pods are also attacked and show blackish spots. Spraying with Bavistin (0.1 g /l) or Bordeaux mixture at fortnightly interval will control the disease.

Powdery mildew

This is caused by a fungus *Erysiphe chioracearum* under prolonged humid conditions. White powdery pustules appear on lower surface of leaves resulting in yellowing and death of leaves. Spraying of wettable sulphur (2g/l) at fortnightly interval is recommended for control.

Insect Pests

Jassids (*Amrasca biguttula biguttula*)

Wedge shaped pale green jassids suck sap from undersurfaces of leaves causing marginal yellowing, cupping and drying of leaves. Due to intense hopper burn, defoliation also occurs. Infestation is serious during summer. Prophylactic spray of neem oil-garlic mixture at fortnightly intervals is advantageous for avoiding pest incidence.

Fruit borer

Borer infestation results in toppling and death of young seedlings, withering and drying up of individual leaves and central shoot. Fruits will be damaged severely. Spray of carbaryl or thiodan or endosulfan or fenvalerate or cypermethrin or deltamethrin is effective for control of borer. Summer ploughing and clean cultivation are also helpful in reducing pest infestation.

Nematodes

Root knot nematode infects roots causing galls premature leaf fall, wilting and decline in growth and fruit production. Symptoms in the field generally appear as well defined patches. Crop rotation with non host plants like wheat, rice and corn should be practiced as a regular measure. Successive deep ploughing during summer and soil solarisation gives very good control. Treating field with nematicides also can be adopted.

Seed production

For seed production, adjust sowing in such a way that dry weather coincides with maturation and drying of pods and incidence of yellow vein mosaic disease is minimum. Being an often cross-pollinated crop, provide an isolation distance of 400 m from other varieties. Field inspection and rouging should be conducted at pre-flowering, flowering and fruiting phases. Harvesting of initial two fruits will be helpful in promoting growth of plants. Average seed yield is 1.0-1.5 t/ha.

MDU1

- This variety was evolved at Agricultural College and Research Institute, Madurai, TNAU, by gamma irradiation of the seeds of Pusa Sawani.
- The fruits are light green in colour with long styler end.
- The plants are compact with close arrangement of nodes.
- It is also susceptible to yellow vein mosaic disease.
- Yield is 10-11 tonnes/ha.

Lam Hybrid Selection-1 (Haritha)

- Developed by ANGRAU and released for cultivation in the state during 1983.
- Plant height 120-150cm with occasional branching tendency.
- Fruits are slender, long, and green and five ridged.
- Tolerant to yellow Vein mosaic virus (YVMV).

Janardhan

- It was released by ANGRAU. The plant is vigorous, branching.
- Fruits are small 6-8 cm long suitable for canning and export.
- Tolerant to yellow vein mosaic.

Punjab Padmini

- This was developed at Punjab Agricultural University, Ludhaina fruits are dark green in colour and each fruit weighs 20g.
- It tolerates yellow vein mosaic to certain extent under field conditions.

CO 1

- This is a pure line selection from Hyderabad "Red Wonder".
- The fruits are pinkish red in colour.
- It has got a yield potential of 12 tonnes/ha.
- It is susceptible to yellow vein mosaic disease.
- It was developed at the Department of Horticulture, Tamil Nadu Agricultural University, Coimbatore.

CO 2

- It is a F₁ hybrid developed at the vegetable department of the College of Horticulture, TNAU, Coimbatore.
- The fruits are very long 22-25 cm. thick with 7-8 edges and light green in colour.
- It has a yield potential of 15-16 tones/ha.
- However it is highly susceptible to yellow vein mosaic disease and hence cannot be recommended for growing during summer season.
- Because of its bigger fruit size it can be used for preparation of dehydrated products.

CO 3 (Hy8)

- It is an F₁ Hybrid between Prabhani Kranti and MDU 1 and has a yield potential of 16-18 tones/ha.
- It is moderately resistant to yellow vein mosaic.
- Suitable for growing during kharif as well as summer.
- It was developed at Dept. of Olericulture, Horticultural College and Research Institute, TNAU, Coimbatore

1. Largest producer of okra in the world?
 - a. China
 - b. USA
 - c. India
 - d. Japan
2. _____ is rich in stem fibres and commonly used in paper industry
 - a. Tomato
 - b. Bhendi
 - c. Soybean
 - d. Watermelon
3. The vector for YVMV of bhendi is
 - a. Jassids
 - b. Whitefly
 - c. Flea beetle
 - d. Red spider mite
4. _____ variety of bhendi is resistant to YVM and suitable for summer sowing
 - a. Parbhani Kranti
 - b. Arka Abhay
 - c. Arka Anamica
 - d. CO-3
5. Gur or brown sugar is developed by clearing cane juice with _____ roots and stems
 - a. Asparagus
 - b. Brinjal
 - c. Amaranthus
 - d. Bhendi

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR CUCURBITACEOUS VEGETABLES

Crops belonging to family Cucurbitaceae are generally known as 'Cucurbits'. It consists of a wide range of vegetables either used for salad purpose (cucumber) or for cooking (all gourds), pickling (West Indian gherkin) or as dessert fruit (muskmelon, water melon) or candied or preserved (ash gourd). As a group, cucurbits occupy the largest area in India and in other tropical countries. Its use is not primarily because of calories, minerals or vitamins since they are generally low to moderate in nutrients with a few exceptions like bitter gourd (rich in vitamin C 96 mg/100g), parwal and chow chow (calcium – 531 mg and 140 mg / 100 g respectively). From the nutritional point of view, cucurbit seeds are valued for their high oil and protein contents. Seed proteins of cucurbits are comparable to that of legumes and are richer in methionine.

Taxonomic classification of the family is differently by botanists. The family Cucurbitaceae comprises about 117 genera and 825 species in warmer parts. Chakravarthy (1982) estimated 36 genera and 100 species in India.

General features

Cucurbit vegetables have the following common features:

1. Long tap root system – Tap root may grow up to 175-180 cm and laterals are confined to top 60 cm. Hence crops like bottle gourd, ash gourd and parwal are largely utilized in river bed cultivation.
2. Branched stem-Stem is 3-8 branched and prostrate / climbing and spread up to 9-10 m in *Cucurbita* and *Lagenaria*. Crops like *Cucurbita pepo* have short internodes and are bushy. Nodes usually produce roots by touching on soil
3. Leaves are simple, mostly 3-5 lobed, palmate and rarely pinnately lobed (*Citrullus* sp.).
4. Tendrils on axils of leaves are simple in *Cucumis*, simple or bifid in others and absent in bush types.
5. Cucurbits are highly cross pollinated and pollination is done by honey bees and bumble bees. Flowers are born in axils of leaves and are solitary or in racemose clusters. Individual flowers are unisexual, large and showy.
6. Fruit is essentially an inferior berry and is called as “pep” due to hard rind when mature. Fruits can be stored for long period in ash gourd, pumpkin, oriental pickling melon, etc. while keeping quality is less in cucumber, snake gourd, bitter gourd, etc. The fruits of all cucurbits except chow chow are many seeded.

7. Seeds are borne in parietal placentation-Placenta is the edible portion in water melon while in ash gourd, ridge gourd and smooth gourd it is endocarp. In muskmelon, edible portion is mostly pericarp with a little mesocarp.
8. Cucurbits are mostly seed propagated. A few are vegetative propagated like parwal and coccinia.
9. Most cucurbits are annuals except chow chow and coccinia, both having perennial habit.
10. Cucurbitacins – Majority of cucurbits are characterized by presence of bitter principles, cucurbitacins at some portions of plant and at some stages of development. Cucurbitacins are tetracyclic triterpins having extensive oxidation levels. Its highest concentration is in fruits and roots and is less in leaves. Pollen grain also carries fairly good amount of bitter principles. This is a common problem in oriental pickling melon, cucumber and bottle gourd and is rarely noticed in ridge gourd and snake gourd. The consumers usually remove fruit tips during conception to avoid possible chance of bitterness in fruits.
11. Sex forms – A wide range of sex forms like monoecious, andro monoecious, gynandro monoecious and dioecious forms are noticed in the family.
 - *Hermaphrodite form* - This is the most primitive form and bisexual flowers only are produced in a plant. This is noticed in Satputia variety of ridge gourd and in a few lines of cucumber and mush melon.
 - *Monoecious form* - This is the advanced form and plants produce both male and female flowers in a plant. Majority of the cucurbits exhibit monoecious condition.
 - *Andromonoecious form* – Muskmelon and some cultivars of water melon produce both male and bisexual flowers in a plant. However, non dessert forms like oriental pickling melon, photo under *Cucumis melo* are monoecious.
 - *Gynomonoecious* - This is noticed in cucumber and the plants produce female and bisexual flowers.
 - *Gynoecious form* - Lines producing female flowers alone are rarely noticed in cucumber and have got great potential for commercial F₁ production.
 - *Trimonoecious form*- This is a condition wherein, the male, female and bisexual flowers are produced in a single plant
 - *Dioecious form* – Male and female flowers are produced on separate plants in parwal, coccinia and kakrol.

Flowering

Majority of cucurbits start flowering 30-45 days after sowing and it follows a definite sequence. An alternate sequence of male and female flowers follows upto fruit set. The first 4-6 flowering nodes bear male flowers and alter female flowers. Developing fruits in a vine determine production of further female flowers further down in the vine. In crops where immature fruits are harvested at tender stage, this kind of inhibiting mechanism will not be perceptible. But in melon, pumpkin, ash gourd etc. even if perfect or female flowers are produced in the vine, fruits may not set or develop fully or shed in immature condition. That is why number of fruits / vine in a seed crop will be less (4-5) than in a vegetable crop (12-15) in bottle gourd, ash gourd and cucumber.

Pollination

Pollination takes place early in morning between 6-8 am in cucumber, pumpkin, muskmelon and watermelon. Pollination is altered in the day when temperature is high in bottle gourd and ridge gourd. In snake gourd and pointed gourd, anthesis takes place during night and pollination early in the morning.

In pumpkin, pollen production is more while in muskmelon, pollen production is scanty and pollen grains are sticky due to oily film surrounding them.

Extent of cross pollination in cucurbits is 60-80%. They are entomophilous and bees, beetles and moths cause pollination.

Sex modification

Majority of cucurbits are monoecious and sex ratio (male: female) ranges from 25-30:1 to 15:1. Sex ratio is influenced by environmental factors. High N content in the soil, long days and high temperature favour maleness. Besides environmental factors, endogenous levels of auxins, gibberellins, ethylene and abscisic acid also determine sex ratio and sequence of flowering. A primordium can form either a female or a male flower and it can be manipulated by addition or deletion of auxins. Endogenous application of plant growth regulators can alter sex form, if applied at 2-4 leaf stage. High ethylene level induces female sex and is suggested to increase female flowers in cucumber, musk melon, summer squash and pumpkin. In cucumber, maleic hydrazide (50-100 ppm) GA 3 (5-10 ppm), Ethrel (150-200 ppm), TIBA (25-50 ppm), boron (3 ppm) also induce female flowers.

Gibberellins promote maleness and are antagonistic to the action of ethylene and abscisic acid. In fact, gynoecious line of cucumber is maintained by inducing male flowers through spray of GA 3 (1500-2000 ppm). Silver nitrate (300-400 ppm) also induces maleness.

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR RIDGE

GOURD

Ridge Gourd (*Luffa acutangula* Roxb.) (2n = 26) (Hindi : Ghia tori) &

Smooth Gourd (*Luffa cylindrica* Roem.) (2n = 26) (Hindi: Kali tori)

Both ridge or ribbed gourd and smooth or sponge gourd belong to genus *Luffa*. Genus name was derived from the product “Loofah” used as bathing sponges, scrubber pads, doormats, pillows, mattresses, cleaning utensils, etc. Both species contain a gelatinous compound called luffein.

Both crops are cultivated on a commercial scale and grown in homesteads for its immature fruits which are used as cooked vegetable. Fibre of mature dry fruits is used as a bath sponge. As tender fruits are easily digestible and appetizing, it is prescribed for those who are suffering from malaria and other seasonal fevers.

Luffa acutangula



Luffa cylindrica



Origin and distribution

Origin of ridge gourd is not known. Smooth gourd may be a native of South Asia or Africa or Australia.

Varieties-Ridge gourd

Developing institution	Variety	Special features
IIHR, Bangalore.	Arka Sumeet	Fruits lush green, cylindrical, 55 cm long 2.5 cm girth and 380 g weight with prominent ridges, delicate aroma. Days to first harvest 50-55.
	Arka Sujat	Fruits lush green, cylindrical, medium long (35-45 cm) and average weight (350g). Yield 63 t/ha in 100 days.
IARI, New Delhi.	Pusa Nasdar	Fruits club shaped, light green in colour, 15-20 fruits / plant, yield 15-16 t/ha.
GBPU&T, Pantnagar.	Pant Torai-1	Fruits 5 cm long and club shaped, yield 10 t/ha. More suitable for rainy season.
Tamil Nadu Agricultural University	CO.1	Fruits long (60-75 cm), first harvest in 55 days, 10-12 fruits / plant weighing 3-4 fruits / kg.
	PKM-1	Fruits dark green, average weight 300g,

		yield 28-30 t/ha in 160 days.
	CO.2	Fruits very long (90-100 cm), weighing 350-400g., green with shallow grooves, duration 120 days, yield 25 t/ha.
HARP, Ranchi	Swarna Manjari	Tolerant to powdery mildew. Fruits elongated, medium sized, highly ridged, green with soft flesh. Days to first harvest 65-70 days. Yield 18-20 t/ha in 140-150 days.
	Swarna Uphar	Fruits elongated, medium sized (200g), ridges with soft weak flesh. Days to first harvest 65-70. Fruits lush green, cylindrical, 55 cm long 2.5 cm girth and 380 g weight with prominent, ridges, delicate aroma. Days to first harvest 50-55.
Punjab Agricultural University, Ludhiana.	Punjab Sadabhar	Fruits long, 3-5 cm thick and slightly curved, yield 10 t/ha.
KKV, Dapoli	Konkan Harita	Fruits dark green, 30-45 cm long, tapering at ends, 10-12 fruits / plant.

Satputia is a cultivar in Bihar which is hermaphrodite and produces pale green small fruits in clusters. In each cluster 5-7 fruits are produced. Yield is 20-25 t/ha.

Varieties – Sponge gourd

Developing institution	Variety	Special features
IARI, New Delhi.	Pusa Chikni	Early variety. Fruits smooth dark green and cylindrical, 15-20 fruits / plant.
	Pusa Supriya	Fruits pale green, 15-20 cm long, straight and slightly curved at stem end, pointed distal end with long peduncle, average fruit weight 110 g at vegetable harvest stage. Yield 10-11 t/ha.

	Pusa Sneha	Suitable for long distance transport, fruits dark green, 20-25 cm long with hard skin and soft flesh. Yield 12 t/ha.
MPAU, Rahuri.	Phule Prajakta	Fruits medium green with dark green sutures, yield 15 t/ha.
BAC, RAU, Sabour, Bihar	Rajendra Nenua 1	Fruits long, greenish white, smooth and thick, resistant to fruit fly and fruit rot. Yield 25 t/ha.

Climate and soil

Like bitter gourd, ridge gourd and smooth gourd are typical warm season crops and come up well during summer and rainy seasons. Optimum temperature required is 25-27°C. Ideal soil is fertile well drained loam rich in humus.

Cultivation practices

Both ridge and smooth gourd are grown during summer and rainy season by sowing seeds during January – February and June – July, respectively. Seeds are sown in raised beds, furrows or pits @ 3.5-5.0 kg/ha for ridge gourd and 2.5-5.0 kg/ha for sponge gourd. Since seeds are with hard seed coat, it is advisable to soak seeds overnight in water. A row-to-row distance of 1.5-2.5 m and hill to hill distance of 60-120 cm is required for both crops under bower or trellis system. When it is trailed to ground under pit system, a row-to-row spacing of 1.5-2.0 m and pit-to-pit distance of 1.0-1.5 m are recommended for both crops.

Manure and fertilizer requirements, irrigation and intercultural operations are same as that of bitter gourd.

Harvesting

Crop is ready for harvest in about 60 days after sowing. Both crops are picked at immature tender stage. Fruits attain marketable maturity 5-7 days after anthesis. Over-mature fruits will be fibrous and are unfit for consumption. To avoid over-maturity, picking is done at 3-4 days interval. Harvested fruits are packed in baskets to avoid injury and can be kept for 3-4 days in a cool atmosphere.

Yield: 7-5 – 15.0 t/ha.

Pests and Diseases of Cucurbits

Cucurbits are affected by a large number of insect pests, nematodes and diseases. Major pests and diseases affecting cucurbit vegetables are discussed below:

Pests

Fruit fly, red pumpkin beetle and epilachna beetle cause damage to most of cucurbits. In addition, insects like gall fly; aphids, leaf hopper, ants, worms, underground semi loopers, leaf miners, fruit borers and mites affect specific cucurbits. Intensity of infestation varies from place to place.

Fruit fly (*Bacterocera cucurbitae*)

This is a major pest of majority of cucurbits especially that of bitter gourd, snake gourd, pointed gourd, muskmelon, oriental pickling melon, watermelon, tinda and pumpkin. Adult fly has reddish brown body with transparent and shiny wings, bearing yellow-brown streaks. It lays eggs singly or in clusters of 4-12 in flower or developing fruits or ripening fruits with the help of sharp ovipositor of females. Eggs hatch in 2-9 days and maggots feed on internal contents of fruits causing rotting. Pupation is in ground at a depth of 1.5-15.0 cm. Infestation is more during rainy season.

Adopt following package for control of fruit fly:

1. Cover developing fruits with paper cover or polythene cover immediately after anthesis and pollination.
2. Collect and destroy affected fruits by dipping in hot water or insecticide solution. Do not leave infested fruits on gourd.
3. Use light trap and poison baits during night. Spray a bait solution containing 200 g gur or sugar and 20 ml Malathion 50 EC in 20 l of water as coarse droplets on lower surface of leaves.
4. Spraying on under surface of leaves of maize plants grown in rows at a distance of 8-10 m in cucurbit field is also effective as flies rest on such tall plants.
5. Hang baits containing sex attractants like pheromones or protein hydrolysate with Furadan granules. Hanging coconut shells with pieces of fully ripened fruits of "Mysore poovan" banana or toddy or molasses along with Furadan granules also attract and kill fruit flies.

Red Pumpkin Beetle (*Aulacophora foveicollis*)

Beetle attacks most of cucurbits especially melons, bottle gourd, pumpkin, cucumber, water melon etc. Bitter gourd is not seen attacked by beetle. Beetles eat the leaf lamina causing defoliation particularly at cotyledon stage of crop. Grubs feed on underground stem and root portion of plants causing holes / galleries and result in drying up of plants. As insects pupate in the soil, deep ploughing soon after the crop exposes and kills grubs and pupae.

Application of Furadan 3 G granules 3-4 cm deep in soil near base of just germinated seedlings will take care of young seedlings from attack of beetle.

Epilachna beetle (*Epilachna septima*)

Epilachna beetle is a serious pest of bitter gourd and snake gourd. Adult flies feed on foliage causing holes and defoliation. A large number of yellow coloured thorny grubs are seen on under surface of leaves and feed on chlorophyll resulting in skeletonisation of leaves. Mechanical control by way of collection and destruction of egg masses and grubs are very effective as they are seen as a colony. It can also be controlled by spraying Carbaryl (0.2%) or Metacystox (0.15%).

Aphids (*Aphis gossypii*)

Aphids suck sap from leaves of cucurbits like ash gourd, snake gourd, mush melon, water melon, cucumber etc. causing crinkling of leaves. It also transmits mosaic virus. Control aphids by spraying Malathion (0.1%) or tobacco decoction

Leaf hopper (*Amrasca biguttula biguttula*)

During summer months, jassids cause heavy loss to bitter gourd crop. Green coloured hopper and its nymphs are seen in large numbers on under surface of leaves and suck sap causing typical hopper burn symptoms. Initially neem oil garlic mixture at fortnightly interval is effective for control of hopper. Spraying of Acetaf, Imidachloprid etc. control hoppers effectively.

Red spider mites (*Tetranychus sp.*)

Larvae, nymphs and adults of mites lacerate leaves from under surface and suck sap resulting in production of white patches between veins in *Cucumis melo*. Infested leaves turn yellow and fall off prematurely. In severe cases, intense webbing occurs giving a dusty appearance to under surface of leaves. Mites can be controlled by spray of neem oil garlic mixture or Kelthane or Dicofol on under surface of the leaves.

Leaf miner (*Lyriomyza trifolii*)

This polyphagous pest causes characteristic white twisting lines in ash gourd, *Cucumis sativus* and *Cucumis melo*. Severe leaf mining accelerates leaf drop and retards growth and yield of plants. Mated females puncture leaves and lay eggs in leaf tissues. After hatching, larvae start feeding in palisade mesophyll cells of leaves while moving inside. Mines start from margins of leaves and progress towards centre. Yellow larvae can be seen at the end of mines. Larval duration is 4-6 days. When larva is ready to pupate, it cuts a semicircular slit on leaf surface and fall down on ground. Larvae emerge from leaves during early morning before 8.00 a.m. For control of miner, trap adults to yellow cards applied with adhesives. Burning infested

dried leaves will help in reduction of population. Spraying neem oil garlic mixture early in morning before sunrise will be an effective control.

Gall fly (*Lasioptera falcate*)

Gall flies, having shape of mosquitoes, lay eggs in soft stem of bitter gourd, snake gourd, coccinia etc. Emerging larva feed inside stem. Since large numbers of larvae are seen inside stem, affected portion becomes bulged and subsequent growth of stem is arrested. Restrict irrigation and nitrogen fertilizers once infestation is noticed. Cutting and removal of galls also should be practiced regularly. Spray systemic insecticides under sever infestation.

Diseases

Fusarium wilt (*Fusarium oxysporum*)

Fusarium wilt is a serious disease water melon, musk melon, bottle gourd etc. In young seedlings, cotyledons drop and wither. Older plants wilt suddenly and vascular bundles at the collar region show brown discolouration. Being a soil borne disease, chemical control is very difficult. Cultivation of resistant varieties and crop rotation with resistant crops are viable methods for overcoming the disease. To some extent, the disease can be checked by hot water treatment of seeds at 55°C for 15 minutes and by drenching soil with carbendazim.

Collar rot (*Rhizoctonia solani*) / Pythium rot (*Pythium sp.*)

Characteristic symptom of the disease is appearance of dark brown water-soaked lesions girdling the base of stem at soil level followed by death of plants. It is more serious under water logged conditions and during rainy seasons. Treating seeds with Thiram @ 3 g/kg of seed before sowing, sowing of seeds on raised beds, drenching vines with Redomyl (0.2%) or Carbendazim (0.1%) are recommended for control of the disease.

Powdery mildew (*Sphaerotheca fuliginea*)

This disease is more destructive in pumpkin, squashes, bottle gourd, melon and cucumber, that too, during rain free periods. Symptoms appear as white to dirty grey spots or patches on leaves which become white powdery as they enlarge. Powdery coating covers entire plant parts and causes defoliation. Fortnightly spray of Karathane (0.5%) or Calixin (0.05%) or Carbendazim (0.1%) are recommended for control of powdery mildew.

Downy mildew (*Pseudoperonospora cubensis*)

Disease is prevalent in areas of high humidity, especially during rainy season, on crops like bitter gourd, snake gourd, melon, bottle gourd and ridge gourd. Symptoms appear as water soaked lesions on under surface of leaf lamina and angular spots on upper surface corresponding to the water-soaked lesions on under surface. Disease spreads very fast.

Plucking and destruction of affected leaves and spraying Dithane M-45 (0.2%) on under surface of leaves give effective control.

Anthracnose (*Colletotrichum lagenarium*)

This disease is endemic in warm and humid conditions where rainfall and humidity are high. Cucurbits like watermelon, bottle gourd, cucumber and snake gourd are more susceptible to disease. Different types of symptoms are observed on leaves, petioles, stem and fruits. Symptoms on young fruits appear in the form of numerous water soaked depressed oval spots, which coalesce covering large areas. Under humid conditions, pink masses of spores can be seen in centre of these spots. Pink gummy exudation may also be seen on lesions due to exudation of spores. Symptoms on vines occur as brownish specks which grow into angular to circular spots. Girdling of affected portion leads to general blight symptoms. Clean cultivation and crop rotation minimize disease incidence. Treating seeds with Carbendazim @ 25 g/kg of seed and spraying crop at 10 days intervals with Indofil M-45 (0.35%). Benomyl or Carbendazim (0.1%) gives effective control.

Alternaria blight and fruit rot (*Alternaria cucumerina*)

This is a serious disease under warm and humid conditions in crops like musk melon, water melon, bottle gourd, snake gourd, cucumber and pumpkin. Symptoms appear as yellow spots on leaves which turn brown and finally turn black on aging. They usually start from margins and produce concentric rings. Severely affected vines look like burnt charcoal. Use of disease free seeds, clean cultivation and crop rotation are effective for control of disease. Spray of 0.25% Indofil M-45 at 10-15 days interval is effective for disease control.

Mosaic

Viral disease are causing extensive damage to different cucurbits like pumpkin and squashes, water melon, ridge gourd, bitter gourd, ash gourd, melon, cucumber and coccinia. Viral diseases are becoming serious due to intensive and continuous cultivation of a crop with indiscriminate use of plant protection chemicals. Several viruses like aphid transmitted cucumber mosaic virus, watermelon mosaic viruses like aphid transmitted cucumber mosaic virus, watermelon mosaic virus, mechanically transmissible tobacco virus group, non sap transmissible but white fly transmissible yellow vein mosaic virus etc. cause malformation and damage to plants. Symptoms expressed by host plant vary with virus and crop. Mosaic mottling, curling and twisting of leaves, shortening of internodes, stunted growth are common symptoms and vegetative growth, flowering and productivity are adversely affected once crop is infected.

Complete control of the diseases is not possible. Adoption of practices like collection of seeds from healthy virus free plants, seed treatment with hot air (70°C for 2 days) or hot water (55°C for 60 minutes), clean cultivation and removal of alternate hosts particularly weeds, avoiding relay cropping of susceptible crops, prophylactic spray of organic pesticides, control of vectors by spraying insecticides, use of biocontrol agents, cultivation of tolerant / resistant varieties, avoiding cropping during mosaic prone season and areas, either alone or in combination have to be tried for raising a mosaic free crop. Selection of methods for control of viral diseases should be based on intensity of infection, mode of transmission, etc.

Nematodes

Cucurbits are highly susceptible to nematode infestation particularly of root knot nematode *Meloidogyne incognita acrita*. Symptoms include premature leaf fall, wilting and decline in growth and fruit production. Roots of infected plants show typical galls / knots. Cultivation of resistant varieties, crop rotation with non-host plants, successive deep ploughing during hot weather, soil solarization with polythene sheets and soil fumigation with nematicides are advocated for control of root knot nematode.

Application of fertilizers in Tamil Nadu

Apply 10 kg of FYM, 100 g of NPK 6:12:12 g mixture as basal per pit and N @ 10 g per pit 30 days after sowing.

1. The word *Luffa* is originated from _____ because of its sponge characteristics.
 - a. Greek
 - b. Latin
 - c. Arabic
 - d. Sanskrit
2. The optimum temperature for the growth of ridge gourd is ____ °C
 - a. 10-15
 - b. 15-25
 - c. 25-35
 - d. 35-40
3. _____ is a variety of ridge gourd which is moderately resistant to downy mildew
 - a. Arka Nasdar
 - b. Pusa Nasdar
 - c. Arka Sujat
 - d. CO - 1
4. _____ is a super long variety of ridge gourd
 - a. CO 1
 - b. CO 2
 - c. Pusa Chikini
 - d. None
5. A total number of _____ harvest can be done at an interval of 5-7 days in ribbed gourd
 - a. 3-5
 - b. 6-7
 - c. 8-10
 - d. 11-13

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR ASH GOURD

Ash Gourd (Wax Gourd) (*Benincasa hispida* Cong.) (2n = 24) (Hindi): Petha)

Ash gourd is cultivated for its immature as well as mature fruits which are used as a cooked vegetable and are used in confectionary and ayurvedic medicinal preparations. The delicacy 'Petha' made out of ash gourd is famous all over India. A small fruited medicinal ash gourd is also grown in Kerala. The famous ayurvedic preparation 'Kooshmanda rasayana' is made of ash gourd fruits. Ash gourd is good for people suffering from nervousness.

Origin and distribution

Crop originated in Asia specifically in Java and Japan. It is grown throughout old world tropics and is less common in new world tropics. In India, the crop is widely grown in UP and Delhi for preparation of 'Agra petha' and in southern states for use as vegetable.

Botany

Genus *Benincasa* is monotypic and the only species is *B. hispida*. Wild forms do not exist in this species. Ash gourd is diploid with $2n=24$. It is a vigorous but slow growing trailing annual. Due to long tap root system, ash gourd is considered as an ideal crop for river bed cultivation. Stem and all other parts are covered with bristle-like hairs. This monoecious crop produces large male flowers with long pedicels and female flowers with densely haired ovary and short peduncle on same plant. Corolla is yellow in colour and large in size. Ratio of staminate to pistillate flowers is 34:1. Anthesis takes place at 4.30 – 7.30 a.m. and anther dehiscence is at 3.00 – 5.00 a.m. Stigma is receptive from 8 hours before to 18 hours after anthesis.



Variety

Variability in ash gourd is limited except for size and shape of fruits. The improved varieties are:

Developing Institution	Variety	Special features
Kerala Agricultural University, Thrissur.	KAU Local	Medium sized oval to oblong fruits with high flesh thickness, fruit length 45-55 cm. Length: Breadth ratio 2.05, fruit weight 6.1-8.1 kg, productivity 28.2 t/ha.
	Indu	Medium sized round fruits, tolerant to mosaic disease, av. fruit length 24.3 cm.
Tamil Nadu Agricultural University.	CO.1	Fruits round, av. fruit weight 5-6 kg. Duration 140 days.
	CO.2	Fruits small and long spherical, av. fruit weight 3.0 kg.
APAU, Hyderabad.	APAU Shakthi	Fruits long and cylindrical, yield 30-35 t/ha in 140-150 days.
UAS, Bangalore.	"Karikumbala"	Local cultivar where the fruits are covered with ashy coat.
IIVR, Varanasi.	IVAG.502	Fruits oblong with average weight of 12-13 kg. Yield 30-35 t/ha.

In addition to above open pollinated varieties, a few F_1 hybrids like MAH 1; MHAG 2 etc. are developed under private sector in the country.

Climate

Ash gourd is a warm season crop and is susceptible to frost. The crop comes up very well in humid and high rainfall areas also. The ideal temperature for growth and production is 24-30°C.

Season

In areas, where winter is mild, crop is grown throughout the year. As a rainfed crop, it is sown by May in Kerala and by June-July in Tamil Nadu. In North India, it is mainly grown during summer and rainy seasons.

Cultivation

Growth and cultivation practices like spacing, fertilizer requirement and irrigation are similar to that of pumpkin.

Germination and fruit set are better, when 3-4 months old seeds are used for sowing than fresh seeds. Initial growth of ash gourd plant is slow when compared to pumpkin. Hence, fast growing and short duration crops like cucumber, oriental pickling melon etc. can be grown as intercrops along with ash gourd.

Seed rate recommended is 0.75 – 1.0 kg/ha under pit system in Kerala and 5.0 kg/ha under furrow system in North Indian conditions. If fruits are harvested at tender stage at frequent intervals, apply fertilizer in more splits as top-dressing.

Harvest

Fruits are harvested at immature and fully mature stages depending on demand in each locality. Immature fruits are harvested one week after anthesis and harvesting is done at weekly intervals. Mature fruits for storage, long distance transport and for seed extraction are harvested after full development of waxy coating on fruit surface.

Yield 10-15 t/ha when fruits are harvested at mature stage.

25-30 t/ha when fruits are harvested at immature stage.

Seed production

Follow common procedure of cucurbits for seed production. For seed purpose, fruits are allowed to mature till vines and fruits stalks are completely dried. It is advisable to preserve the fruits for 2-3 months before extraction of seeds. Seeds along with placenta are scooped out from cut fruits and allowed to ferment overnight. Seeds are then washed in running water and allowed to dry till 8% moisture content. Germination of seeds extracted from freshly harvested fruits is very low. To avoid the dormancy factor, fruits as such or seeds after extraction are preserved for 2-3 months before sowing. Seed yield is 175-200 kg/ha.

Application of fertilizers: Apply 10 kg FYM per pit and 100 g of NPK 6:12:12 mixture/pit and 10g N/pit 30 days after sowing.

1. Botanical name of Ash gourd
 - a. *Benincasa hispida*
 - b. *Trichosanthes cucumerina*
 - c. *Cucurbita maschata*
 - d. *Cucurbita pepo*
2. _____ is the common native confectionary prepared from ash gourd in North India
 - a. Petha
 - b. Jam
 - c. Jelly
 - d. None

3. Ash gourd is predominantly a _____ crop
 - a. Monoecious
 - b. Dioecious
 - c. Androgynocious
 - d. None
4. In ash gourd, the sex ratio varies from _____
 - a. 20:1 to 33:1
 - b. 40:1 to 45:1
 - c. 5:1 to 10:1
 - d. 10:1 to 15:1
5. The maturity indices for harvesting wax gourd is
 - a. Appearance of ashy bloom
 - b. Disappearance of ashy bloom
 - c. Wine drying
 - d. Petiole drying

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR BOTTLE GOURD

Bottle Gourd - *Lagenaria siceraria* (Mol.) Standl. (2n = 22) (Hindi: Lauki)

Bottle gourd is extensively grown in India and fruits are available throughout the year. The name bottle gourd is due to bottle like shape of fruit and its use as a container in the past. Fruits at tender stage are used as a cooked vegetable and for preparation of sweets and pickles. Hard shells of mature fruits are used as water jugs, domestic utensils, floats for fishing nets, etc. As a vegetable it is easily digestible. It has cooling effect and has diuretic and cardiotoxic properties. Fruit pulp is used as an antidote against certain poisons and is good for controlling constipation, night blindness and cough. A decoction made out of leaf is taken for curing jaundice. Seeds are used in dropsy.

Origin

Originated in tropical Africa, the crop is domesticated in Asia, Africa and New World.

Botany

Bottle gourd is a climbing annual with a duration of 3 ½ to 4 months. Flowers are solitary, chalky white in colour and open at night. Fruits are fleshy and vary in shape and size.



Varieties

Developing institution	Variety	Special features
IIHR, Bangalore	Arka Bahar	Fruits straight without crook neck medium sized each weighing 1.0 kg at marketable stage, fruit light green and shining, yield 40-50 t/ha.
IARI, New Delhi.	Pusa Naveen*	Fruits cylindrical, straight and free from crooked neck. Average weight 550 g.
	Pusa Summer Prolific Long (PSPL)	Long fruits having a length of 40-50 cm
	Pusa Summer Prolific Round (PSPR)	Round fruits having a diameter of 15-18 cm.
	Pusa Sandesh	Round green medium sized fruits weighing 600 g. Early variety ready for picking in 55-60 days. Yield 29-32 t/ha.
	Pusa Meghdoot	F ₁ hybrid between PSPL and Sel.2 Fruits long and light green.
	Pusa Manjari	F ₁ hybrid between PSPR and Sel.11. Fruits round and light green.
	Pusa Hybrid 3	F ₁ hybrid having green and slightly, club shaped fruits without neck. Yield 42.5 t/ha.
NDAU&T, Faizabad, UP.	Narendra Rashmi	Moderately tolerant to pumpkin beetle, powdery mildew and downy mildew. Fruits bottle shaped having shallow neck, average weight 1.0 kg. Yield 30 t/ha.
Punjab Agricultural University, Ludhiana	Pusa Komal	Fruits medium size with oblong shape and light green skin. Tolerant to CMV, early harvest (70 DAS), potential yield 40 t/ha.
	Punjab Round	Fruits round, light green and shining. Yield 15.5 t/ha.

CSAUA&T, Kanpur.	Kalyanpur Long Green	Fruits long with tapering with some what pointed blossom end, yield 30 t/ha in 120 days.
	Azad Nutan	Early variety with long neck free fruits weighing 1.5 kg.
MPAU, Rahuri	Samrat	Fruits cylindrical without crook neck, greenish white, 30-40 cm long weighing 700-800 g, yield 43 t/ha.
CBPUA&T, Pantnagar	Pant Sankar Lauki 1	This F ₁ hybrid has medium long fruits. Released by Central Variety Release Committee (CVRC) in 1999.
TNAU, Coimbatore	CO.1	Pale green coloured and bottle shaped fruits with narrow neck and round bottom. Yield 25-30 t/ha.

* Varieties released / identified by AICRP (Vegetables)

Heterosis

A good number of F₁ hybrids, Pusa Meghdoot, Pusa Manjari, Pusa Hybrid 3 and Pant Sankar Lauki 1 were developed in public sector in bottle gourd. F₁ hybrid Varad (MGH 4) developed by Mahyco, Jalna yields 60-65 t/ha. It has cylindrical bright green, 40-45 cm long fruits weighing 600-750 g.

Climate

Bottle gourd is a typical warm season vegetable. Though crop tolerates cool climate better than musk melon and water melon, it cannot tolerate frost. Well drained fertile silt loam is ideal for cultivation of bottle gourd. Crop is quite suitable for river bed cultivation because of its deep tap root system. A deep soil supports vines for a long period.

Season

Crop is grown during summer and rainy season. In places where water is not scarce, it is grown throughout the year.

Land preparation and sowing

Land preparation and sowing are similar to that of ash gourd. Land is ploughed to a fine tilth and furrows are made at a distance of 2.0-3.0 m. After incorporating farmyard manure, seeds are sown in furrows at a distance of 1.0-1.5 m between plants. When bottle gourd is trained on bower, follow a spacing of 3.0 x 1.0 m. In sloppy land, sowing is done in pits with 2-3

plants / pit. Soaking seeds 12-24 hours in water or in succinic acid (600 ppm) for 12 hours improves germination. Seed rate recommended is 3-6 kg/ha.

Training and pruning

As bottle gourd puts forth good vegetative growth, proper training and pruning are advantageous. Training plants to bower helps to tap sunlight more effectively and yield as high as 80 t/ha was obtained. Axillary buds of growing vines should be removed till vines reach the bower height. When vine reaches bower, apical bud is removed at 10-15 cm below bower to allow 2 or 3 branches to spread on bower. After formation of 4-5 fruits, vines are again pruned allowing 2-3 axillary buds only to grow on primary vines. It is also advisable to remove all yellow and pale coloured older leaves near bottom portion.

Interculture

Bottle gourd is highly responsive to heavy application of manures and fertilizers. Follow fertilizer package and interculture operations as that of ash gourd and bitter gourd.

Harvesting

Fruits are harvested at tender stage when it grows to one third to half. Fruits attain edible maturity 10-12 days after anthesis and are judged by pressing on fruit skin and noting pubescence persisting on skin. At edible maturity seeds are soft. Seeds become hard and flesh turn coarse and dry during aging. Tender fruits with cylindrical shape are preferred in market. Harvesting starts 55-60 days after sowing and is done at 3-4 days intervals. While harvesting, care should be taken to avoid injury to vines as well as to fruits. Plucking of individual fruits is done with sharp knives by keeping a small part of fruit stalk along with fruit. Average yield is 20-25 t/ha for open pollinated varieties and 40-50 t/ha for F₁ hybrids.

Fruits can be stored for 3-5 days under cool and moist condition. For export purpose, fruits are packed in polythene bags and bags are kept in boxes of 50-100 kg capacity.

Application of fertilizers in Tamil Nadu

Apply 10 kg of FYM (20 t/ha) 100 g of NPK 6:12:12 mixture as basal and 10 g of N per pit 30 days after sowing.

- 1) The origin of bottle gourd is
 - a. Asia
 - b. Java
 - c. India
 - d. Europe
- 2) After drying _____ vegetable is used as domestic utensils
 - a. Pumpkin
 - b. Bottle gourd
 - c. Sanke gourd
 - d. Watermelon

- 3) Among the cucurbits _____ is most drought hardy crop
- a. Pumpkin
 - b. Bottle gourd
 - c. Cucumber
 - d. Japan
- 4) The average yield of bottle gourd varies from _____ t/ha
- a. 5-10
 - b. 10-20
 - c. 25-30
 - d. 40-50
- 5) The maturity indices for harvesting bottle gourd is
- a. Higher pubescence
 - b. Less pubescence
 - c. Fruit turns light green
 - d. Fruits turn dark green

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR BITTER GOURD

(Syn: Bitter cucumber, Balsam pear)

(*Momordica charantia* L.) (2n = 22)

(Hindi: Karela)

Bitter gourd is an important vegetable in South Indian states, particularly in Kerala and is grown for its immature tuberculate fruits which have a unique bitter taste. Fruits are considered as a rich source of vitamins and minerals and 88 mg vitamin C per 100 g. Fruits are used after cooking and delicious preparations are made after stuffing and frying. During periods of glut in market, fruits are sliced, partially boiled with salt and dried under direct sunlight and stored for months. This is used after frying. Bitter gourd fruits have medicinal value and are used for curing diabetes, asthma, blood diseases and rheumatism. Drinking fresh bitter gourd juice is recommended by naturopaths. Roots and stem of wild bitter gourd are used in many ayurvedic medicines.

Origin and distribution

Bitter gourd is of old world origin and is a native of tropical Asia, particularly in the Indo Burma region. It is widely grown in India, Indonesia, Malaysia, China and tropical Africa.

Botany

Genus *Momordica*, to which bitter gourd belongs, has the following four species in India.

M. charantia (cultivated bitter gourd)

M. charantia var. *muricata* (Highly bitter and small fruited wild bitter gourd)

M. dioica (kakrol, spine gourd)

M. cochinchinensis (sweet gourd of Assam)

M. balsamina – Immature fruits are used as vegetable or picked.

All the species have $2n=2x=28$.

M. dioica



Momordica cochinchinensis



Momordica balsamina



M. charantia is propagated through seeds and is monoecious. *M. dioica* and *M. cochinchinensis* are propagated through underground tubers and are dioecious in nature. Both species have small fruits covered with spines. Ram (2002) reported main difference between the two species.

Kakrol or sweet gourd (<i>Momordica cochinchinensis</i> Roxb)	Kartoli or spine gourd (<i>Momordica dioica</i> Roxb)
Roots develop bigger tuber	Roots develop small tuber.
Leaves are bigger.	Leavers are small.
Flowers large and white to light yellow in colour.	Flowers small and yellow in colour.
There are three small circular dots at the base of petals which are deep blue.	No circular dot on the base of petals.
Anthesis during early morning (3.30-6.30 hours) and flowers take 72 hours to open.	Anthesis during evening (16.30-18.00 hours) and flowers take 7-22 minutes to open.
Fruits are large and oblong	Fruits are small and round to oval.
Individual fruit weight is around 60-80g and attains upto 500g.	Individual fruit weight is around 10-15 g and attains upto 30g.
Fruit ripening starts from periphery to inner	Fruit ripening starts from inner to periphery.
Fruit light green to light yellow in colour	Fruits dark green in colour.
Tough spines on fruit.	Smooth and false spines on fruit.
It takes 26 days to reach edible maturity from days to bud formation	It takes 20 days to reach edible maturity from days to bud formation.
Short flowering and fruiting period	Flowering and fruiting continue for long period.

Bitter gourd is a monoecious annual climber with duration of 100-120days. Leaves are palmately 5-9 lobed. Flowers are axillary with long pedicel and are yellow in colour. Stamens are 5 in number with free filaments and united anthers. Stigma is divided. Fruit is pendulous, fusiform, ribbed with numerous tubercles. Bitterness of fruit is due to the presence of an

alkaloid, Momordicin. Anthesis is from 4.00 a.m. to 7.00 a.m. Anther dehiscence takes place in between 5.00 a.m. and 7.30 a.m. Stigma is receptive 24 hours before and after anthesis.



Varieties

Consumer preferences in bitter gourd vary from region to region depending on size, colour, presence or absence of tubercles / ridges and bitterness of fruits. Accordingly a number of varieties are developed in India and details are furnished below:

Developing institution	Variety	Special features
IIHR, Bangalore	Arka Harit	Fruits short, spindle shaped, green coloured with smooth regular ribs and moderate

		bitterness. Yield 9-12 t/ha.
IARI, New Delhi	Pusa Vishesh	Selection from a local collection and suitable for growing during summer. Fruits glossy green medium long and thick.
	Pusa Do Mausami	Fruits dark green, club like with 7-8 continuous ribs. Fruit weight 100-120 g. Yield 12-15 t/ha.
	Pusa Hybrid 1	Fruits medium thick, long and gloss green, yield 20 t/ha in 120 days
Kerala Agricultural University	Priya (VK1)*	Extra long green spiny fruits with white tinge at styler end, av. Fruit length 39 cm. av. Fruit weight 235 g. productivity 24.5 t ha ⁻¹
	Preethi(MC 4)*	Medium sized white fruits with spines, av. Fruit length 30 cm, av. Fruit girth 24 cm, av. Fruit weight 0.31 kg. productivity 15.0 t/ha ⁻¹
	Priyanka	Large white spindle shaped fruits with smooth spines, thick flesh and less seeds. Av. Fruit length 25 cm. av. Fruit girth 20 cm. av. Fruit weight 0.30 kg. Productivity 28.0 t/ha ⁻¹
Tamil Nadu Agricultural University	CO.1	Fruits dark green with medium length (20-25 cm) and weight (100-120 g). Yield 14 t/ha.
	Coimbatore Long Green	Extra long fruits (60 cm) with dark green colour.
	MDU.1	Fruit weight 300-450 g. yield 15-18 t/ha. Induced mutant with long (30-40 cm) greenish white fruits, fruit length 30-40 cm, yield 30-35 t/ha.
	Coimbatore Long White	Extra long fruits (60-65 cm) with white colour, yield 15 t/ha.
	COBgH 1	F ₁ hybrid developed by crossing MC 84 x

		MDU1. Fruits are light green in colour, plumpy with more warts, each weighs 200g.-300g. Yields 44.40 t/ha in 115-120 days. It is rich in momordicin (2.99 mg per 100g).
Konkan Krishi Vidya Peeth, Dapoli	Konkan Tara	Fruits green, prickly, medium long (15-16 cm) and spindle shaped. Yield 24 t/ha.
Punjab Agricultural University, Ludhiana.	Punjab 14	Plants bushy and bear light green fruits with average weight of 35 g. Yield 14 t/ha.
CSAUA&T. Kanpur	Kalyanpur Baramasi	Fruits long (30-35 cm), light green, thin and tapering, tolerant to fruit fly and mosaic, yield 20 t/ha in 120 days.
MPKV, Rahuri.	Hirkani	Fruits dark green, 15-20 cm long, spindle shaped with warts and prickles, yield 14 t/ha in 160 days.
	Phule Green	Fruits dark green, 25-30 cm long, prickled, tolerant to downy mildew, yield 23n t/ha in 160-180 days.

Climate and soil

Bitter gourd is a warm season crop with wide adaptability. Ideal temperature for its growth and flowering is 25-30°C. Crop can be grown even in places of slightly lower temperature and high rainfall areas. Production of female flowers, fruit set and growth of plant are seen affected above 35°C and will be susceptible to viral infections. As seeds have a hard seed coat, germination is affected below 10°C.

Well drained and fertile sandy loam or silt loam is ideal for the crop.

Season

In hills, the crop is sown during April-May. In plains where season is early, bitter gourd is sown during January-March in states like Rajasthan and Bihar. In states where winter is late and prolonged, sowing is done in February-March. In areas where winter is mild, crop is sown throughout the year. In Kerala, when bitter gourd is grown in an intensive way, sowing is done

during January-February for summer crop, May-June for kharif crop and September for rabi crop.

Kakrol and sweet gourd are normally grown during rainy season in fertile soil rich in humus. Performance is better under partially shaded condition.

Land preparation and sowing

Preparation of land, sowing and other cultural practices for bitter gourd is similar to that of cucumber except that bitter gourd is trained to bower or cut branches of trees. In Kerala, the crop is cultivated in an intensive way. Land is ploughed to a fine tilth and pits of 60 cm diameter and 30-45 cm depth are made at a spacing of 2.0-2.5 x 2.0 – 2.5 m. well rotten farmyard manure @ 20-25 t/ha is applied in pits and filled with top soil up to 3/4th height and 4-5 seeds are sown in each pit @ 5.0-6.0 kg/ha.

Since bitter gourd seeds have a hard seed coat, soak 2-3 months old seeds overnight in cold water. Seeds are then stored in moist cloth and kept for one or two days for germination. Seeds immediately after germination are sown in pits. Mechanical scarification is effective for germination of seeds soon after harvest.

Irrigation

Bitter gourd cannot tolerate drought or water stagnation. Frequent irrigation at 2-5 days interval especially at fruiting stage is necessary for high yield. Under Kerala condition, crop is irrigated at 3-4 days interval during initial stage and at alternate days during fruiting.

Manures and fertilizer application

In addition to 20-25 t/ha of farmyard manure, a fertilizer dose of 70 kg N, 25 kg P₂O₅ and 25 kg K₂O / ha is recommended by Kerala Agricultural University. Initial dose of farmyard manure is applied in pits and incorporated with top soil. Apply 1/3rd N and full dose of P and half dose of K either just before sowing or 10-15 days after sowing as basal dose. ½ K can be applied 45 days after sowing. Remaining fertilizers can be applied in several split doses (5-6) at fortnightly intervals. Since bitter gourd is harvested frequently, fertilizer also should be applied in several splits.

Drenching pits with cow dung slurry at fortnightly intervals, top-dressing with poultry manure and organic cakes are practiced by bitter gourd farmers in Kerala.

Application of fertilizers:

Apply 10 k of FYM per pit (20 t/ha) 100 g of NPK 6:12:12 per pit as basal and 10 g of N per pit 30 days after sowing.

Interculture

Being a shallow rooted crop, deep intercultural operations should be avoided. Land, particularly pits, should be kept weed-free by frequent hand weeding, hoeing and light earthing up along with application of fertilizers. Excess lateral branches, if any, may be pinched off for allowing plants to reach bower height at the earliest. Erect bower when plant starts vining. Plants may be trailed to bower by erecting small twigs in pits. Erection of bower or pandal is a costly operation and nearly 20% of cost of production is for making bower alone. Height of bower is adjusted as 2 m and is usually made of bamboo poles, G1 wire and thin coir or plastic wire. Bower once erected can be utilized for raising at least three crops.

Plant growth regulators

Application of several plant growth regulators like MH (50-150 ppm), CCC (50-100 ppm), Ethrel (150 ppm), silver nitrate (3-4 ppm), boron (3-4 mg/ha) at 2-leaf stage and 4 leaf stage increases the female flowers and yield in bitter gourd. Soaking of seeds with Ethrel or boron (3-4 mg/kg) also increases yield in bitter gourd.

Harvesting

Harvesting starts 55-60 days after sowing. Picking is done when fruits are fully grown but still young and tender. Seeds should not be hard at the time of harvest. From a good crop, 15-20 harvests are possible and harvesting is done twice a week. If fruits are allowed to ripen on vines, further bearing is adversely affected.

Fruits after harvest are packed in thin gunny bags or directly packed in tempo and marketed. Since keeping quality of fruits is less, fruits should be marketed without any delay to nearby markets on the same day itself. Otherwise tubercles will be dropped and freshness and appearance of fruits will be adversely affected.

Yield: 11-25 t/ha.

Seed Production

For seed purpose, fruits are harvested when fruits turn yellow in colour. Seeds along with red placenta are rubbed against a hard surface and washed in running water and dried under shade. Seed yield: 200-250 kg/ha.

- 1) Mode of pollination in bitter gourd
 - a. Self pollination
 - b. Cross pollination
 - c. Often cross pollination
 - d. None
- 2) The chromosome number of bitter gourd
 - a. 22
 - b. 24

**ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR COLE
CROPS CABBAGE**

CABBAGE – *Brassica oleracea* var. *capitata* Linn

Family: Crucifereae

Chromosome Number: $2n = 2x = 18$

Origin and History

Cabbage originated from a wild non heading type, 'Cole wart' (*Brassica oleracea* var. *sylvestris*). The genus *Brassica* includes about 100 species, majorities of which are native to the Mediterranean region. The crop is attributed to Mediterranean centre of origin. It is also considered that the real headed cabbage was evolved in Germany. The Savoy cabbage originated in Italy and spread to France and Germany in the sixteenth and seventh centuries. At present, cabbage is grown in Caribbean countries, Indonesia, Malaysia, Central East and West America.



Nutritive Value and Uses

Cabbage leaves are low in calories (27 per cent), fat (0.1 per cent) and carbohydrates (4.6 per cent). It is good sources of protein (1.3 per cent) which contains all essential amino acids, particularly sulphur containing amino acids. Cabbage proteins are comparable to pea proteins, in biological value, digestibility and NPU. Cabbage is an

excellent source of minerals such as calcium (39 mg), iron (0.8 mg), magnesium (10 mg), sodium (14.1 mg), potassium (114 mg) and phosphorus (44 mg). It has substantial amounts of β carotene provitamin A), ascorbic acid, riboflavin, niacin and thiamine. Ascorbic acid content varies from 30-65 mg per 100 g fresh weight. Cooking or shredding of cabbage and leaving it exposed to air can result in substantial loss of ascorbic acid. Red cabbage is a rich source of anthocyanin pigments. Both mono and diacylated cyanidin derivatives have been identified in red cabbage. Cabbage contains thermo labile sulphur compounds, which evolve sulfurous odours. The major volatile sulfur compounds (dimethyl disulfide and hydrogen sulfide) of cooked cabbage are derived from a precursor of 1, S methyl cysteine sulfoxide, a free amino acid. The presence of 2-propenyl isothiocyanate in both white and red cabbage and 3-butenyl isothiocyanate in red cabbage has also been reported.

Cabbage is used commonly as vegetables. It is also used for salad mixed in tomato, green chilies, beetroot etc. Flavour in cabbage leaves is due to the glycoside sinigrin. Cabbage contains goitrogens which cause enlargement of thyroid glands. The thioglucosides with their associate enzyme (s) impart the desirable culinary flavour to cabbage, broccoli and cauliflower. The thioglucosides (sinigrin) are non goitrogenic which depends upon enzymatic hydrolysis in presence of the enzyme (progoitrin and epi-goitrin) is the precursors of an anti thyroid compound called goitrin. The goitrin is formed subsequent to hydrolysis and then through cyclization of an unstable isothiocyanate containing hydroxyl group. The total glucosinolate content of white cabbage cultivars ranged from 299-1288 ppm, whereas the goitrin content varied from 1.2 to 26.0 ppm. Although the enzymatic hydrolytic products from the glucosinolates are goitrogenic, some of these breakdown products have anticancerous properties. It has also been reported that most of the goitrogen properties of cabbage could be lost during cooking. Cabbage is well known for its medicinal properties. In ayurvedic medicine, cabbage leaves are prescribed for cough, fever, skin diseases, peptic ulcers, urinary discharge and hemorrhoids. Fresh cabbage juice is reported to contain a heat labile antipeptic ulcer component. A clinical study has indicated that concentrated cabbage juice is significantly effective in healing peptic ulcers. Cabbage is one of the best sources of a sulphur containing amino acids. Fresh cabbage juice is reported to have anti bacterial activity and has been shown to inhibit the growth of various strains of lactic acid bacteria. Cabbage is also reported to have significant anti cancer activity. Model studies and epidemiological data in humans have confirmed the protective role of cabbage studies and epidemiological data in humans have confirmed the protective role of cabbage on the development of cancer.

Area and production

India is the third largest cabbage producer in the world. It is mainly grown in the states like Uttar Pradesh, Orissa, Bihar, Assam, West Bengal, Maharashtra and Karnataka

in the country. Area, production and productivity from 1987-1988 to 1998-99 in India are given in Table - 1.

Table 1

Area, Production and Productivity of Cabbage in India

Year	Area (in 000'HA)	Per cent of total area	Production (in 000'MT)	Per cent of total production	Productivity to MT / HA
1987-88	42.6	1.0	602.0	1.2	14.1
1991-92	177.3	3.2	2771.2	4.7	15.6
1992-93	188.9	3.7	3236.8	5.1	17.1
1993-94	231.7	4.8	3592.9	5.5	15.5
1994-95	216.8	4.3	3906.3	5.8	18.0
1995-96	218.4	4.1	3861.7	5.4	17.7
1996-97	210.2	3.8	3613.4	4.8	17.2
1997-98	228.2	4.1	5323.8	7.3	23.3
1998-99	239.9	4.1	5624.8	6.4	23.4

Source : Horticultural Data Base (2000) NHB Gurgaon.

Productivity of cabbage during 1998-99 was 23.4 t /ha in India which was near to the world average productivity 24.1 t /ha. The highest productivity was in Tamil Nadu. The various cabbage growing belts in different states of India are as given below (NHB, 2000)

- **Uttanchal** : Almora, Chamoli, Utrkashi and Dehradun
- **Uttar Pradesh Plains**
- **Himachal Pradesh**
- **Haryana** :Hisar, Sonapat, Gurgaon, Ambala, Karnal and Panipat.
- **Rajasthan** : Jaipur, Alwar and Ganganagar.
- **Assam**
- **Bihar** : Patna, Nalanda, West and East Champaran, Muzzafarpur, Vaishali, Bhagalpur, Darbangha and Madhubani
- **Gujarat** : ehsana, Khera, Baroda and Gandhinagar.
- **Maharashtra** : Nasik and Pune
- **Orissa** : Baleshwar, Balangir, Cutak, Dhankanan, Ganijam, Koenjhar and Koraput.
- **Karnataka** : Belgaum, Hassan, Belvey, Mysore, Dakshin Kannad and Tamil Nadu (The Nilgiris).

Apart from India, the other major producers in the world are China, Russian Federation, Japan, Korea, Republic, Poland, USA, Indonesia and Ukraine.

Classification

Bailey (1930) classified the cultivated Oleracea into 7 divisions.

A. The leaf races grown for the open foliage

- i) Branching shrubby kales - *B. oleracea* var. *fruticosa*
- ii) Common biennial mostly unbranching kales- *B. oleracea* var. *acephala*.
- iii) Low cabbage like Portuguese kales- *B. oleracea* var. *tranchuda*.

B. The head races grown for the compact leaf head or buds

- iv) Edible product a terminal head, the cabbage- *B. oleracea* var. *capitata*.
- v) Edible product lateral small heads or buds, the Brussels sprouts- *B. oleracea* var. *gemmifera*.

C. The inflorescence races grown for the modified thickened flower shoots of malformed flowers.

- vi). Flowers only partially if at all modified- *B. oleracea* var. *italica*.
- vii). Flowers thickened and malformed into a head or several head- *B. oleracea* var. *botrytis*.

Cabbage can also be classified in various ways

1. **Place of Origin:** (a) *B. oleracea* var. *capitata* ssp. *mediterranea*, e.g. Mediterranean cabbage (b) *B. oleracea* var. *capitata* ssp. *orientalis*, e.g. Oriental cabbage (c). *B. oleracea* var. *capitata* ssp. *europaea*. E.g. European cabbage.
2. **Botanical Colour and Form of Heads :** (a) *B. oleracea* var. *capitata* L.f. *alba*, e.g. white cabbage (b) *B. oleracea* var. *capitata* L.f. *rubra*, e.g. red cabbage (c) *B. oleracea* var. *sabauda* e.g. savoy cabbage.
3. **On the Basis of Head Shape (Choudhary, 1976).** : (a) Round shape head or ball head type (Golden Acre, Pride of India, Copenhagen Market and Mammoth Rock Red (b) Flat head or drum head type (Pusa Drum Head) (c) Conical head type (Jersey Wakefield) (d) Savoy type ('Chieftain').
4. **Classification Based on the Size and Shape of the Head (Allen, 1914):** (a) Wakefield and Winnings Kadet group:- head are small, conical and very early (Jersey Wakefield, Charleston Wakefield). (b) Copenhagen Market group:-round heads, early large head, (Copenhagen Market, Golden Drumhead, Globe, Bonanza). (c) Flat Head or Drumhead group:-heads flattened from both ends (Pusa Drum Head, Early round Dutch, All Head Early, Succession, All Seasons). (d). Savoy group:-leaves are wrinkled; heads are of very high quality, limited commercial use (Drum Head Savoy, Improved American Savoy, and Chieftain). (e) Danish Ball Head group:-leaves are thin, heads compact solid, medium sized, good keeping quality, fine texture (Danish Ball Head, Hollander, Wisconsin Ball Head). (f) Alpha group:-The earliest group head, very small, solid head limited commercial uses, (Miniature Marrow). (g) Volga group:-thick leaves, shining blue coloured leaves, loose bottom (Volga). (h) Red

Cabbage group:-similar to Danish Ball Head except red colour of leaves (Red Rock, Red Dutch, Large Red).

Varieties / Hybrids

Bajrang (BSS-50)

The hybrid has been developed at Beejo Sheetal Seeds Pvt. Ltd., Jalna. Heads are dark green, smooth, highly compact. The outer leaves are upright. It matures in 65 days but can stand on the field for 45 days after maturity. It can tolerate high temperature (up to 36°C) and resistant to fusarium wilt. Average head weight is one kilogram.

BSS-44

The hybrid has been developed at Beejo Sheetal Seeds Pvt. Ltd., Jalna. The head is roundish, average weight 2.5 kg and mature in 75 days after transplanting. But, head can also stand for 20 days in field after maturity. This hybrid is resistant to fusarium wilt.

Copenhagen Market

This is still being grown but on a limited area. This is an introduction, which has been replaced by Golden Acre and 'Pride of India' because of their earliness and smaller head size.

Early Drumhead

It is an early variety having light green foliage. Leaves are medium to large, curving inward and enclosing the head loosely. Leaves formed, the head fold over each other at the centre. The heads are flat.

Golden Acre

This is an earliest variety evolved by selection from the Copenhagen Market and recommended by IARI for cultivation. It takes about 60-65 days from transplanting to head formation. It has fewer outer leaves which are cup shaped and arranged in two whorls. The heads are solid, short core and weighing of about 1.0-1.5 kg. The heads should be harvested immediately after head formation; otherwise, cracking may take place. If the timely sowings are not done, then the heads formation will be conical (Tiwari *et.al.*, 1977). The variety has also been highly suitable for spring and summer growing in the hills.

H-113

This is a self-incompatible based hybrid between Sel-8 and 83-6 line, developed at IARI, Regional Station, and Katrain. Plants bear roundish, compact head (13.5 x 16 cm), bluish green and waxy leaves, 0.5-0.7 cm stalk length and 50-60 cm frame size (13.5 x 16 cm). It gives average yield of 473.5 q/ha in 60-68 days of crop duration.

Harirani Gole

It is good hybrids for medium alters maturity. It produces medium sized ball shaped dark blackish green, solid head with good wrapper leaves. Each head weight is 1.5-2.0 kg. It can be harvested after 95-100 days of transplanting.

Kranti

It is ready for harvesting within 60 days after transplanting. It is good for close spacing. Heads are round and compact with 0.8 -1.2 kg per head weight.

Jersey Wakefield

It is an introduction with pointed head, which preferred by some growers. It takes about 55-60 days for head formation. The outer leaves are few and slightly crinkled. Average weight is 1.0 - 1.5 kg. It has better taste.

Late Drumhead

It is late group variety. It takes about 105-110 days from transplanting to head formation. Stalk is short with small frame and few outer leaves. Heads are uniform, solid, large flat; drum shaped and pale green in colour.

Pride of India

It is an introduction and recommended by Dr. Y.S.Parmar University of Horticulture and Forestry, Solan. The plant type of this variety is similar to 'Golden Acre'. But it is about a week altering in maturity. It has bigger sized heads, weighing about 1.5 to 2.0 kg per head.

Mitra

It is an early hybrid with excellent head to plant ratio. Heads are fresh green, uniform, compact, ball shaped with weight around 0.8 to 1.2 kg each. It has good field retention ability.

MCV-1

Heads are ready after 80 days from transplanting. It has round shape, bigger head (1.5-2.5 kg) and compact. The foliage is dark green with waxy margins.

Pusa Ageti

It has been developed from TKCBH-28 (F1 hybrid) procured from Taiwan Selection were made F1 generation onwards by using simple recurrent selection. It is the first variety which seed can produce in subtropical climate. It takes about 70-90 days from transplanting to harvesting. Head weight varies from 600 to 1,200 g, yielding 110-380 q/ha, depending upon the time of transplanting. It has medium sized frame, small stalk, upright growing habit, and wax coated grey green foliage, broad lamina with prominent midrib and waxy margin.

Pusa Drum Head

It is an important variety, selected and released by IARI, Regional Station, Katrain (Kullu Valley). Plants have wider frame with 20-25 light green outer leaves with prominent midribs and venation. Heads are solid and flat weighing about 2 to 4 kg. It takes about 80-90 days from transplanting to head formation and is probably the earliest variety among the Drum Head Group. It also possesses field resistant to black leg (Swarup et al., 1968).

Pusm Mukta (SEL.8)

This is a new variety developed at IARI, Regional Station, Katrain (Kullu Valley) by hybridization between EC 24855 x EC 10109. The light green foliage with wavy margins is a distinguishing character of the variety. It has short stalk, medium frame, and slightly bigger leaves than Golden Acre and wavy puckered at the margins. The heads are compact, slightly flattish round with a loose wrapper leaf at the top. It is about a week later than Golden Acre and average head weight is 1.5-2.0 kg. It is resistant to black rot (*Xanthomonas campestris*) and has been specially identified for the areas, where this disease is a problem.

Pusa Synthetic

This variety has been developed from IARI Regional Station, Katrain (Kullu Valley). It is an early synthetic variety. The yield potential of this variety is 350-460 q/ha.

Red Cababge

All the red cabbage cultivars are tolerant to diamond back moth insect which is serious pest of cabbage. It has distinct coat of wax and produces a head of 1-2 kg, taking about 90 days from transplanting to head formation.

September

It is an introduction from German Democratic Republic is the most popular in the Nilgiris hills and recommended for cultivation by Tamil Nadu State Department of Horticulture. The foliage is dark green with wavy margin. The stalk is long and heads usually tilt on one side after formation. It has solid, flattish round to slightly oblong heads. It has very good keeping quality. This variety takes about 96 to 100 days from transplanting to head formation.

Sri Ganesh Gol

The hybrid has been developed at Maharashtra Hybrid Seeds Co. Ltd., Jalna and recommended for cultivation in Andhra Pradesh, eastern Part of Madhya Pradesh and Orissa. Plants are vigorous. Heads are round, compact, attractive, bluish green and become ready for harvest in 90 to 95 days after nursery sowing. It is resistant to yellowing. It is good transport quality. It gives an average yield of 500 to 750 q/ha.

Suhda (BSS-115)

The hybrid has been developed at Beejo Sheetal Seeds Pvt. Ltd., Jalna. Heads are highly compact and mature in 75 days. This hybrid can be grown round the year. The average weight of head is 2-3 kg. This hybrid is resistant to fusarium wilt.

Suvarna (BSS-32)

The hybrid has been developed at Beejo Sheetal Seeds Pvt. Ltd., Jalna. Heads are round and average head weight is 3 kg. This hybrid has strong smooth outer leaves. It matures in 110 days.

Questo

It is a high yielder hybrid and has ability to stand over severe hot conditions. Head can stand in the field conditions up to 70 days. After maturity, heads are compact round and very solid with dark blackish colour. It is good for tropical climate.

Climatic Requirements

Cabbage can be grown easily under a wide range of environmental conditions but cool moist climate is most suitable. The optimum soil temperature for seed germination is (22-26.2°C). The optimum temperature for growth is between (25.2 to 34.2°C). Whereas, temperature above 43.2°C, growth is arrested in most of the cultivars. Minimum temperature for growth of cabbage is just above 0°C. It is reported that after cold treatment at 4 to 10°C for 7-9 weeks, the plant bolt sooner and flower more abundantly than when exposed to such temperatures for shorter period but before this temperature treatment, plants must have passed juvenile phase. (Nieuwhoff, 1969).

Soil Conditions

Cabbage can be grown in wide range of sandy to heavy soils. Early cultivars grow well in light soils, whereas, maturing ones perform better on heavy soils. However, well-drained soils give larger yields. The optimum pH of soil for cabbage cultivation is between 6.0-6.5. Most of the cabbage is somewhat tolerant to salt. In saline soils, the plants show die back of leaf margins and dark foliage and it become more susceptible to diseases like black leg.

Sowing Time

Seed-sowing time varies in different parts of India. In hills, especially, in high hills, seeds are sown in May - June for summer / autumn crop. In the hilly areas which receive heavy rains, the summer and autumn crop is rather limited and sowing is undertaken in autumn to harvest them in late spring in early summer by over watering them. In the plains of northern India, sowing in situ or in seedbed starts from early August and continue till November for the late cultivars. In eastern India, sowing is generally started from mid to late September. Sowing is delayed further for areas in the southern hills except in the western and southern peninsular, where the crop can be grown almost round the year by selecting proper cultivars / hybrids.

Seed Rate, Methods of Sowing and Transplanting Distance

About 200-500 g/ha seed is required. Cabbage is a transplanted crop. In India, the seeds are sown in a seedbed. In the plains, the seed beds for early crop require cover to save the small seedlings from rains, while in the high hills, it may be better to grow them under glass flames or poly tunnels. However, the seedlings of mid season or late cultivar may be raised in the open. The soil of nursery bed should be well prepared and free from disease organisms. The sieved well rotten farmyard manure or compost 2 2-3 kg/m² must

be added in the seedbed. Before sowing, the seed should be treated with any one of fungicide like Thiram, Cerasan, Agrosan or Bavistin @ 2 g/kg seeds. The optimum spacing between rows in the nursery bed is 10 cm and the depth of sowing should be 1.5-2.5 cm. For planting one hectare 200-300 m² seedbed at the rate of 1 to 2 g per sq. m is required. One-gram seed would give rise to about 1000 seedlings. After sowing, the seed is properly covered with a thin layer of mixture of fine manure and soil. The beds are leveled gently. A regular and good moisture supply is needed for rapid germination of seed and the optimum growth of seedlings. To keep the upper soil of seedbed moist, a thin layer of dry grass is spread on the beds and watering is done in the form of shower either with watering cane or with the help of a sprinkler. But, the seed bed cover should be removed as soon as the emergence of young seedlings above the ground starts. If there is over crowding of seedlings due to thick sowing, the extra seedlings should be thinned out. Attention should also be given for control of diseases and insect pests in the nursery. "Damping off" caused by different fungi viz. *Pythium spp.* *Rhizoctonia spp.* is common and severe disease in nursery. The spray of blitox-50 @ 0.3 per cent is effective against this disease.

Generally, 4-6 weeks old seedlings are ready for transplanting but older seedlings up to 8 weeks age can also be transplanted. However, older seedlings have adverse effect on the establishment and growth of young plants. The optimum time of transplanting varies in different climatic conditions. The planting in plains of India can be done from August to December and in hills from April to August. Early maturing cultivars like "Golden Acre" does well in the plains because of shorter cool period, while, "Drum Head Late", "Pusa Drum Head" and other late maturing varieties performs better in hills, where, cool temperature are available for longer duration. However, cultivars of all maturity groups can be grown in hills of north India by planting on suitable altitudes at optimum time. The planting distance may be varying according to cultivar, planting season and soil conditions. The following distances are generally recommended on the basis of maturity of cultivars viz., for early 45 x 45; cm or 60 x 30 cm, mid 60 x 45 cm and late 60 x 60 cm. The planting is done on the flat land, ridges or in furrows depending on climate and soil conditions. For early planting, ridge method will be more suitable, especially, in areas where the rain occurs at the time of planting. In saline soils, planting should be done in furrows.

Nutritional Requirements and Their Management

Manure's and fertilizers requirements in cabbage are depend upon fertility status of the soil which is determined by soil testing. However, if soil testing is not possible, then 200-250 q/ha farmyard manure should be applied. It should be thoroughly mixed in the soil before 15-20 days of transplanting. The quantity of nitrogen, phosphorous and potash varies from place to place, as given in Table 2.

Table 2: Recommendations of quantity of nitrogen, phosphorous and potash in cabbage in different states of India (Anon, 2000).

State	Nutrients (kg/ha)			Variety
	N	P	K	
Madhya Pradesh (Jabalpur)	180	50	50	Pride of India
Uttar Pradesh (Kanpur)	180	60	60	Pride of India
Bihar (Sabour)	150	-	-	Pride of India.

Half quantity of nitrogen and full quantity of each phosphorous and potash is applied at the time of transplanting. Remaining quantity of nitrogen is applied at 30-45 days of transplanting.

Intercultural Operations

Regular intercultural operations are necessary for proper aeration of root system and control of weeds to promote healthy plant growth. Two three manual weddings are required. The herbicides like Trifluralin @ 0.5 kg/ha (soil incorporation) and Fluchloralin @ 0.5 kg/ha (soil incorporation) can be used for weed control in cabbage.

Use of Plant Growth regulators

The recommended plant growth regulators (PGRs) in cabbage are given in Table 3.

Table 3
Recommended Plant Growth Regulators (PGR'S) in Cabbage

Name of PGR'S	Concentration (mg/l)	Method of application	Attributes affected	References
NAA	0.1	Seed treatment/	Improves head	Chhonkar and Jha, 1963
IBA	0.4	Foliar spray	Size and yield	Chauhan and Bordia, 1971 Sinha, 1977.
NAA + chelated Zn	100 + 0.2 (per cent)	Foliar spray at 45 days after transplanting	Increases yield	Mishra <i>et al.</i> , 1984.

Water Management

Cabbage is very sensitive to soil moisture. Maximum growth and yield can only be obtained when a plentiful supply of water is available to the plants throughout the growth. First irrigation is given just after transplanting of seedlings and thereafter, irrigation may be

done at 10-15 days interval according to season and soil conditions. But optimum soil moisture should be maintained regularly. Cabbage is usually irrigated by furrow method of irrigation. Excessive irrigation in early stages causes superficial rooting and washing down of nutrients. Heavy irrigation should also be avoided when the heads have formed, as it will result in splitting of heads.

Harvesting, Yield and Storage

The harvesting of cabbage is done when the heads reach at marketable size. The early cultivars grown under comparatively warmer conditions develop loose head at the initial stage, but become harder at maturity. In some cultivars, the heads start cracking soon after the maturity. In such cases, the quality of head deteriorates fast, if harvesting is delayed. Hence, harvesting should be done at right stage for getting good quality head. The early cultivars take 60-80 days, medium 80-100 days and later 100-130 days for harvesting after transplanting. The yield of early cabbage variety ranges between 300-400 q/ha, whereas, medium and late cabbage 400-600 q/ha in northern plain. Cabbage can be stored at 0°C and 90-95 per cent RH for about 2 to 8 months (Mercontilia, 1989).

Diseases and Pests

Diseases

Fungal Diseases

Downy Mildew (*Peronospora parasitica*)

Plant can be infected at any time during their growing period. Young plants infected early show a white mildew growth mostly on the under side of leaf. Later, however, slight yellowing shows up the corresponding upper surface. The young leaf may drop off. Older leaves usually persist and the infected areas enlarge as they turn tan and papery. When the disease is severe the whole leaf dies.

Control Measures

It can be controlled by spray the seedling in the nursery bed with copper oxychloride (0.3 per cent)

Wire Stem (*Rhizoctonia solani* Kuhn)

It may attack different stages of growth. Young seedlings suffer the worst. Young plants show soft water soaked spot on the stem just above the ground. The cotyledons wither and the plant eventually falls over and perishes. The fungus also causes head rot in cabbage. The first sign of infection is a reddish brown discoloration on the stem at the soil level. The area is constricted and the plant may be bent or twisted without breaking.

Control Measures

Regulating moisture levels, seed treatment and soil drenching with Dithane M-45 (0.2 per cent) or Bavistin (0.1 per cent) can be used for protection against the disease.

Black Spot (*Alternaria brassicae* (Berk) Sacc.)

The first symptom is a small dark spot on the leaf surfaces. As the spot enlarges, concentric rings develop. The diseased spot enlarges progressively and defoliate plants. It is a destructive disease on seed crop, affecting pods and seeds.

Control Measures

Spray Captan (0.2 per cent) or Copper oxychloride (0.5 per cent) for the control of disease (Sridhar, 1982).

Cabbage Yellow (*Fusarium oxysproum* f. sp *conglutinans* (Wollenweber) Snyder and Hansen)

Affected plants have a sickly dwarfed yellow appearance, lower leaves drop one by one and growth of the plant becomes stunted. The fungus is seed borne and can also in soil persist many years. Disease development is promoted by warm weather conditions.

Control Measures

Disease management is difficult. Field sanitation, crop rotation and using disease free seeds are useful for controlling the disease up to some extent. Since, resistant cultivars are available, it is better to use them rather than to try other means of control. There are two types of resistant reported.

Type A

Single dominant gene controls the resistance, found first in cabbage cultivars All Head Early, Copenhagen Market, Glory of Enkhuizen (Walker and Wellman, 1928). It is stable at different soil temperature. This apparently has been derived directly from *B. oleraceae* var. *sylvestris*.

Type B

The cabbage cultivar Wisconsin Hollander has this type of resistance. Both A and B types are found in Wisconsin All season.

Black Leg (*Phoma lingam*) (Tode ex Fr.) Desm

It occurs in most of the regions especially in area with rainfall during the growing period. The fungus is carried by the seed and hence it may occur from the early stage. Stem of the affected plant when split vertically, shows severe black discoloration of sap stream. Whole root system decays from bottom upward. Frequently, the affected plants fall over in the field.

Control Measures

- (i) As the main infection is through seeds, hot water treatment can be prevented
- (ii) Spraying Copper oxychloride or with Organomercuric compound and
- (iii) Use of resistant variety like Pusa Drumhead.

Bacterial Diseases

Black Rot of Crucifers (*Xanthomonas campestris* pv. *Campestris* (Pammel) Dowson)

The disease was first observed in the USA on cabbage in 1891, but the causal bacterium was identified during 1895. In India, disease was first described in 1928 on cabbage from Pune, Maharashtra (Patwardhan, 1928). The infected plant become stunted, often one side of cotyledon turn yellow to black bend down and drop off prematurely. Many lower leaves are also shed off early. The remaining leaves may turn yellow with blackened veins. Development of 'V' shaped chlorotic to yellow lesions take place from the leaf margin. The vein and vein let turn black and the leaf tissue necrotic and brittle. Lesion progress towards the midrib and from this systematic infection further spread into stem and root. Vascular tissues in affected parts become conspicuously black, followed by internal break down of fleshy tissue. Black sunken spots may develop on succulent seed stocks and siliqua.

Control Measures

Considerable reduction in disease has been observed when seeds are treated with Plantomycin (100 ppm) (Kishan, 1981a) or Agrimycin 100 (100 ppm) (Rao and Kishan, 1986) or Streptocyclin (100 ppm) (Shah et al., 1985) or Auromycin (1: 1000) (Trivedi and Patel, 1972).

Spot of Cabbage (*Pseudomonas cichorii* (Swingle) Staff)

It was first reported from USA in 1956. In India, it was reported by Trivedi and Patel (1972) in 1961 from Solan. The spots on cabbage heads are circular to oblong, translucent, buff to brown, 7-12 mm in diameter, sunken and having typical donations. Lesions on the inner leaves are irregular on outline, almost black in colour and localized near the margin of young leaves. The vascular bundles of stem become dark brown. Elongated and sunken lesion, 5-7 cm in size also develops on petiole and mid ribs of the lower leaves.

Control Measures

As in black rot of cabbage.

Club Root (*Plasmodiophora brassicae* War.)

This is a typical root parasite. Club root is particularly prevalent in soils with a pH above 7. Once affected, it causes irregular galls on the roots and these on the lateral roots take the shape of spindle. Leaves become yellowish and wilt.

Control Measures

- (i) At the planting time, 250 ml of 0.05 to 0.10 per cent solution of mercuric chloride may be applied for direct control.
- (ii) Roots are treated with 4 per cent calomel paste before transplanting and
- (iii) Use of resistant variety like Badger Shipper.

Pests

Leaf Webber (*Crocidolomia binotalis* Zelelr): Adult moths are small and light brown coloured. Eggs are laid in clusters on the under surface of leaves and held together by gelatinous glue.

Control Measures

- (i) Most of the insecticides recommended for diamond back moth control are also effective against leaf Webber.
- (ii) In biological control, major natural mortality factors for leaf webber was recorded parasitization by *Bracon hebetor* Say and *Palexorusta solennis* (Wlk) in the late larval instars (Singh, 1978).

Mustard Sawfly (*Althalia lugens proxima* Klug)

The blackish caterpillar that attacks all Cole crops and feed on leaves of young seedling in the early stages. The infested leaves become curl and falls on the ground when touched.

Control Measures

- (i) If low infestation and number of attacked plants are few, hand picking of caterpillar, is the best method of controlling the larvae.
- (ii) Dusting the plants with sevin @ 20-25 kg per hectare or spraying the same @ 5 g per litre of water is also effective to control this insect.

Mustard Aphids (*Lipaphis erysimi* Kalt)

This is a greenish white small insect that attacks cabbage and other cole crops, when there is a cloudy weather. They suck the sap from the plants. The affected leaves get curled and plants wither and die.

Control Measures

- (i) Aphid can effectively be controlled by spraying the crop with any one of the insecticides like Methyl Dematon (Metasystox-25 EC, Hexasystox-35 EC, etc.) or Dimethoate (Rogar 30 EC, Methoate 30 EC, Sumidon, Demidon, etc. @ 1 ml per litre of water or Phosphomidon (Demacron 100 EC, Sumidon, Demidon, etc.) @ 0.5 ml per litre of water, starting just after the germination of seed and subsequently at an interval of 15 days.
- (ii) Soil application of Phorate 10 G @ 15 kg/ha or Thimmet 10 G @ 12 kg per hectare in two doses i.e., half at the time of planting and other half at the time of earthing up has also been effective against aphids.

Diamond Back Moth (*Plutella xylostella* L.)

In India, it was first recorded in 1914 (Fletcher, 1914) on cruciferous vegetables. A small slender pale green caterpillar that feeds on leaves and makes holes in them. The infested crop becomes unsuitable for marketing.

Control Measures

The pest can be control by (i) Foliar spray twice or thrice Cypermethrin (0.2 kg a.i.) or Femvalerate (0.1 kg a.i. /ha) or Sulprofos (1.0 kg a.i./ha) or Prothiophos (0.75 kg a.i./ha). (ii) Under All India Co-coordinated Vegetable Improvement Projects on control of diamond back moth (DBM) results revealed that against DBM and leaf Webber, three sprays of Femvalerate @ 50g.a.i./ha has found to give maximum cost benefit ratio at IIHR, Bangalore (Anon, 2000). The use of mustard as trap crop proved quite effective in controlling diamond back moth incidence. Hence, this practice has been recommended to control diamond back moth throughout India. Mustard crop should be sown 15 days before cabbage planting. Two to three sprays of Dichlorphos @ 1 kg a.i./ha in mustard and two sprays of Cartap hydrochloride @ 500 g.a.i./ha or 5 per cent neem seed kernel extract in cabbage, starting from primordial stage of the crop at 15 days interval has been recommended.

Cabbage Borer (*Hellula undalis* F.)

A white brown caterpillar that mines the leaves and feed on shoots. Later, it burrows into the stem of cabbage. The affected plants wilt, remain dwarf or may even die.

Control Measures

Chemicals recommended for diamond back moth and leaf Webber control are also effective for cabbage borer.

Cabbage Butter Fly (*Pieris brassicae* Linn.)

The maggots first attack the young rootlets and then burrow into the main roots. The affected plants become yellow, wilt and sometimes they may die.

Control Measures

Sprays of 0.15 per cent Carbaryl and 0.4 per cent fungicide give adequate control of the pest (Atwal and Singh, 1969).

Painted Bug (*Bagada crucifer arum* Kirk.)

The adult and nymph of this pest suck the sap from the plants and retard their normal growth.

Control Measures

Same as for aphids.

Seed Production and Seed Certification Standards

Seed Production

Climatic Requirements

Cabbage thrives in a relatively cool, moist climate with moderate rainfall, well distributed during the growing season. It can withstand frost in the head stage. It requires a dormant period of cool temperature to bolt and initiate seed stalks and flower. Cool temperatures, however, are effective only after stem diameter, is one cm at least. In temperate climates, this occurs during the winter after the first season growth. Flowering

and seed production follow in the second year. Headed plants form seed stalks when exposed to mean temperature of about 5°C for six to eight weeks. In India, seed production of cabbage is possible only in hilly areas.

Land Requirements

Land to be used for seed production of cabbage should be free from volunteer plants.

Methods of Seed Production

Being a biennial, cabbage requires two seasons to produce seed. In the first season, the heads are produced and in the following seasons seed production follows. The seed crop can be left in situ or transplanted during autumn. In situ method is usually followed for certified seed production and the later for nucleus seed production.

In situ method, the crop is allowed to over winter and produce seed in their original position, i.e. where they are first planted in the seedling stage. In the transplanting method, the mature plants are uprooted. After removing whorls, the plants are immediately reset in a well prepared new fields in such a way that the whole stem below the head goes underground with the head resting just above their surface.

There are three methods to produce seed of cabbage.

Stump Method

In this method, when the crop in the first season is fully mature, the heads are examined for true to type. The plants with off type heads are removed. Then heads are cut just below the base by means of a sharp knife, keeping the stem with outer whorl of leaves intact. The beheaded portion of the plant is called “stump”. The heads are marketed and the stumps either are left in situ replanted in the second season i.e. during autumn. The following spring, after the dormancy is broken, the bud sprout forms the axils of all the leaves and leaf scars.

Advantages

- (i) Gives extra income by way of sale of heads.
- (ii) The crop matures 12-15 days earlier than the head intact method and
- (iii) Seed yield is slightly increased.

Disadvantages

In this method, flowering shoots are decumbent and require very heavy staking otherwise they breakdown very easily while interculturing or spraying.

Stump with Central Core Method

In this method, when the crop is fully mature in the first season, the heads are examined for true to type. Plants with off type heads are removed and rejected. Then the heads are chopped on all sides with downward perpendicular cuts in such a way that the central core is not damaged. This is an improvement over stump method in that the shoots

arising from the main system are not decumbent. During the last week of February and until 15th March, when the heads start bursting, two vertical cross cuts are given to the head. Taking care that the central growing point is not injured. In the absence of such cuts, the heads burst out irregularly and sometimes the growing tip is broken. The operation is completed by going around the field twice or thrice during this period.

Advantages

(i) Shoots arising from the main stem are not decumbent, hence very heavy staking is not required and (ii) Seed yield is increased.

Disadvantages

The chopped heads cannot be marketed.

Head Intact Method

In this method, when the crop is fully mature in the first season, the heads are examined for true to type. The plants with off type heads are removed from the field. The head is kept intact and only a cross cut is given to facilitate the emergence of a stalk.

Advantages

- (i) The removal for heads (stump method) or chopping of heads on all sides (central core intact method) is not required. This saves time and labour.
- (ii) Very heavy staking is not required.

Disadvantages

The seed yield is slightly low as compared to stump, or stump with central core intact method.

Brief Cultural Practices (*in situ* Method)

Time of Sowing and Transplanting

The sowing time of different varieties should be so adjusted as to complete head formation by the end of October or first week of November, at that time, the mean temperature falls to 10°C or below, at this temperature, the heads stand best for overwintering. Early varieties like 'Golden Acre' should be sown from 10th to 25th July and transplanted when the seedlings are three to four week old, during the second fortnight of August. This sowing time must be strictly adhered to, as the crop from the early sowings has matured head during September (20°C). The heads get infected with bacterial stock rot, which sometimes is very severe. The late crop, planted during September does not form heads and bolts directly during spring and the seed grower is not able to ascertain purity of the crop. Medium late varieties like Bruppe's Sure Head, and alter varieties like Drum Head, which takes about 2 to 3 months to produce mature heads, should be sown during the second and first fortnight of June, respectively and transplanting finished by the first week of August. The mean temperature 22.5°C, 20°C and 14°C of August, September and October, respectively, afford optimum requirements for growth and head formation. The later

transplanted crop starts head formation during spring and continues up to June and usually does not produce seed stalks.

Method of Nursery Sowing

The seeds are sown in raised nursery beds in a manner as described earlier in commercial production of cabbage.

Source of Seed and Seed Rate

Obtain nucleus / breeder's / foundation seed from source approved by a seed certification agency. For main season and alter varieties, 375 to 400 g seeds/ha and early varieties, 600-700 g seeds/ha.

Preparation of Land for Transplanting

Prepare the land to a fine tilth by repeated ploughing and harrowing followed by leveling.

Manure and Fertilizers

Cabbage grows satisfactorily only when the supply of organic mater is liberal. For good crop, apply 500 to 600 quintal of farmyard manure per hectare at the time of land preparation. Apply 100 kg/ha I nitrogen, 60 kg/ha phosphorus and 60 kg/ha of potash by drilling, or by broadcasting, sufficiently before transplanting the seedlings. Give another dose of 50 kg/ha nitrogen as surface application at the time of seed stalk emergence during March. Extra application of nitrogen may be given as and when there is a need before flowering starts, depending upon the condition of the crop.

Transplanting

Three to four week old seedlings are transplanted. Transplanting should preferably be done in the evening and the field irrigated immediately afterwards.

Spacing

Late varieties - 60 x 60 cm; Medium varieties 60 x 45 cm; Early varieties 45 x 45 cm.

Irrigation

Cabbage requires a continuous supply of moisture. Irrigate the crop as frequently as required. Heavy irrigation should, however, be avoided when the heads have formed. A sudden heavy irrigation after a dry spell may cause bursting of heads.

Hoeing and Weeding

At least three weddings and hoeing till the end of October are essential. One weeding and earthing up during November and December and the second during March when seed stalks have emerged, control weeds and also help in proper drainage during winter and thereafter.

Staking

After the flower stalk are sufficiently developed, staking is necessary to keep the plants in an upright position.

Handling the mature head

After the planted crop has fully developed heads at the close of autumn, the next step is the handling of these plants for seed production. Handling of plants can be done by any one of the three methods i.e. stump, stump with central core intact methods, described earlier.

Rouging

The first rouging is done at the time of handling of the mature heads. All off type plants, diseased, or otherwise undesirable types, are removed at this stage. The second rouging is done before the heads start bursting. The loose leafed, poorly heading plants and those having a long stem with heavy frame must be rouged out at his stage. It is highly undesirable to keep such poor plants in the seed plots. Subsequent rouging for off types, diseased plants affected by, black leg, soft rot or leaf spot should be done from time to time as required.

Harvesting and Threshing

Cabbage starts seed stalk elongation from 10-20th March when the mean temperature rises to 10-13°C. Flowering and pod formation starts during the first week of April at mean temperature of 13-18.5°C. From 15th April to 15th May, the crop is in full flush of flowering and fruiting. The ripening of pods commences by 15th June to 20th June and the harvesting continues up to second week of July. At mean temperatures below 20°C during June and July, the maturity of crop is delayed at least by a fortnight and the harvesting may continue up to July end. To avoid shattering of seeds, the whole crop is harvested in two or three lots with sickles. Generally, the early plants are harvested first, and when the pod colour is about 60-70 per cent of the rest of the crop changes to yellowish brown, it is harvested completely and piled up for curing. After 4-5 days, it is then threshed with sticks and sifted with hand sifters. After thoroughly drying, seeds are cleaned and stored.

Seed yield: 500-600 kg per hectare.



Cabbage bolting



Cabbage seeds



Seed Certification Standards

I. Field Inspection

A minimum of three inspections should be done, the first before the marketable stage, the second at the marketable stage and the third at flowering stage.

II. Field Standards

A. General Requirements

1. Isolation: Seed fields should be isolated from the contaminants shown in column 2 and column 3 of the said Table:

Contaminants	Minimum disease(Meters)	
Fields of other varieties	1600	1000
Fields of the same variety not conforming varietal purity	1600	1000

B. Specific Requirements:

Factors	Maximum permitted (per cent) *	
Off types	0.10	0.20
** Plants affected by seed borne diseases	0.10	0.50

* Standards for off types should be met at and after flowering and for seed borne diseases at final inspection.

** Seed borne diseases shall be Black leg (*Leptosphaeria maculans* (Desm.) Cos. & de Not). Black rot (*Xanthomonas campestris* cv. *campestris* (Pamm.) Dawson), Soft Rot (*Erwinia carotovora* L.R. Jones).

III. Seed Standards

Factors	Standards for each class	
	Foundation	Certified

1	2	2
Pure seed (minimum)	98.0 per cent	98.0 per cent
Inert mater (maximum)	2.0 per cent	2.0 per cent
Weed seeds (maximum)	5/kg	10/kg
Weed seeds (maximum)	5/kg	10/kg
Germination (minimum)	65 per cent	65 per cent
Moisture (maximum)	7.0 per cent	7.0 per cent
For vapour-proof containers (maximum)	5.0 per cent	5.0 per cent

1. Cabbage is propagated by

- a. Seeds
- b. Heads
- c. Leaf cuttings
- d. Meristem tip culture

2. Commercial part of cabbage is

- a. Head
- b. Curd
- c. Leaf
- d. Stem

3. Alkaloid present in cabbage

- a. Sinigrin
- b. Tomatin
- c. Salanine
- d. Tangerine

4. Whiptail is caused due to the deficiency of

- a. Molybdenum
- b. Nitrogen
- c. Phosphorus
- d. Potash

5. _____ is the method of commercial seed production in cabbage

- a. Head to seed
- b. Seed to seed
- c. Stump method
- d. All the above

**ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR COLE
CROPS CAULIFLOWER**

CAULIFLOWER - *Brassica oleracea* var. *Botrytis*

Family: Cruciferae

(Chromosome Number: $2n=18$)

Origin and History

The name cauliflower consists of two Latin words, 'caulis' and 'floris', former means cabbage and the later means flowers. It is originated from wild cabbage known as 'Cole warts', through mutation, human selection and adoption. Dr. Jemson at Saharanpur introduced it to India in 1822 during the period of East India Company (Swarup and Chatterjee, 1972). The original introduction was "Cornish types", which originated in England followed by temperate types, originated in Germany and Netherlands in 18th century. The present tropical Indian cauliflower developed as a result of inter crossing between European and Cornish types. Another development also took place in India, resulting in tropical types resistant to high temperature and high rainfall. These types are grown in Indian plains from May to September followed by temperate types commonly known as snowball cauliflower got established around Mediterranean region particularly in Italy. Its further development and improvement were achieved in North and North Western Europe extending its cultivation to 60°N. The development of Indian cauliflower types made it possible to extend its growing area in the tropics and subtropics of the world. The crop is presently cultivated from 11°N to 60°N. The different types of cauliflower like Cornish, Northerns, Roscoff, Angers and Erfurts originated from the Italians independently in different region like Cornish and northern England, Roscoff and Angers in France and Erfurts or Snowball in Germany and the Netherlands. Cornish type, perhaps the first to be introduced in India, has itself gone out of cultivation after contributing many genes to Indian varieties like resistance to black rot, self-incompatibility, curd flavour, open plant habit, exposed yellow loose curds etc. (Swarup and Chatterjee, 1972).

Nutritive Value and Uses

The edible part of cauliflower is known as curd, which consists of a shoot system with short internodes, branches apices and bracts. The edible portion of this vegetable is approximately 45 per cent of the vegetable as purchased. It has high quality of proteins and peculiar in stability of vitamin C after cooking. It is rich in minerals such as potassium, sodium, iron, phosphorus, calcium, magnesium etc. It also contains vitamin A (Nath, 1976) Conew (1959) has made an analysis on fresh weight basis. Cauliflower contains 92.7 per cent water and the food value per 100 g of edible ascorbic acid 70 mg, thiamine 0.2 mg, riboflavin 0.1 mg

and niacin 0.57 mg. Sulphur containing compounds viz; hydrogen sulfide methanethiol, ethanethiol, propanethiol and dimethyl sulfide in addition to acetaldehyde and 2- methyl propanol have been identified in cooked cauliflower. Cauliflower seedlings are used for salad and green. The curd is used in curries, soups, and pickles. In abundant areas of production, cauliflower curd is cut in to pieces, dried and preserved for off-season use. The therapeutic effect of cauliflower has been well documented. The inflorescence extract has been used in the treatment of scurvy, as a blood purifier and as an antacid. The seeds have contraceptive properties. Cauliflower extract has been reported to be effective in the inhibition of initiation and promotion of carcinogenesis in *in vitro*. Potential chemo preventive agents include ascorbic acid, carotenoids, tocopherols, isothiocyanates, indoles and flavonoids.



Area and Production

India is the largest producer of cauliflower in the world. Out of total 5335447 ha of land under vegetables, cauliflower occupies nearly 4.4 per cent area under cauliflower during the year 1998-99. Production of cauliflower was 4680600 tones during the year 1998-99. The area, production and productivity of cauliflower from 1987-88 to 1998-99 are given in Table 1.

Table 1: Area, Production and Productivity of Cauliflower in India

Year	Area (in 000'HA)	Per cent of total area	Production (in 000'MT)	Per cent of total production	Productivity to MT / HA
1987-88	75.1	1.8	558.60	1.10	7.4
1991-92	202.8	3.6	2998.10	5.10	14.8
1992-93	230.7	4.6	3612.20	5.70	15.7
1993-94	188.5	3.9	2872.50	4.40	15.2
1994-95	216.1	4.3	3244.10	4.80	15.0
1995-96	220.0	4.1	3244.10	4.80	15.0
1996-97	233.9	4.1	2474.00	3.50	11.20

1997-98	248.2	4.4	4471.00	6.20	18.00
1998-99	155.4	4.4	4680.60	5.30	18.40

Source: Horticultural Data Base (2000) NHB, Gurgaon.

The growing belts in different states in the country are as given below (NHB, 2000).

- **Uttanchal** : Nainital, Pithaurgarh and Dehradun
- **Uttar Pradesh Plains**
- **Himachal Pradesh** : Shimla, Kullu and Sirmour
- **Haryana** .
- **Rajasthan**.
- **Bihar** : Santhal, Pargana, Purina, Katihar, Sitamarhi, Samastipur, Saharsa, Dhanbad, Patna, Nalanda, West and East Champaran, Muzzafarpur, Vaishali, Bhagalpur, Darbangha and Madhubani
- **Gujarat**: Mehsana, Khera, Ahmedabad and Baroda..
- **Maharashtra**: Nasik, Nagpur and Kolhapur.
- **Orissa**.
- **Karnataka**: Hassan, Bangalore (Rural and Urban), Kolar and Mysore.

Apart from India, the other major producers of cauliflower in the world are China, France, Italy, UK, USA, Spain, Poland, Germany and Pakistan.

Classification

Swarup and Chatterjee (1972) classified the cauliflower varieties in various groups as given in Table 2.

Table 2: Classification of cauliflower varieties

Cauliflower types	Country of origin	Probable period of first cultivation	Characters
Italian or original	Mediterranean	16 th Century	Plants short; leaves erect broad with rounded tips, bluish green, curds good not protected.
Cornish	England	Early 19 th Century	Plants vigorous, long stalked; leaves loosely arranged, broadly wavy; curds flat; irregular, loose, not

			protected, yellow, highly flavoured.
Northerns	England	19 th Century	Leaves petioles, broad, very wavy, serrated; curds good, well protected.
Roscoff	France	19 th Century	Plants short; leaves long erect, slightly wavy with pointed tip, midrib prominent, bluish green; curds white or creamy, hemispherical and well protected.
Angers	France	19 th Century	Leaves very wavy, serrated, grayish green, curds solid and well protected.
Erfurt and snowball	Germany and Netherlands	18 th Century	Plants dwarf; leaves short, erect, curds solid and well protected.
Indian cauliflower	India	Late 19 th Century	Plants short, long stalked; leaves loosely arranged, broadly wavy; curds flat, somewhat loose, yellow to creamy, not protected and highly flavoured.

Crisp (1982) has also classified the groups of cauliflower according to the phylogeny as given in Table 3.

Table 3 Classification of Cauliflower on the Basis of Phylogeny

Group name	Characteristics	Common types
Italian	Very diverse, include both annual and biennials and curds with peculiar conformations colors	Jezi, Naples (Autumn Giant), Romanesco and Flora Blanca.
North European annuals	Developed in Northern Europe for at least 400 years. Origin unknown, perhaps Italian Eastern Mediterranean.	Alpha, Mechelse, Erfurt and Danish.

North West European biennials	Developed from Italian material with in 300 years	Angers, old English, Roscoff St. Malo, Walcheran.
Asian	Recombinants of European annuals and biennials, developed within last 250 years, adapted to tropics	Four maturity groups are recognized by Swarup and Chatterjee (1972).
Australian	Recombinants of European annuals and biennials and perhaps Italian stock, developed during the last 200 years.	Not yet been categorized.

Further, cauliflower varieties can also be classified on the basis of maturity. Most of the early Indian varieties of cauliflower are called by the name of the month in which the curds are mature and become ready for harvest, viz., 'Kunwari (September-October maturity), Katki' (October-November maturity), 'Agahani' (November maturity), 'Posi' (December maturity), 'Maghi' (January maturity). Most of these varieties are highly heterozygous for maturity, plant growth and curd traits. The cultivars are classified into five groups on the basis of curd maturity (Table 4).

Table 4 Classification of Cauliflower on the Basis of Maturity

Maturity	Varieties	Temperature requirement for curd initiation and development
Early	Early Kunwari	20°C - 27°C
September maturity	Pusa Early synthetic	
October maturity	Pusa Deepali	20°C - 25°C
(Mid October-Mid November)	Pant Gobhi-2	
Mid Early	Improved Japanese	16°C - 20°C
November maturity	Pusa Hybrid-2	
(Mid November-Mid December)	Pusa Hybrid-3	
	Pusa Sharad	

	Pant Gobi-4	
Mid Late	Pusa Synthetic	12°C - 16°C
December maturity	Pusa Shubra	
(Mid December-Mid January)	Pusa Himjyoti	
	Punjab Giant-35	
Late Snowball	Pusa Snowball-1	10°C - 16°C
	Pusa Snowball K-1	

Varieties / Hybrids

DANIA

It is developed from IARI, Regional Station, and Kalimpong for eastern hilly area. Plants are strong having medium sized curd. This variety is tolerant to the stress conditions.

EARLY KUNWARI

It is an early variety suitable for growing in Punjab, Haryana, Himachal Pradesh and Delhi, selected by PAU, Ludhiana. The leaves are bluish green heavy with waxy bloom. Curds are semi-spherical with even surface and ready for harvesting from mid September to mid-October. This variety has been recommended for sowing from middle to the end of May.

HISAR-1

It suitable for mid late season under Haryana conditions. It bears medium to large size white heads. It yields 250 q/ha.

IMPROVED JAPANESE

It is an introduction from Israel. Plants are erect Leaves are bluish green. It can not tolerate hot season. It is recommended for sowing in north Indian plains from July end to early August. Curds are compact, white and maturing in late November to mid-December at 16-20°C.

PANT GOBI-2

It is composite variety developed from GBPUA&T, Pantnagar Curds are ready for harvesting from October onwards. An average yield of this variety is 100q/ha.

PANT GOBHI-3

It is a synthetic variety, combining eight inbred lines of katki group and released from GBPUA&T, Pantnagar. Plants are having relatively longer stem and sparse semi erect leaves. Curds are hemispherical, creamy white, medium compact, non-ricey and mature in 110 days. Average yield potential is 120 q/ha.

PANT GOBHI-4

It is released from GBPUA&T, Pantnagar by simple recurrent selection of Aghani group and recommended for cultivation in 1995 for Uttar Pradesh stat. Plants are medium in growth with upright leaves. Curds are round, creamy white and solid. This variety is free from riceyness.

PANT SHUBRA

It is developed through simple recurrent selection and released from GBPAUA&T, Pantnagar in 1985 by Central Sub-committee on Crop Standard, Notification and Release of Varieties for cultivation in northern parts of the country. It belongs to third maturity group. Curds are compact, slightly conical, creamish white in colour, non-ricey and non-leafy. It is suitable for rainy season. Curds do not fade even under delayed harvesting and storage.

PUNJAB GIANT-26

It is a main season variety developed by PAU, Ludhiana. Plant is 57 cm tall with a spread of 75 cm. Curds are solid, white and medium in size.

PUNJAB GIANT-35

It is suitable for late season cultivation. Curds are compact, medium sized and snow white. The average yield of this variety is 225 q/ha.

PUSA AGHANI

This variety has been developed from IARI, New Delhi. Curds are ready for harvesting in the month of November-December. Curds are big in size, solid and white in colour. An average yield of this variety is 150-160 q/ha.

PUSA DEEPALI

This has been developed through inbreeding from the local material at IARI, New Delhi and recommended for general cultivation in entire north India particularly Delhi and Punjab. Plants are medium tall. Leaves are erect, short, green and waxy. Curds are compact, self-blanching, white and medium in size. A uniform curd well protected by leaves and riceyness is almost absent. It is recommended for sowing from May end to early June. Curds are ready in the October when the average temperature is around 20-25°C.

PUSA EARLY SYNTHETIC

It is released in 1990 by IARI, New Delhi. Plants are erect with bluish green leaves. Curd is small to medium in size, flat, creamy white and compact. It is suitable for early cultivation in northern and southern states. The average yield is 117 q/ha. It is resistant to riceyness.

PUSA HIM JYOTI

It is released from IARI, New Delhi and suitable for transplanting in hill tract in the month May and August. Plant is straight with bluish green leaves. Curd is quietly white, solid and round. It is ready in 30 days after transplanting for harvesting. Yield of this variety is 160 q/ha.

PUSA HYBRID-2

It is recommended for cultivation in 1993 from IARI, New Delhi. Plants are semi-erect with bluish green. Leaves are green, long, upright and covered the curd at initiation stages. Curd is creamy-white and highly compact. It matures in 120 days after transplanting. The yield potential of this variety is 230-250 q/ha. It is resistant to downy mildew. This variety is recommended for cultivation in humid Bengal-Assam basin and Sub-humid Sutlej Ganga-Alluvial Plains.

PUSA KATKI

This is one of the earliest variety released from IARI, New Delhi, which maturing is in October-November and having medium plants, bluish green and waxy leaves. It is suitable for sowing in the middle of May. Late planting beyond middle of August does not give good size curds.

PUSA SHARAD

The IARI variety release committee has released this variety in 1999. Plants are semi-erect and open types with small stalk. Leaves are glabrous, bluish-green, long petiolate oblong with narrow apex, wavy margin, prominent mid rib and ear like lobes at the base of lamina. Its marketable curd becomes ready 85 days after transplanting. It is about two weeks early in maturity over the standard cultivar, 'Improved Japanese'. Curds are white, knobby, very compact, semi-dome shaped and about 750-1000 g in weight. Average yield is 260 q/ha about 20 per cent higher and 14.5 days early in maturity over Improved Japanese. It is suitable for cultivation in Uttar Pradesh, Punjab, Haryana, Bihar, Rajasthan and West Bengal.

PUSA SHUBRA

Plants are erect with somewhat long talk and light bluish green leaves. Curds are compact and white having average curd weight is 700-800g. It is highly tolerant to riceyness. It takes 125-130 days for 50 per cent curd and best temperature for curding is 12-16°C. The yield potential of this variety is 250-300 q/ha. This variety is resistant to black rot under both field and artificial conditions.

PUSA SNOWBALL-1

It is a derivative of the cross between EC 12013 and EC 12012 and released from IARI, Regional Station, Katrain (Kullu Valley) in 1977 by the Central Sub-Committee on Varietal

Release for growing throughout the country, where Snowball groups are grown. It is a late variety and suitable for cool season. The optimum average temperatures for curd initiation and development are 10-16°C. Its sowing time in north India is from mid-September to end of October. Leaves are straight, upright and inner leaves tightly cover the curd. Curds are very compact, medium in size and snow white.

PUSA SNOWBALL-2

Central Sub-committee on Varietal Release Committee, New Delhi, releases it in 1977 for general cultivation throughout the country. It is suitable for late sown conditions. Its outer leaves are upright, while, inner leaves cover the curd initially. The Curd remains white even on exposure. Curds become ready by the end of January or beginning of February (10-16°C). This variety could not become popular because of its poor seeding ability.

PUSA SNOWBALL K-1

This is also developed at IARI, Regional Station, Katrain (Kullu Valley) and is tolerant to black rot caused by *Xanthomonas compestris* (Gill *et al.*, 1983). Amongst the snowball types, it has best quality curds, which are snow white in colour and retain it even if the harvesting is delayed. The leaves are puckered, serrated and light green in colour. It is also late by a week than Pusa Snowball 1 and 2, which will further extend the cauliflower availability period.

PUSA SYNTHETIC

It is a mid-season variety, synthesized from 7 inbred lines with good combining ability, released from IARI, New Delhi. It has erect plants with 24-28 leaves varying in colour. Plants frame is narrow to medium. Curds are somewhat creamy white to white, compact becomes ready from mid-December to mid-January (12-15°C). It is suitable for planting from mid-September to late September in North India.

PAWAS

It is most suitable for early crop, which can be grown from middle May to August. It produces 700-800 g average curd weight and ready within 60 days after transplanting.

SWARNA

It can be grown from September to December in plain and around the year in the hills. Curds are white, compact and ready within 80-85 days after transplanting. It yielded 1-2.5 kg on an average curd weight.

SUMMER KING

It produces whitish round shaped curd and ready for harvesting with 65 days after transplanting with 400-500 g an average curd weight. It can be grown during summer season in northern plain.

Climatic Requirements

The cauliflower has a wide range in adaptation to diverse climatic conditions, prevailing in temperate subtropics and tropical parts and therefore, the cultivation of cauliflower is wide spread in many countries of the world. The optimum temperature for growth of young plants is around 23°C, but in later stages 17-20°C are most favourable. The tropical cultivars show growth even at 35°C. In temperate regions, the growth of young seedlings may be ceased, when temperatures are slightly about 0°C, while, the early cultivars grown in plains of north India and other tropical parts can grow even at 35°C or still higher temperature (Nieuwhof, 1969). Lower temperatures ranging from 5°C to 28-30°C are needed for transition from vegetative to curding phase. The temperature higher or lower than the optimum required for curd formation of the cultivars may cause physiological disorder viz. riceyness, leafy curd and blindness.

Soil conditions

Cauliflower can be grown in all types of soil with good fertility and good regime. In light soil, the plants are most sensitive to drought and therefore, adequate moisture supply is important. For early crops, the light soils are preferred, while, loamy and clay loam soils are more suitable for mid season and late maturing types. Cauliflower is relatively more sensitive to deficiency of boron and molybdenum, and it has high requirement of magnesium. The deficiency of magnesium may quickly appears in acid soils. High pH reduces the availability of boron.

Sowing Time

The optimum time of seed sowing in the nursery varies greatly depending upon climate, varieties and their temperature requirement for curd formation. The nursery for mid season crop can be grown successfully by protection of beds from heavy rains during July-August is essential. The seedlings for mid late and late crop can be conveniently raised, because of favourable temperature conditions. Depending upon curd maturity of the varieties, the following sowing times have been recommended (Table 5).

Table 5 Recommended Sowing Times of Cauliflower (Swarup and Chatterjee, 1972).

Groups	Time of sowing of seeds	Time of curd maturity
Early maturity group		
I (a)	May-June	September
I (b)	First fortnight of July	October to mid November

Mid season maturity group II	July-August	Late November to mid December
Mid late maturity group III	September	Late December to mid January.
(Snowball type)	October	Mid January onwards

Seed Rate, Methods of Sowing and Transplanting Distance

For cultivation of cauliflower in one hectare, 200-500 g seed would be needed, though, in the early crops, the requirement may be more to the tune of 1 kg. For raising nursery, the nursery beds should be prepared by addition of well rotten farmyard manure or compost @ 10 kg/m². The soil of the beds is made friable by through digging / ploughing and harrowing and breaking the clods. The sterilization of soil by drenching, the nursery beds with formalin @ 1:49, about 15-20 days before seed sowing is beneficial for preventing the attack of the fungal diseases. After drenching, the beds should be kept covered with polythene for a week and then beds are again dug and left open for 5-6 days. So that, there is no injurious effect of formalin to the seeds. The nursery must be raised about 15 cm high from ground surface for efficient drainage. The sowing should be done in shallow furrows at 10 cm apart. The depth of furrows may be 1.5-2 cm. After sowing the seed, the furrows are covered with a mixture of sieved fine manure and soil and the beds are gently leveled at the surface. The beds should be covered with a proper mulching material like dry cane grass or polythene before watering. In the initial stage, water is applied with a water cane over the grass mulch but in later stage when plants are 15-20 days, old watering through furrows may be done. However, the grass cover or polythene should be removed as soon the emergence of seed sprouts. The beds should also be covered and shaded for protection against hot sunshine and rains especially in early season nursery. Weeding and intercultural of nursery beds should be regularly done for raising healthy seedlings. Generally, the seedlings are ready for transplanting in 3-6 weeks after seed sowing, depending upon variety, temperature and soil fertility. In case of early crop, 5-6 weeks old seedlings have better establishment and less mortality in the field, while, in mid-season and late varieties 3-4 weeks old seedlings may be transplanted. The planting distance may vary according to the variety, climate and soil. Normally, the seedlings of early varieties are planted to 60 cm row to row and 30-45 cm plant to plant distance. The main season and late varieties are planted at spacing of 60-75 cm between rows and 45-60 cm between plants.



Nutritional Requirements and Their Management

Manure and fertilizer requirements in cauliflower are depend upon fertility status of the soil, which is determined by soil testing is not possible, then 150-200 q/ha farmyard manure should be applied in the soil before 15-20 before transplanting. It should be mixed thoroughly in the field. The quantity of nitrogen, phosphorous and potash should be given after determining the fertility status of soil. However, research carried out under All India coordinated Vegetable Improvement Project for different state of the India; following recommendations for quantity of nitrogen phosphorous and potash have been given (Anon, 2000).

- A dose of 40 kg N/ha as basal + 40 kg N/ha as top dressing + 30 kg N/ha as foliar spray ahs been recommended for variety Snowball-16 under Sabour conditions. However, for Pantnagar conditions, 60 kg N/ha as basal + 30 kg as foliar spray in three splits has been recommended for the same variety. Further, at Kalyanpur, the best response was 60 kg N/ha as basal + 60 kg N/ha as top dressing in two equal splits.
- Application of 150 kg N/ha + 120 kg P₂O₃ per hectare has been recommended for obtaining economic yield under Kalyanpur conditions.
- For variety Pant Shubra, recommendation of 100 kg N, 60 kg P₂O₃ and 60 kg K₂O per hectare has been recommended for Faizabad conditions.

In addition to NPK, borax @ 15 kg/ha and ammonium molybdate @ 15 kg/ha should also be applied in deficient soil of boron and molybdenum, respectively. Half doses of nitrogen and full doses of each phosphorus and potash are applied at the time of transplanting. Remaining quantity of nitrogen is applied 30-35 days after transplanting.

Intercultural Operations

The intercultural operations should be done regularly to keep the crop free from weeds and aeration of the root system. Hoeing should not be deep to avoid injury to the roots. Usually, in medium heavy and clay soils, there are crust penetration in root system are

hindered, which affect plant growth. During rainy season, the roots of plants in ridge planting maybe exposed, which requires adequate earthing. When earthing or ridging is done, the side dressing of nitrogenous fertilizer should also be done for healthy growth of the crop. In commercial weed control, basalin @ 2-3 kg a.i/ha + 1.2 hand weeding or tenoran 50 WP @ 1 kg a.i. /ha can be used.

In cauliflower, for getting quality curd, blanching is an important operation to protect the curds from yellowing due to direct exposure to sun. The curds may also loose some of their flavour, because of this exposure. This problem generally occurs in such varieties of early and mid season maturity group, which have spreading and open plant type. In some varieties, the curd remains naturally protected and surrounded by inner whorls of leaves. These are called self-blanching types. Drawing and tying the tips of leaves when curds are fully developed may do the blanching. The other way to place a leaf a cauliflower over the curd 4-5 days prior to harvest.



Use of Plant Growth Regulators

Various recommendations on use of plant growth regulators (PGRs) are given in Table 6.

Table – 6 Recommended Plant Growth Regulators (PGRs) in Cauliflower

Name of PGRs	Concentrations (mg/l)	Method of application	Attributes affected	References
HBA	10	Seedling treatment	Increases yield	Chhonkar and Sharma, 1966.
GA + NAA + Mo	100+120+0.2 per cent	Foliar spray	Increases yield	Muthoor et al. 1987
GA + Urea	50 +1 per cent	Foliar spray	Increases yield	Amarender and Reddy, 1989

GA3	50	Foliar spray twice at 20 and 40 days after transplanting	Increases yield	Vijay Kumar and Rai, 2000
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Water Management

First irrigation is given just after transplanting. Further irrigation will depend upon weather, soil type and variety. However, regular maintenance of optimum moisture supply is essential during both growth and curd development stage. For early and mid season crop, usually, lesser number of irrigation is needed because of rains. In areas having rainfall, the planting is done on ridges, furrow irrigation should be given.

Harvesting, Yield and Storage

The harvesting is done as soon as the curd attains right maturity and they are compact, with white colour of the curds is maintained, If the harvesting is delayed, the curds become over mature, whose quality is deteriorated. Such curds may turn loose, leafy, ricey or fuzzy. The over mature curds should be sorted out while sending the produce to market. For harvesting, the curds are cut off stalk well below the curd with a sharp cutting knife or sickle Yield of the cauliflower varies greatly depending upon variety, maturity group and season. Early maturing cultivars have an average yield of 80-120 /ha. The main season cauliflower produces 150-200 q yield/ha. while Snowball group and other late maturing cultivars gave the highest yield of 250-300 q/ha, because of highly compact curds and larger plant population per unit area. Cauliflower can be stored successfully at 0°C and 90-95 per cent RH for 2-4 weeks (Hardenburgs et al., 1990).

Diseases, Pests and Physiological Disorders

Diseases

Most of the diseases, which affect cauliflower, are similar to diseases of cabbage. However, some specific diseases of cauliflower are described below:

Stalk Rot (*Sclerotinia sclerotiorum* (Lib) De Bary)

Leaves when infected, turn light green and alter yellow and shed prematurely. Black soft rot later often appears on petioles and mid rib touching. The soil is covered with flubby growth of fungus. Stem on the ground levels show girdling. Cool (20-25°C) and 95-100 per cent conditions are ideal for disease initiation and spread (Sharma and Sharma, 1985).

Control Measures

Crop rotation is highly effective in decreasing disease incidence (Gupta *et al.* 1986). Application of benlate (0.02%) and MBC (0.02%) have found to be effective in reducing disease incidence (Sharma and Sharma, 1985).

Insect-Pests

All the insect-pests, which damage cabbage, are also harmful to cauliflower and follow same control measures.

Physiological Disorder

Cauliflower suffers from a number of physiological disorders, which manifest in different type of disease syndromes. Some physiological disorders depend mainly on hereditary factor, whereas, other are fluctuation occurring in temperature, air, water, humidity, organic and inorganic nutrition. Important physiological disorders, affecting cauliflower are described below:

Riceyness

It manifests in the elongation on peduncle wearing flower buds, rendering curds, granular, loose and somewhat velvety. A premature initiation of floral bud is characterized by riceyness in cauliflower and is considered to be of poor quality for marketing. At IARI, New Delhi, it has been found that this disorder may result from any temperature higher or lower than the optimum required for particular cultivars. Riceyness mainly and harvesting has been delayed. If late variety planted early, riceyness develops due to the prevalent of high temperature, however, it can also appear at lower temperature. Hereditary factors have also been reported for riceyness. Heavy dose of nitrogen and high relative humidity also contributes to riceyness. It can be controlled by cultivation of genetically pure seed and appropriate varieties with recommended cultural practices.

Fuzziness

It appears as the flower pedicels of velvety curds elongate. The anomaly is both hereditary and non-hereditary. Cultivation of cauliflower, out of their normal season encourages fuzziness. Sowing good quality seed in right season under proper cultural practices, minimized fuzziness.

Leafiness

This disorder is commonly seen by formation of small thin leaves from the curd which reduces quality of curd. Extremely small green leaves appear in between the curd segment due to inheritable or non-heritable factors. Prevalence of high temperatures during curding phase aggravates leafiness. Certain varieties are more sensitive to leafiness or bracketing than other. It can be controlled by selection of varieties according to their adaptability.

Browning (Brown Rot or Red Rot)

It is caused by boron deficiency which is influenced by soil pH. The availability of boron decreases at neutral soil reaction. It is characterized by sign on the young leaves that become dark green and brittle. The old leaves pucker, chlorotic and often drops off. Sometimes, the downward curling of older leaves followed by development of blisters when boron deficiency is severe. The leaves remain small and the growing point may die. However, in later stage, water soaked, light brown to dark brown spots formed on the stem and branches may ultimately lead to the formation of cavities formed on the stem and branches may ultimately lead to the formation of cavities and a hollow stem. Curds may also show irregular water soaked spots. Which alter change to a rusty brown colour. The affected curds remain small and acquire a bitter taste. This may be controlled by application of borax or sodium borate or sodium tetra borate at the rate of 20 kg/ha a soil application. In case of acute deficiency, spray of 0.25 to 0.50 per cent solution of borax at the rate of 1 to 2 kg/ha depending upon growth, soil reaction and extent of deficiency.

Whiptail

Deficiency of molybdenum causes 'whiptail' syndrome, especially, in highly acidic soils. Because high manganese concentrations in such soils hinder the uptake of molybdenum which seldom occurs when the soil pH is 5.5 or higher. The young cauliflower plants become chlorotic and may turn white, particularly along the leaf margins. They also become cupped and wither. The leaves blades fail to develop properly, and the leaves are ruffled and distorted. In older plant, the lamina of the newly formed leaves are irregular in shape, frequently, consisting of only a large bare midribs and hence, the common name "whiptail". It can be corrected by application of lime or dolomite limestone to raise the soil pH up to 6.5 or higher. Sodium or Ammonium molybdate at the rate of 1-2 kg/ha as soil application can also control "whiptail" of cauliflower.



Buttoning

Development of small curds with inadequate foliage in cauliflower is known as buttoning. It is also referred to as premature heading. The leaves are so small that can not cover the formed head. Causes of buttoning are (i) Transplanting of more than 6 week-old seedlings. Generally, over aged seedlings when transplanted in the field take more time in establishment due to less developed root system. A poor development of root system is possible due to insufficient availability for nutrients and inadequate space for the development of root system due to crowding of seedlings, allowed for longer duration in the nursery beds. The growth rate of such over aged seedlings is usually slow. Not only this they could not put on optimum vegetative growth and start forming curds, which further could not grow into normal size and causes buttoning. Temperature below the optimum during growing period delays maturity. (ii) Planting as early variety in late vice versa leads buttoning. (iii) Hot and dry weather is unfavorable for vegetative growth of plants, but favourable for inducing curd formation and inhibits further enlargement. Curds remain very small in size like buttons. (iv) When soil moisture becomes limiting factor, it checks the growth of the plants, which in turn, causes early formation of curds checks the growth of the plants, which in turn, causes early formation of curds without maintaining their further enlargement. (v) Transplanting of seedlings, obtained from poorly managed nursery bed. Such seedlings may not have high potential for their vegetative growth, which is almost important for the formation and enlargement of normal curds. (vi) Slow plant growth in the nursery, over crowding, insufficient water, lack of weeding, bad condition of the soil, excessive crowding, insufficient water, lack of weeding, bad condition of the soil, excessive salt concentrations, low lying area or field with shallow and poor top salt may also cause buttoning. (vii) Vigorously grown nursery plants with thickened stems and sessile foliage being already generative have a tendency of button formation in the field. The check in growth may be caused by root injury by insects or by some diseases (especially *Rhizoctonia spp.*). It can be controlled by (i) Nursery should be properly look after to avoid any check in the plant growth. (ii) An adequate amount of nitrogen and water should be applied. (iii) Do not delay transplanting and (IV) Cultural practices should be carried out well in time and water logging and overcrowding should be avoided.

Blindness

It means the plant without terminal buds or when the growing point collapse at an early stage and the terminal buds fails to develop and plant becomes blind. It occurs in over wintered plants and any practice interfering in growth of the terminal bud may lead to blindness. Plant grows without terminal bud and fails to form and curd. It is characterized by the leaves that

develop are large, dark green, thick and leathery owing to the accumulation of carbohydrates. Sometimes, the axillary bud develops but the plant fails to produce a marketable curd. The main cause of blindness are low temperature when plants are small and when damage occurs to the terminal bud during, handling of the plants or injury by insect-pests. It can be controlled by avoiding young plant from low temperature exposure and care seedlings. While planting and handling, seedlings are avoided damage from insect-pests.

Chlorosis

In cauliflower magnesium deficiency causes chlorosis when grown on highly acidic soils. Chlorosis shows on interveinal and yellow mottling of lower leaves. The affected leaves turn bronze in colour and become stiff. In severely deficient plants, abscission of the lower leaves occurs and results into small curd formation. It can be controlled by applying magnesium oxide @ 300 kg/ha, liming the soil with dolomite limestone to bring the soil pH to 6.5 are an effective control measure. Use of a fertilizer containing soluble magnesium, keeps it under control.

Hollow Stem

It may be due to boron deficiency and higher supply of nitrogen nutrition. Hollowness caused by boron may be identified by water soaked and discoloured tissue, whereas, hollowness caused by nitrogen, the stem is perfectly clear while with no sign of disintegration. It can be controlled by spraying of borax at 0.1 to 0.3 or soil application of borax @ 15-20 kg/ha. If hollow stem is used by boron deficiency. However, for normal type of hollowness, spacing the plants closer together or by reducing the fertilizer doses.

Frost Injury

In cauliflower, leaves of young seedling turn yellowish-white on both the surfaces. Petioles become flaccid and white, midrib along with adjacent parenchyma and stem may also be injured. Fully grown curds of cauliflower are more sensitive to frost damage, than the smaller ones. However, in cabbage the younger leaves are particularly sensitive to frost, as that the centre of the heads turns brown, while, outwardly the head appears healthy, similar symptoms also occurs in Brussels sprouts. It can be minimized by irrigating the field on anticipating the danger of frost and by raising the field temperature by creating smoke.

Pinking

Sometimes curds show pink tinge, this appears due to the exposure of curds to high light intensities. Under this condition, anthocyanin form and gives rise pink colour curds. This disorder is not so common.

1. _____ types of cauliflower are self blanching.
 - a. Early season
 - b. Mid season
 - c. Late season
 - d. All the above

2. The edible part of cauliflower is known as
a. Head b. Curd c. Stem d. Leaf
3. The premature initiation of flower buds is called as _____.
4. Snow ball is a variety of -----.
5. _____ type of cauliflowers are self blanching.

**ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR COLE
CROPS – KNOL- KHOL**

Brassica oleracea var. *gongylodes*

Knol-khol (*Brassica oleracea* var. *gongylodes*) is known by many names in India. It is popular in Kashmir, West Bengal, Maharashtra, Assam, Uttar Pradesh, Punjab and some parts of south India, but it is not cultivated commercially. It is characterized by the formation of knob (tuber) which arises from a thickening of the stem tissue above the cotyledons. The fleshy turnip-like enlargement of the stem develops entirely above the ground. This knob is harvested for human consumption as raw or cooked vegetable, though in some parts, young leaves are also used.



Climate and soil

Knol-khol thrives best in a relatively cool, moist climate. In temperate regions, the early varieties are sensitive to early bolting but under subtropical conditions, this problem is not much since the vernalization effect of low night temperature is counteracted by high temperatures during the day with the result that mean temperature hardly goes below 10°C. The high temperature after planting delays the bolting of plants that have been vernalized on the seed bed. It grows well with a monthly average temperature of 15°–20°C, maximum and minimum average being 24°C and 4.5°C. In late varieties, low temperature does not have stimulating effect on bolting in early stages. It is vernalized in the later stages only as other biennial cole crops when the plant has made some growth. It can withstand extreme cold and frost better than other cool season crops.

Varieties that are susceptible to bolting lack a juvenile phase and become generative without producing knobs if exposed after germination to low temperature. When the low temperature occurs at the knob formation stage, the round and flat round varieties produce long oval-shaped knobs. The low temperature or frost conditions sometimes develop the anthocyanin pigments on knobs or plant parts. These pigments are intensified, if there is lack of N and P in soil, deteriorating the quality of knobs, especially of green types.

Knol-khol can be grown on all types of soils. A soil rich in manures and fertilizers produces excellent knobs. Sandy loam is ideal for an early crop and clay or silt loam for higher yield and late crop. It does not grow well in highly acidic soil. The optimum pH is 5.5–6.8.

Varieties

Some of the promising varieties available in India are Sutton's Earliest Purple (Sutton), Golith White (Sadashiv), Early White Vienna, King of the Market and Early Purple Vienna (Verma, Pocha). Although research stations and some private seed companies are engaged in testing and maintenance of varieties, no serious attempt has been made for the improvement of the crop as the available introductions are well-suited to our conditions. The recommended varieties are:

King of North

It has a plant height of 20–30cm foliage is dark green, knob flattish-round, leaf sheath large and well-spread over the knob. It matures 60–65 days after transplanting.

In Europe, Wiesmoor Forcing White and Gaugels Forcing White are resistant to bolting and mature 30–45 days after planting. These are early varieties characterized by the horizontal position of the lower leaves. The late varieties mature 70–100 days after planting. The earliest variety in this group is Purple Speck while Goliath, is late.

Large Green

It has green, round, large-sized knobs with small tops. The knobs are tender, delicately flavoured with white flesh. It is ready for harvesting in 76 days with an average yield potential of 225–250q/ha. It has been recommended for mid and high hills of the western Himalayas.

Purple Vienna

This is about one week late than White Vienna. Knobs are purplish-blue with greenish-white flesh. It has purple leaves. It requires 55–65 days for knob formation with slightly better yield potential than White Vienna.

White Vienna

This is an early variety with globular, light green, smooth, tender, medium-sized knobs having creamy-white tender flesh with delicate flavour. Its plants are dwarf, leaves and stems

are medium green. It has a yield potential of 150–200q/ha. It matures 55–65 days after transplanting. Early White Vienna has dwarf plants, short tops and globular round knobs. It takes 50–60 days for knob formation.

Cultivation

Knol-khol is usually propagated by seed, the seed rate being 1–1.5kg/ha. Seed should be given a hot water treatment (50°C) for half an hour against black rot and Apron 35 @ 2g/kg seed against downy mildew before sowing in disease-prone areas. The seedlings are raised in the nursery beds. About 4–6 weeks old seedlings are ready for transplanting.

Generally, 60cm wide and 2.5m long nursery beds are prepared. For 1m² nursery 100g of fertilizer mixture containing 15g each N, P and K and 2.5–4kg farmyard manure mixed well in soil and raised nursery bed must be prepared with 30cm channel along with the nursery. On light and drought sensitive soils, sunken nursery beds are preferred. Acidic soils should be limed. For minimizing the seedling damage, the nursery beds should be treated with formalin (40% formaldehyde diluted in 5–6 parts of water). Soil is saturated with this solution, requiring 5 litres/m². Fumes are then confined by covering nursery beds with burlap or canvas or polythene for 2 days and then the soil is aerated well for at least 4 days before sowing. This treatment can be replaced by the use of Captan (0.3%) for soil drenching. Seeds are sown in rows at a distance of 5–6cm for ease in manual hoeing, weeding and thinning. In too close spacing, the seedlings are liable to be attacked by damping off disease and become lanky. Proper spacing results in stocky and vigorous seedlings. A depth of 1.5–2cm is optimum since deeper sowing delays the germination. The nursery bed is covered with grass to conserve moisture for uniform germination. It is watered as and when required with watering can. The mulch is removed just before the seed germination to control damping off, drenching with Dithane M-45 (0.2%) is recommended. Nitrogenous fertilizer (urea) may be added in the spray when the seedlings growth is poor. However, excessive N results in tender and lanky plants that show poor establishment after transplanting. Seedlings are hardened in the nursery by restricting the water supply for about a week before transplanting in the field to enable them to withstand the shock of transplanting.

Planting

In the plains of north India, planting may be done in September, while in the milder winter regions, October is best time for planting. In the hills of northern India, seeds are sown from March–April to August. About 5–6 week old seedlings are transplanted for summer and autumn crops. The growing of nursery in March– April needs protection from cold and frost for which low cost polyhouses may be used.

Preparation of land is done by 2–3 ploughings, firstly with soil turning plough and after ploughings with ordinary plough/tiller or disc harrow to get fine tilth. The beds and channels are prepared to facilitate irrigation. Transplanting of seedlings is done in the evening and/or on cloudy days. The soil around the plant should be well pressed to establish contact with the roots. This process should be followed by light irrigation. The dead plants should be replaced and gaps be filled 5–6 days after transplanting. The transplanting is done at a closer spacing of 25cm × 25cm, 25cm × 30cm, 25cm × 40cm or 30cm × 45cm depending on climatic conditions and fertility of the soil. The yield is more in close spacing but the size of knobs is reduced. The early varieties may be planted at closer spacing while the late ones require wider spacing.

Manuring and fertilization

Knol-khol responds well to manuring, as it is a heavy feeder. A yield of 20 tonnes/ha removes about 100kg N, 85kg P and 170kg K. Excess of N may cause abundant leafy growth and a delayed crop. Split application of N is more beneficial. Half of N along with full quantity of P and K are applied at the time of transplanting. The remaining half N is applied in 2 equal split doses, 3 weeks after transplanting and the other at the knob development stage. The farmyard manure is added to soil 4–6 weeks before transplanting. Optimum N and K doses are necessary to get good flavoured knobs.

The deficiency of B, Mo and N may induce physiological disorders such as browning, whiptail and buttoning. Foliar application of urea (1–2%) to correct the N deficiency is useful and economical. Multiplex (0.2–0.3%) can be added in the spray to correct the general micronutrient deficiencies. However, to correct deficiency alone, 10–15kg/ha of borax as soil application or 2 sprays of 0.3% borax on the crop are beneficial. In highly acidic soils, Mo deficiency can be overcome by liming or soil application of ammonium molybdate @ 200–300g/ha at a concentration of 0.01–0.1%.

Aftercare

Steady growth is of utmost importance. Any check in the growth causes knobs to be fibrous and woody. On the other hand, too rapid growth after slow initial growth may result in cracking knobs though a lot of varietal variation exists. The knobs may become elongated in close spacing due to lack of light as in knobs growing in the shade. The production of elongated knobs may also be induced by high temperature and excess of N. Cracking of knobs also occurs if the long-dry spell is followed by moist conditions or irrigation, because of increased root pressure.

The intercultural operations are performed mainly to check the weed growth to make the soil loose and to maintain proper moisture condition. Since its root system is shallow, hoeing is

done to keep the crop weed-free. Presence of weeds in the early stages reduces the yield due to poor growth of the plants. Timely hoeings help check the weed population. As soon as the weeds start appearing, shallow hoeing should be done. Once the weeds are well-established, their removal disturbs the root system of plants resulting in weak growth. No sooner the soil is covered with foliage, hoeing is stopped. Hoeing during the knob development stage is discouraged and weeds if any removed by hand.

Treflan (Trifluralin @ 0.5 litre/ha) and Semeron (Desmetrayne @ 1kg/ha) applied before transplanting control both monocot and dicot weeds. Use of black polythene mulch for controlling weeds can also be made. Recently the effectiveness of Stomp (Pendimethalin @ 1–2kg/ha) in controlling weeds has been recommended. Practice of a weedicide application supplemented with 1 or 2 hand hoeings is useful and economical.

Irrigation

Knol-khol requires a continuous supply of moisture for uniform growth and development of knobs. First irrigation is done immediately after transplanting and thereafter irrigation is done when needed, depending on soil and weather conditions. Irrigations at 15 days interval are adequate. Heavy irrigation should be avoided. Irrigation should be applied when the moisture content of the soil has dropped below 50% of field capacity. At the time of maturity of knobs, irrigation is detrimental.

Harvesting and Post harvest management

The knobs are harvested by cutting the stem just below it by a sharp knife or sickle before they are fully grown. After that they become tough and woody. The demand is fairly high for knobs of smaller size of about 5–8cm diameter. In preparing the produce for the market, the root portion is removed and the plants are tied in bunches along with the tender leaves. It is also marketed after removing both leaves and roots.

The knobs of early varieties may have an average weight of 200–250g while those of late ones weigh up to 1kg. Generally, the yield may vary from 12–30t/ha.

1. In knolkhol _____ variety is commonly grown in India?
2. Commercial part of knolkhol is _____
3. Mode of pollination of knolkhol _____
4. Botanical name of knolkhol _____
5. Chromosome number of knolkhol.

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR ONION

Allium cepa L. ($2n = 2 \times = 16$)

(Hindi: Pyaz)

Onion is valued for its bulbs having characteristic odour, flavour and pungency, which is due to the presence of a volatile oil – allyl-propyl-disulphide. Pungency is formed by enzymatic reaction when tissues are broken. Bulbs are suited for storage for a long period and for long distance transport. It is used as salad and cooked in many ways in curries, fried, boiled, baked and used in making soups, pickles etc. Value addition in onion is done by marketing dehydrated onions and onion flakes. Onion bulb is rich in minerals like phosphorus (50 mg / 100 g) and calcium (180 mg / 100 g). Many medicinal uses are reported for bulbs and is commonly used as diuretic and applied on wounds and boils. Onion greens are also used by harvesting crop at pencil thickness and when small bulb is formed.

India is the second largest producer of onion in the world, next to China and ranks third in export of onions, next to Netherlands and Spain. During 2001-2002, a total of 52.52 lakh metric tones of bulbs was produced from an area of 4.96 lakh hectares in India. Maharashtra is the leading onion producing state in India followed by Karnataka and Gujarat. The crop is grown on extensive scale in Orissa, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Rajasthan and Bihar.

Origin and taxonomy

Onion originated in Asia. According to Vavilov (1951), onion originated in Pakistan. Jones and Mann (1963) proposed the area comprising Pakistan, Iran and mountain areas to the North as primary centre of origin of onion.

The following types of onions are grown in India:

1. Common onion (*Allium cepa* var. *cepa*) – with large bulbs born singly and propagated through seeds. It is mainly used as salad or in curries.



Multiplier onion or potato onion (*Allium cepa* var. *aggregatum*) – producing small bulbs borne in clusters and generally propagated through small bulbs. Mainly used for seasoning curries.



2. Shallot (*Allium cepa* var. *ascalonicum*) – Produces bulbs in clusters on surface of soil. This perennial onion rarely produces seeds and is propagated through bulbs.



3. Tree onion or Egyptian onion (*Allium cepa* var. *viviparum* / *proliferum*) – This viviparous plant produces a perennial underground bulb and is not widely cultivated. The bulb-lets produced in place of umbel are used for pickling and seasoning. Bulb-lets are also used for propagation.





Capsules



Walking onions



Walking onion flowers



Onion sets growing green stalks of their own

4. Chive (*A. schoenoprasum*) ($2n=16, 24, 32$). This is a hardy perennial bunching herb grown for their hollow green leaves. It is propagated by root division and is tolerant to extreme cold and drought.



In addition, a perennial bunching species, *A. fistulosum* is very common in China and Japan and is grown for its edible tops and leaf bases.



Botany

Onion is a biennial herb with a characteristic smell. The leaves are tubular and the bulbs are formed by the attachment of swollen leaf bases to underground part of stem which is small and rudimentary. Flowers are produced during second phase after formation of bulbs. Flowering structure is called an 'umbel', which is an aggregate of many small inflorescences (cymes) of 5-10 flowers. Length of peduncle commonly known a 'scape' varies with variety. Though individual flowers are hemaphrodite, they are cross pollinated due to protandry. Cross pollination is achieved by honey bees when they visit flowers for nectar. Stigma becomes receptive 3-4 days after shedding of pollen grains. Artificial selfing is done by covering all umbels of a plant together and by shaking or rubbing each other or by introducing flies.

Male sterility

Jones and Clarke (1943) reported male sterility formed by interaction of nuclear gene and cytoplasmic factor. It is presumed that there are two types of cytoplasm – normal (N) and sterile (S). All male sterile plants have 'S' cytoplasm which is inherited maternally through egg. A recessive gene 'ms' in homozygous condition results in sterile pollen grains when carried in plants with 'S' cytoplasm [S(msms)]. Plants with 'N' cytoplasm [N(MsMs)], N(MsMs), N(msms) and plants with genetic constitution S (MsMs) and S (Msms) are fertile. Besides modifier genes, environmental factors also cause variation in expression of male sterility.

Male sterile plants ([S (ms ms)]) are usually designated as 'A line'. They can be maintained by crossing with male fertile 'B line' having fertile cytoplasm – N (msms). B line can be identified by crossing 'A line' with several other lines and if the progeny turns out to be completely male sterile in a particular case, that particular parent will be considered as B line with N (msms). Fertility of 'A line' can be maintained by crossing with 'C line' having a

constitution of N (Msms) as pollen parent. Progeny segregates in the ratio of 1 male sterile: 1 male fertile. 'C line' is generally designated as fertility restorer line.

Climate

Onion is a cool season vegetable and grows well under mild climate without extreme heat or cold or excessive rainfall. It does not thrive when the average rainfall exceeds 75-100 cm during monsoon period. The young seedlings withstand freezing temperature. The ideal temperature for vegetative growth is 12.8 – 23.0°C. For bulb formation it requires long days and still higher temperature (20-25°C). Even though onion is treated as a long day plant, for bulb formation and its development, varieties differ in their response to length of day. Most of cultivars grown in plains of North India are short day cultivars. Long day varieties will not produce bulbs under short day conditions and short day cultivars if planted under long day conditions will develop early bulbs. For seed production, temperature has more relevance than photoperiod.

Varieties

Onion varieties differ in size, colour of skin, pungency, and maturation etc. of bulbs. Large sized bulbs are mild in pungency and are sweet in taste compared to small sized onions. Red coloured cultivars are more pungent than silver skinned varieties and keep better in storage. Yellow cultivars have less demand in the market. The local cultivars are known and marketed after the names of places where they are grown. Poona Red, Nasik Red, Bellary Red, Patna Red and Patna White are common in onion trade.

Most of the improved varieties were developed through mass selection from local collections of segregating populations. A brief description of improved varieties is given below:

Developing institution	Variety	Special features
IIHR, Bangalore	Arka Niketan (Sel-13)*	Bulbs globular and pink with a weight of 100-180g, thin neck, highly pungent, TSS 12-13%, good storage quality. Yield 42 t/ha in 145 days.
	Arka Kalyan (Sel-14)*	Bulbs globular and pink with a weight of 130-190 g, TSS 11-13%, good storage quality. Suitable for kharif season only. Moderately resistant to purple blotch. Yield 47 t/ha in 140 days.
	Arka Bindu	Bulbs small, crimson red colour with 12.5%

	(Rose onion)	TSS. Yield 25 t/ha in 90-95 days.
	Arka Pragathi	Bulbs globular with thin neck and deep pink with high pungency. Early variety with good storage quality. Yield 45 t/ha in 130 days.
IARI, New Delhi	Pusa Red*	Bulbs red, globular, 5-6 cm in diameter and 70-90 g in weight, less pungent, good keeping quality, TSS 12-13%, yield 25-30 t/ha in 125-140 days.
	Pusa Ratnar*	Bulbs bronze deep rd, flat globular, less pungent and good keeping quality, yield 32.5-35 t/ha in 145-150 days.
	Pusa White Round	Bulbs medium to large, attractive round, good keeping quality, suitable for dehydration, yield 32.5 t/ha in 125-140 days.
	Pusa Madhvi	Bulbs light red, good keeping quality, yield 30-40 t/ha.
	Pusa White Flat	Good for dehydration and green onion, yield 33-35 t/ha.
	Early Grano	Introduction from USA with large globular yellow coloured bulbs having mild pungency, suitable for salad purpose and for green onion purpose, poor keeping quality, yield 50-60 t/ha in 95 days.
IARI Regional Station, Katrain	Brown Spanish	Long day type suitable for hills, yield 28 t/ha in 160-180 days.
NHRDF, Nasik	Agrifound Dark Red*	Bulbs dark red, globular 4-6 cm in diameter, moderately pungent, TSS 13%, good keeping quality, yield 30-40 t/ha in 160-165 days.
	Agrifound Rose	Suitable for export bulbs dark red, yield 19-20 t/ha.
VPKS, Almora, UP.	VL 3	Bulbs medium size, globular, red and pungent. Yield 25 t/ha in 145 days.
MPKV, Rahuri	N-2-4-1*	Bulbs brick red, globular, 6.1 cm in diameter,

		pungent and firm with good keeping quality, TSS 12-13%, yield 30 t/ha in 140 days.
	N-257-9-1*	Bulbs globular and white, suitable for rabi season, suitable for dehydration. Yield 25 t/ha in 125 days.
	Baswant-780	Bulbs crimson red with 12% TSS. Yield 25 t/ha in 125 days.
	N-53 (Nishad-53)	Suitable for kharif season. Bulbs shining red, less pungent, globular, yield 15-20 t/ha.
HAU, Hisar	Hisar-2	Bulbs light red, yield 20 t/ha.
Punjab Agricultural University, Ludhiana.	Punjab Naroya*	Bulbs red, medium to large, round with thin neck, tolerant to purple blotch, yield 37.5 t/ha. In 123 days.
	Punjab Selection*	Bulbs red, globular, 5-6 cm in diameter and 50-70 g in weight, good keeping quality, yield 30 t/ha.
	Punjab Red Round*	Bulbs shining red, globular, medium size with thin neck, yield 28-30 t/ha.
	S-148*	Bulbs white, flat round, average weight 80 g, TSS 12-13%, good storage quality, yield 25-30 t/ha in 140 days.
CSAU&T, Kanpur.	Kalyanpur Red Round	Bulbs light red, yield 20 t/ha.
RAU, Rajasthan	Udaipur 102	Bulbs white suitable for dehydration, yield 25-30 t/ha.

Hybrid vigour

IIHR, Bangalore has developed F₁ hybrids like Arka Kirtiman, Arka Lalima and Arka Pitamber. A brief description of the above hybrids is given below :

Arka Kirtiman - F₁ hybrid of CMS 65 x Selection 13-1-1. Suitable for kharif and rabi seasons, bulbs medium size and dark red, yield 45-60 t/ha, good keeping quality, suitable for export to Gulf countries.

Arka Lalima – F₁ hybrid of MS 48 x Selection 14-1-1, bulbs globe shaped and deep red each weighing 120-130 g, good shelf life of 5 months, tolerant to purple blotch, suitable for export to Gulf countries.

Arka Pitamber (IIHR Yellow) – Short day variety with globe shaped yellow bulbs, average bulb weight 80 g, moderately resistant to purple blotch, yield 35-38 t/ha.

Soil

Onion prefers a well drained, loose and friable soil rich in humus. It is sensitive to high acidity and alkalinity and the ideal pH is 5.8 to 6.5.



Methods of planting

The following three methods of planting are followed depending on soil, topography, climatic conditions and economic aspects:

1. Raising seedlings and transplanting
2. Planting bulbs directly in the field.
3. Broadcasting or drilling of seeds directly in the field.

Transplanting method

This is the most common method practiced for irrigated crop as it results in high yield and large size bulbs. In plains, seeds are sown during October-November for a Rabi crop. In hills, seeds are sown from March to June. Seeds are first sown in well prepared nursery beds of 90-120 cm width, 7.5-10.0 cm height and convenient length. Ratio between nursery area and main field is about 1:20. Seed rate varies from 8 to 10 kg/ha. Seedlings of 15 cm height and 0.8 cm neck diameter are ideal for transplanting and this is achieved in 8 weeks. However, it

varies from 6-10 weeks depending on soil, climate and receipt of rain. There is a practice of topping seedlings at the time of transplanting if seedlings are over-grown.

For transplanting, the land is brought to a fine tilth by thorough ploughing, leveling and breaking clods. The field is then divided into small plots of convenient sizes for irrigation and seedlings are transplanted at 15 x 8-10 cm spacing.

Planting of bulbs

This method is practiced in hill slope and in terrace cultivation since seedlings are easily washed off in rain. Medium to small sized bulbs alone are used for plating since large sized bulbs result in early bolting and high cost. Medium sized bulbs obtained from a seedling planted June crop are used for planting in September – October after giving a month rest. Bulbs are dibbled at 15 cm apart on the side of 45 cm wide ridges or in beds or in furrows depending on soil or climate. 10-12 quintals of bulbs are required to plant one hectare.

Broadcasting or drilling method

Direct sowing by broadcasting or drilling at 30 cm apart is practiced in some areas to save labour for transplanting. Here seed requirement is as high as 25 kg / ha. Care should be taken to remove weeds during initial stages to prevent smothering of seedlings by weeds. Usually weeding is done at 10 days interval for the first 1-2 months. When bulbs are 6-8 weeks old, seedlings should be thinned to proper distance which usually synchronizes with gap filling.

Manures and fertilizers

Onion is a heavy feeder of nitrogen and potash and a crop yielding 35 t/ha requires 120 kg N, 50 kg P₂O₅ and 160 kg K₂O, 15 kg Mg O and 20 kg sulphur. Apply 20-25 tones of farmyard manure at the time of first ploughing so that it may get mixed thoroughly during subsequent ploughings. Entire dose of P and K should be applied at the time of final land preparation. Nitrogen should be top-dressed in two equal splits, first half 3-4 weeks after transplanting and second half two months after transplanting.

Application of fertilizers in Tamil Nadu :

Apply FYM 25 t/ha, *Azospirillum* 2 kg and *Phosphobacteria* 2 kg/ha, N 30 kg, P 60 kg and K 30 kg/ha as basal and 30 kg N/ha on 30th day of sowing.

Irrigation

Onion is mainly grown as a irrigated crop in India. Frequency of irrigation depends on soil and climatic conditions. Requirement of water varies with stages of crop. It requires less water immediately after establishment of seedlings and consumption goes on increasing with maximum requirement before maturity, around 3 months after transplanting, and thereafter it is

reduced. So irrigate the crop at 13-15 days interval during early stage followed by subsequent irrigations at 7-10 days interval.

Weeding and inter-culture

During early stages of the crop, plants grow slowly and it is essential to remove weeds. Pre-plant incorporation of Basalin (2 kg a.i./ha) along with one hand weeding at 45 days after transplanting is recommended to control weeds. Being a shallow rooted crop, deep inter-culture operation is likely to injure roots and reduce yield. Generally two hoeings are essential for making soil loose and to cover bulbs.

Harvesting and yield

Onion is ready for harvest in 3-5 months after transplanting depending on variety. Harvesting is done by pulling out plants when tops are drooping but still green. During hot days when soil is hard, bulbs are pulled out with a hand-hoe. Yield varies with season and variety. 15-25 tonnes of bulbs are expected from one hectare of transplanted crop. Yield of kharif crop is comparatively low.

Rainy season onion cultivation

Onion was grown during rabi season only. Development of varieties suitable for rainy season is a significant achievement in onion breeding and it resulted in cultivation of onion in kharif season also. Varieties like N-53, Agrifound Dark Red, Baswant 780 and Arka Kalyan are suitable for growing in rainy season. For a successful crop, seeds are sown by end of May or June, transplanted in August and harvested in December-January. In kharif season, yield will be less and ranges from 15-20 t/ha.

Green onion or Spring onion

Consumption of green onion is almost equal to that of dry onion in the world. Both bulb-forming and non-bulb forming types are used as green onion. For green onion production, seeds are sown in August, transplanted in October and harvested after 75-80 days at tender stage. Varieties like early Grano, Pusa White Flat and Pusa White Round are suitable for green onion purposes. Yield ranges from 40-45 t/ha.

Post-harvest handling

It is estimated that 60-65% of onion produced in India is consumed internally, 5% exported and 30-40% lost by post harvest damage.

Curing

Sprouting and rotting are common problems in storage since bulbs contain high moisture. The bulbs should be adequately cured for proper development of skin colour and to remove field heat before storage of bulbs. It is done till the neck is tight and outer scales are

dried. This will prevent infection of diseases and minimize shrinkage loss. Bulbs are cured either in field or in open shade or by artificial means before storage. During kharif season, bulbs are cured for 2-3 weeks along with top. In rabi, bulbs are cured in field for 3-5 days; tops are cut leaving 2.0-2.5 cm above bulb and again cured for 7-10 days to remove field heat.

Storage

After curing, bulbs are stored in well ventilated rooms by spreading them on dry and damp proof floorings or on racks. Periodical turning of bulbs and removal of rotten and sprouted bulbs is highly essential. A pre-harvest spray of maleic hydrazide (2000-2500 ppm) prevents rotting and sprouting of bulbs stored at room temperature. At BARC, Trombay irradiation of bulbs with very low doses (4000-9000 krads) of gamma rays is effective for preventing sprouting and enhancing storage life of onion bulbs.

Bulbs harvested from kharif crop do not store well for long period. At 0-2-2.2°C under cold storage, bulbs can be stored for long period. NHRDF and NAFED erected storage structures in Nasik for helping farmers. Three types of storage structures, viz., Panipat type 2-tiered, 3-tier onion store and 2-tier model were established by Government itself investing heavily.

Grading

These necked, bolted and decayed bulbs are removed. Cured bulbs are graded based on size, and depending on market to which it is sent. Big sized onion is in demand in New Delhi, medium sized in Kolkata, Patna and small sized onion in North Eastern regions of the country.

Marketing

Between farmers and consumers, several intermediaries are involved in marketing of onions. After entry of NAFED in onion trade, farmers' co-operatives are playing a key role in marketing. Lasalgaon is the biggest onion market in India. November – June is the peak period of onion in market.

Export

India is the third biggest exporter of onion, next to Netherlands and Spain, in world. Major export is to Gulf countries, Malaysia, Singapore, Sri Lanka and Bangladesh. Export of onion is channelised through NAFED. Depending on preference of colour and size of bulbs, different varieties are exported. Middle East countries prefer light red to dark red bulbs. In Malaysia preference is for dark red bulbs. In America and Japan, demand is for yellowish or brown onion having mild pungency. Europe and Japan markets prefer large sized bulbs while in Singapore, demand is for small onions.

Onion accounts for major share (nearly 75%) of vegetables exported from India. Export of 4.4 lakh tones of fresh onion worth of Rs. 332.43 crores during 2001-02 was increased to 8.33 lakh tones worth of Rs. 621.09 crores during 2004-05. During 2004-05 share of fresh onion export was 3.8% of the total export earning from agriculture sector. Major importers for Indian onion are Bangladesh, Malaysia, UAE and Sri Lanka. About 90% of export from India is of big onion (4-6 cm diameter) and 10% of small onion (3-4 cm diameter) and multiplier onion. Large onion exported to Malaysia, Gulf countries, Singapore, Sri Lanka, Bangladesh etc. and small and multiplier onion to Bangladesh, Singapore and Malaysia. Colour preference also varies with the country. Middle East countries demand light red to dark red, Malaysia dark red, Sri Lanka dark red to light red and Bangladesh small onion of light red to dark red. European countries, Japan and America prefer yellowish or brown onions having mild pungency.

Dehydrated onion

Popularity of dehydrated onion is increasing now-a-days. Advantages of dehydrated onion are storage stability and ease of preparation. Commercial processing plants prescribes a shrinkage ratio of 7:1 to 17:1 with a moisture content of 4% in final product. Dehydrated onions are sold in many forms as slices, chopped, minced, granulated and powdered.

Bulbs for dehydration should have the following characteristics:

1. Devoid of any green patches so that it may not develop discoloration on drying. White onions are preferred to red or yellow onions.
2. TSS should be 15-20° Brix in common onion and 25°Brix in multiplier onion.
3. Onion with small neck and root zone and those with tall globe shape are preferred than flat types to permit greater efficiency in topping.
4. Large bulbs are preferred due to economy in harvests.
5. Pungency should be high since dehydrated product is primarily used as flavouring agent.
6. The bulb should have good stability with minimum shrinkage loss and rotting. Moisture content should be around 80%.

South Port White Globe and White Cresole are primarily used for dehydration in Central California and Central America. Varieties like Pusa White Red, Pusa White Flat, S-48 and N-257-9-1 and Udaipur-102 are suitable for dehydration purposes.

Seed Production

Onion is a cross-pollinated crop and isolation distance of 1000-1600 m and 500 m is recommended for production of foundation and certified seeds, respectively. Two methods of seed production are followed-seed to seed method and bulb to seed method. Even though

seed yield is more under seed to seed method, bulb to seed method is followed for production of quality seeds.

In bulb to seed method, bulbs are produced as for market and bulbs with desired quality are replanted for seed production. Bulbs are replanted in first fortnight of October. Normally medium sized bulbs of 2.5 to 3.0 cm diameter are planted on the side of ridges or on beds at 45 x 30-45 cm spacing. 1000 kg bulb is required to plant one hectare. Flower stalks will be produced during third month after planting of bulbs and seeds ripen within six weeks after formation of flower clusters. Heads are harvested when seeds turn black in colour, but before seeds are shed. Seeds are dried in well ventilated rooms under shade and are stored. Seed yield is 800 – 1000 kg / ha.

Seed production of varieties which do not store well in storage is done by seed to seed method.

Multiplier Onion

(Syn : *Aggregatum* onion)

(*Allium cepa* var. *Aggregatum*) ($2n = 2x = 16$)

(Hindi : Cotta pyas)

Multiplier onion is used mainly for seasoning of curries. Unlike common onion, it is propagated through bulb-lets. The small bulbs grows into large ones which again break into smaller ones.

Unlike common onion, multiplier onion comes up well under tropical condition with sufficient soil moisture. Heavy rain during germination and bulb formation stage is highly deleterious for the crop. It prefers well drained loamy soil.

Varieties

The Tamil Nadu Agricultural University developed four varieties viz., Co.1, Co.2, Co.3, Co.4 and CO On 5 and NHRDF, Dindigul one variety – Agrifound Red. A brief description of the varieties is given below:

CO.1 – Bulbs large and pink, 7-9 bulbs / clump, yield 9-10 t/ha in 85 days.

CO.2 – Bulbs large and crimson, 7-9 bulbs / clump, yield 12 t/ha in 65-70 days.

CO.3 – Bulbs pink with a weight of 75 g, 8-10 bulbs / plant, moderately resistant to thrips, good storage quality, yield 15.8 t/ha in 65 days.

CO.4 – Bulbs attractive light pink, 9-13 bulbs / plant. Average weight 90 g/lump. Yield 19 t/ha in 65 days.

COOn 5 - High bulb yield (18.91 t/ha), free flowering and high seed setting ability, propagation through seeds.

Agrifound Red - Each clump weights 65 g with 5-6 light red bulb-lets, TSS 15-16oB, yield 18-20 t/ha in 65 days.

Under Tamil Nadu condition, bulbs are planted during April-May. As in common onion, field is ploughed to fine tilth and ridges and furrows are prepared at 45 cm apart. Medium sized bulbs are planted at a distance of 10 cm on either side of ridges. 1500 kg of bulbs are required to plant one hectare. As in common, seedlings raised from seeds are also used for planting. Cultural practices are same as in common onion. Yield varies from 10-15 t/ha with a crop duration of 2-3 months.

1. India stands second in the production of _____ crop
 - a. Tomato
 - b. Chillies
 - c. Onion
 - d. Bhendi
2. In onion, the outer skin colour is due to the presence of _____

- a. Anthocyanin b. Carotene c. Querctin
d. Lycopene
3. The pungency of onion is due to the presence of _____
4. Sprouting in onion is controlled by spraying _____
a. IAA b. Cytokinin c. Gibberllins d. Maleic hydrazide
5. The maximum viability of onion seed is upto _____ months
a. 8 b. 14 c. 16 d. 24

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR GARLIC

Garlic (*Allium sativum*) is one of the important bulb crops grown and used as a spice or condiment throughout India. It is also important foreign exchange earner for India. It is consumed by almost all people who take onion. Garlic has higher nutritive value than other bulb crops. It is rich in proteins, phosphorous, potassium, calcium, magnesium and carbohydrates. Ascorbic acid content is very high in green garlic.



Nutritive composition of fresh by peeled garlic cloves and dehydrated garlic powder is as follows:

Nutritive Value of Garlic

Particular	Fresh peeled garlic cloves	Dehydrated garlic powder
Moisture (%)	62.80	5.20
Protein (%)	6.30	17.50
Fat (%)	0.10	0.60
Mineral matter (%)	1.00	3.20
Fibre (%)	0.80	1.90
Carbohydrates (%)	29.00	71.40

Energy K. Cal	145.00	--
Calcium (%)	0.03	0.10
Phosphorus (%)	0.30	0.42
Potassium (%)	--	0.70
Magnesium (mg/100 g)	71.00	--
Iron (%)	0.001	0.004
Niacin (%)	--	0.70
Sodium (%)	--	0.01
Copper (mg/100 g)	0.63	--
Manganese (mg/100 g)	0.86	--
Zinc (mg/100 g)	1.93	--
Chromium (mg/100 g)	0.02	--
Vitamin A (IU)	0.40	175.00
Nicotinic acid (mg/100 g)	0.40	--
Vitamin C (mg/100 g)	13.00	12.00
Vitamin B (mg/100 g)	16.00	0.68
Riboflavin B2 (mg/100 g)	0.23	0.08
Thiamin (mg/100 g)	0.06	--

Healthy garlic bulbs contain allicin, colourless, odourless and water-soluble amino acids. On crushing the garlic bulbs the enzyme allinase breaks down into allin to produce allicin of which the principal ingredient is odoriferous diallyl disulphide. Garlic contains about 0.1% volatile oil. The chief constituents of oil are diallyl disulfide (60%), diallyl trisulfide (20%), allyl propyl disulfide (6%), a small quantity of diethyl disulfide and probably diallyle polysulfide. Diallyle disulfide possesses the true garlic odour. Garlic has been cultivated for thousands of years. It is the most ancient cultivated vegetables giving pungency of the genus *Allium*. Original abode of garlic is said to be Central Asia and Southern Europe especially Mediterranean region. Some

authorities consider that *Allium longicuspis* Regael, which is endemic to Central Asia, is the wild ancestor and spread in ancient times to Mediterranean region. It is known in Egypt in Predynastic times, before 3000BC and also to ancient Greeks and Romans. It has long been grown in India and China. Garlic was carried to the Western hemisphere by the Spanish, Portuguese and French. Garlic was not liked by Romans due to strong odour. It was used in England as early as first half of the 16th century. The early domestication of garlic took quite different turn from that of seed propagated leek and onion. Garlic became exclusively vegetatively propagated by cloves or bulbils. Some cultivars are reported to produce flowers but there is no seed setting. Garlic cultivars differ in maturity, bulb size, clove, clove size and number, scale colour, bolting and flowering habits.

Area, Production and Productivity

The production and productivity of garlic in India are very low compared to many other countries. Unawareness of farmers about improved varieties, climate, soil and agro-techniques, diseases and pest damaging the crops and their control measures as well as post-harvest management are though main reasons, inadequate market support is also responsible for limiting the production and productivity indirectly.

VARIETIES

Garlic varieties, Agrifound White, Yamuna Safed, Yamuna Safed 2 and Yamuna Safed 3 have been notified by the Government of India. The varieties developed by NHRDF are given below:

Agrifound White

The variety was notified by Govt. of India in 1989 vide notification no. 28(E) dated 13/4/1989. The variety was developed by mass selection from a local collection obtained from Biharsharif area in Bihar. The bulbs are compact, silvery white with creamy flesh. Bigger elongated cloves with 20-25 in numbers. Diameter 3.5 to 4.5 cm size index 12-15 cm². The variety is susceptible to purple blotch and **stemphylium** blight which are common in the northern parts. TSS 41% dry matter 42.78% and good storer. The yield is 130 q/ha. It is recommended for cultivation in the areas where there is not much problem of purple blotch or **stemphylium** blight in rabi season.

YAMUNA SAFED (G-1)



This variety was notified by Govt. of India in the year 1991 vide notification no.527 (E) dated 16/8/1989. It was developed by mass selection from a local collection obtained from Delhi (Azadpur) market. The bulbs are compact, silvery white skin with creamy flesh. Diameter 4.0 cm to 4.5 cm. Sickle shaped cloves, 25-30 in number, size index of bulb 12-15 cm², diameter of cloves 0.8 to 1.00 cm. The variety is tolerant to insect pests and diseases like purple blotch, stemphylium blight and onion thrips. TSS 38%, dry matter 39.5% and good storer. Yield 150-175 q/ha. It is recommended for cultivation all over the country.

YAMUNA SAFED-2 (G-50)

The variety was notified by Govt. of India in the year 1996 vide notification no.115 (E) dated 10/2/1996. It was developed by mass selection from a local collection obtained from Karnal area in Haryana. The bulbs are compact attractive white creamy flesh, bulb diameter 3.5-4.0 cm, size index 11-12 cm², number of cloves 35-40, diameter 0.75 - 1.4 cm. Clove size index 1.75-2.5 cm², 10 bulb weight 160-



240 g, TSS 38-40%, dry matter 40-41%. Average yield 150-200 q/ha. The variety is recommended for Northern India.

YAMUNA SAFED-3 (G-282)

The variety has done very well in Northern parts and also in Central parts of India. It was developed by mass selection technique from a local collection obtained from Dindigul (TN) in 1990. The leaves are wider than other varieties. Bulbs are creamy white and bigger sized (5-6cm dia). Size index 27-29cm², diameter of cloves 1.2-1.5 cm. 15-16 number of cloves per bulb TSS 38.42%, dry matter 39-43%, medium storer. Average yield 175-200 q/ha. The variety is suitable for export. The variety was notified in the year 1999 vide notification no.1092 (E) dated 26/10/1999.



AGRIFOUND PARVATI

This variety was developed in 1992 by selection from an exotic collection obtained from Hongkong market. The variety is long day type and as such is suitable for cultivation in mid and high hill of Northern states. Bulbs are of bigger size (5-6.5 cm), creamy white colour with pinkish tinge. Size index 16-72 cm², diameter of cloves 1.5 to 1.8 cm, 10-16 cloves in number tolerant to common disease. Average yield 175-225 q/ha, medium storer. Suitable for export.

YAMUNA SAFED-4 (G-323)

The variety has done very well in Zone VI. It was developed by mass selection technique from a local collection obtained from Jaunpur, Uttar Pradesh in 1988. Leaf wide, Bulb- compact, attractive creamy white colour, creamy flesh, bulb diameter 4-5 cm, size index 14-16 cm², no. of cloves 18-23 per bulb, diameter of cloves 0.75-1.0 cm, cloves size index 1.8-2.0 cm², Matures in 165-175 days.



Yield 200-250 q/ha. Storage quality is better than Yamuna Safed-3. Suitable for exports. The variety was notified by Government of India in 2006 vide notification no. S.O. 597(E) dated April 25,2006.

MEDICINAL VALUE

Garlic is one of the important bulb crops grown and used as a spice or a condiment throughout India. According to the Unani and Ayurvedic systems as practised in India, garlic is carminative and is a gastric stimulant and thus help in digestion and absorption of food. Allicin present in aqueous extract of garlic reduces cholesterol concentration in human blood. The inhalation of garlic oil or garlic juice has generally been recommended by doctors in case of pulmonary tuberculosis, rheumatism, sterility, impotency, cough and red eyes. Garlic possesses

insecticidal action. About 1% garlic extract gives protection against mosquitoes for 8 hours. Extract of garlic along with chilli and ginger has beneficial action against soil nematodes. Beneficial use of garlic extract has been found against many fungi.

AGRO TECHNIQUES

Garlic is frost hardy plant requiring cool and moist period during growth and relatively dry period during maturity of bulbs. Bulbing takes place during longer days and at high temperature, exposure to low temperature subsequent to bulb formation, favours the process. The critical day length for bulbing of 12 hrs. along with, temperature also affects bulbing. Exposures of dormant cloves or young plants to temperature of around 20°C or lower depending upon varieties for 1-2 months hasten subsequent bulbing.

SOIL

Garlic can be grown on a variety of soils but it thrives better on fertile, well-drained loam soils. The pH of soil between 6 and 7 is suitable for good crop. Highly alkaline and saline soils are not suitable for garlic cultivation.

PLANTING

The time of planting differs from region-to-region. It is planted from August to October in Madhya Pradesh, Maharashtra, Karnataka and Andhra Pradesh, and from September to November in Northern plains of India. In Gujarat, planting is done during October-November. Proper season for planting in higher hills in Northern part is March-April. It can also be, however, planted during September-October. In West Bengal and Orissa, October-November is best time for planting.

Cloves of 8-10 mm diameter since give increased yield of better quality, care should be taken to select bigger cloves from outer side of bulbs. About 500 kg cloves of 8-10 mm diameter are required to plant one hectare.



MANURES AND FERTILIZERS

Garlic responds very well to organic manures. For a normal soil 50 tonnes of farmyard manure, 100 kg N, 50 kg P and 50 kg K/ha through chemical fertilizer has been recommended. Micronutrients also increase its yield potential.

IRRIGATION

In general, garlic needs irrigation at 8 days intervals during vegetative growth and 10-15 days during maturation. As the crop matures (when the tops first begin to break over or become dry), stop irrigation to allow field to dry out first. Continued irrigation as the crop matures causes the roots and bulb scales to rot. This discolours the bulbs and exposes outer cloves and decreases the market value of bulbs. Irrigation after long spell of drought results in splitting of bulbs. Excessive irrigation results in sprouting.

INTERCULTURE

First weeding is done one month after planting and second one month after first weeding. Hoeing the crop just before the formation of bulbs (about two-and-a-half months after sowing) helps in setting of bigger sized well filled bulbs. Pendimethalin @ 3.5 litres or Goal @ 0.25 kg/ha + 1 hand-weeding gives good control of broad leaf weeds.

HARVESTING AND CURING

Garlic becomes ready for harvesting when its tops turn yellowish or brownish and show signs of drying up and bend over. G 282 is early-maturing cultivar. Harvesting at the stage when tops have fallen over gives good quality bulbs. Bulbs are taken out along with tops and windrowed gathering several rows in each row for curing.

YIELD

The yields of bulbs vary from 100 to 200q/ha depending upon variety and regions.

SEED PRODUCTION

Garlic is propagated by cloves. Well-grown compact bulbs of uniform shape and size are selected. The cloves having 8-10 cm size are used for planting. The planting method and other operations followed for production of seed are the same as for bulbs production.

POST- HARVEST MANAGEMENT

Many operations are performed for getting mature and quality bulbs from the field to the consumer. About 15-50% losses occur if proper post-harvest management practices are not followed. These practices differ from place-to-place. Proper curing, sorting and grading, transportation and storage are essential to minimize these losses.

DRYING AND CURING

Drying and curing are very essential. Drying is done to remove excess moisture from outer skin and neck to reduce storage rot, while curing is an additional process of drying to remove the excess moisture and to allow the colour development and help the bulbs to become compact and go into dormant stage. It is done for about a week in the field for drying. The method and period of curing vary depending on weather at the time of harvesting. Bulbs are covered along with their tops to avoid damage to bulbs from sun. These are also cured for 7-10 days in shade either with tops or after curing the tops by leaving 2.5 cm above the bulbs and removing the roots. Harvesting at 100% neck fall and curing by windrow method have been recommended. The curing in field till foliage turns yellow should be done. Artificial curing can be done by passing hot air at 27.35°C through the curing room. It takes about 48 hours for complete curing process if humidity is between 60 - 75%.

SORTING AND GRADING

Garlic bulbs after curing are run over a grader or graded manually before their storage or marketing. The thick-necked, splitted, injured, and diseased or bulbs with hollow cloves are sorted out. Size grading is done after sorting. It is very much necessary for getting better price and to minimize losses on account of drying and decay. Government of India has prescribed certain grade designations for different qualities of garlic for export. The grade designations and definition of different qualities of garlic have been prescribed.

PACKAGING

In India, garlic bulbs are packed in open mesh jute bags for domestic use. It is packed in bags of 90 and 40 kg capacity each in Andhra Pradesh, Karnataka and other garlic, growing states respectively. As per the garlic grading and packing rules, 18 and 25 kg packing are done in perforated 10 ply corrugated cardboard boxes for export. Nylon-netted bags used for packing and further storage cause minimum losses in storage. In foreign countries, plastic-wooven bags are very commonly used. These have good strength and are also attractive. Since garlic needs less ventilation compared to onion, there is a need to develop suitable packaging to reduce drying loss.

STORAGE

Thoroughly cured garlic bulbs are stored well in ordinary well-ventilated rooms. Garlic with dried leaves can be stored by hanging in well-ventilated rooms. This is, however, not possible on commercial scale because space requirement is more. Storage without tops in nylon-netted bags give better performance at Nasik and Karnal as such the same has been recommended for storage to minimize loss. In Jamangar area (Gujarat), some pockets of Indore

and Mandsaur, Madhya Pradesh and Manipuri and Etah district of Uttar Pradesh, bulbs are stored for 6-8 months. Since garlic stores well for market under a wide range of temperature, controlled conditioned (low temperature) storage are not necessary. Cloves sprout quickly at 4.4°C and prolonged storage in this temperature range should be avoided. Storage at 0.5°C is satisfactory, but high humidities often accompany low temperature storage. Garlic stored at humidity higher than 70% at any temperature develop mould and start rotting. Cold storage of garlic is possible at 32-36°F and 60-70% relative humidity. The storage loss of 12.5% is recorded in garlic stored at 1-5°C and 75% relative humidity compared to 42.4% losses in ambient temperature. UV light treatment for 30 minutes further reduces loss to 8% in cold stores for 150 days storage.

Irradiation with 2-6 krad of cobalt 60 gamma rays have also been recommended for controlling sprouting in storage. The irradiation given to bulbs within 8 weeks of harvesting (before sprout initiation) can inhibit sprouting effectively, reduce weight loss and can prolong storage life for about one year. Doses higher than 10 Kr reduce diallyl disulfide content which gives typical garlic flavour. Storage life of garlic is prolonged and loss in eight is also reduced by spraying 3000 ppm MH 3 weeks before harvesting. Yamuna Safed (G 1), Yamuna Safed-2 (G 50) and G 323 are better storer. Pre-harvest spraying of 0.1% carbendazim and disinfection of premises for handling and storage of garlic also reduce post-harvest losses particularly decay loss. Phosphorus and potassium application reduce weight loss in garlic storage while nitrogen application increases it.

PLANT PROTECTION

Garlic is attacked by many diseases and insects pests. Therefore garlic growers need to know the details of symptoms of diseases and insect pests attacking garlic and their control measures for getting healthy crop. Diseases and insects pests, and their control measures attacking garlic crop are described as under:

DISEASES

PURPLE BLOTCH

Purple blotch (*Alternaria porri*) appears on leaves as small whitish sunken lesions with purple centres that rapidly enlarge. The leaves fall over gradually. Spraying of Mancozeb @ 2.5 g/litre of water at 15 days intervals gives good control.

STEMPHYLIUM BLIGHT

Stemphylium blight (*Stemphylium vesicarium*) appears as small, yellow to orange flecks or streaks on leaf. These soon develop into elongated, spindle-shaped to ovate elongate, diffused spots, often reaching the leaf tips. They usually turn gray at the centre, brown to dark

olive brown with the development of conidiophores and conidia of the pathogen. The spots frequently coalesce into extended patches blighting the leaves and gradually the entire foliage.

CERCOSPORA LEAF BLIGHT

Caused by *Cercospora duddiae*, this disease appears on leaves as small, ash-coloured and irregular shaped spots scattered on leaf lamina. The spots coalesce gradually and results in blighting of foliage. Spraying of ziram or captan @ 2.0 g/litre of water or copper oxychloride @ 3.0 g/litre of water at fortnightly intervals gives good control.

POWDERY MILDEW

Powdery mildew is caused by *Leveillula taurica*. Distinct pale-yellow patches of variable size on abaxial surface of leaf associated with powdery mass are its main characteristics. Sulphur fungicides @ 2.0 g/ litre of water if sprayed at regular intervals of 15 days after disease appearance gives good control.

MOSAIC DISEASE

Garlic plants infected with mosaic virus show typical symptoms of chlorotic mottling and strips on first emerging leaf followed by pale-yellow broken stripes, resulting in typical mosaic pattern on matured leaves. Yellowish dots on leaves, whitish leaf margin or twisting of leaves are also recorded on a few cultivars. Generally symptoms are mild on younger leaves than on matured leaves. Bulbs harvested from mosaic affected plants after maturity remains smaller in size and cloves are fewer in number. Since virus is transmitted through aphids, spraying of monocrotophos @ 0.5 ml/litre of water or methyl demeton @ 0.75 ml/litre of water is useful.

INSECT PESTS

THRIPS

Thrips (*Thrips tabaci*) are perhaps the most important insect pests attacking garlic. They are most common during warm weather. They feed on leaf surfaces, causing them to whiten or silver. They are slender about 1/25" long usually hide in angles of leaves. Spraying of Malathion @ 1 ml/ litre or methyl demeton @ 0.75 ml/ litre of water gives good control if sprayed at frequent intervals. Four sprays of fluvalinate (0.04%) at fortnightly interval at Karnal and malathion (0.1%) at Nasik gave best performance in controlling thrips. Phorate @ 1 kg ai/ha at planting and 30 days after planting controls thrips effectively.

STEM AND BULB NEMATODE

Caused by *Ditylenchus dipsaci*, it is a tiny worm almost invisible to the naked eye which invades the tissues of garlic, and can seriously reduce the yield. The infestation causes the basal portion of mature plants to swell and become spongy and frequently broken by

longitudinal splits. The tissue rots, the leaves and stems become rotten and twisted and the plant is stunted. In severely infested plants, basal plants may be so rotted that it pulls away when the plant is lifted, leaving the roots in the ground. The nematodes are, however, not common in garlic in India.

Pre-planting soil fumigation with dichloro-propene-dichloropropane mixture @ 500 kg/ha is recommended. Ethylene dibromide and dibromochloropropane (Nemagon) should not be used as these leave residues in soil.

MITES

The eriophyid mite, *Aceria tulipae*, a common pest of garlic is so small that its infestations are frequently over-looked. Young garlic plants injured by mites usually have destroyed and twisted leaves with conspicuous yellow or light green streaking. The leaves may not emerge readily from the cloves and leaf blades separate poorly after emergence. Bulbs stored for long period may be severely attacked by mites. The cloves wither and bulbs lose their firmness.

RHIZOGLYPHUS CALLAE AND GLYCOHAQUS DOMESTICUS

These may attack on bulbs in storage. Fumigation of dry bulbs with methyl bromide after harvesting and before storage controls the mites. Application of methyl bromide @ 1kg/1000 cubic feet for 2 hours at 26°C is recommended.

PHYSIOLOGICAL DISORDERS

Sprouting of bulbs in the field is noticed sometimes towards the start of maturity stage of bulbs particularly when there are winter rains or excessive soil moisture and nitrogen supply. This disorder is, however, not of permanent nature and varies from variety-to-variety. Early-planting also causes sprouting. Splitting is also noticed sometimes in some varieties, which is due to delayed harvesting or irrigation after long spell of drought. For past few years rubberification problem is noticed in Rajkot area and also Nilgiri hills of Tamil Nadu. It is increasing day-by-day. The actual cause for the disorder was since not identified, a trial was planned in collaboration with TNAU at HRS, Ooty, during 1995-96. The effects of insecticides, fungicides, micronutrients and growth regulator were studied. It was observed that rubberification was totally controlled by application of micronutrients i.e. zinc sulphate and ammonium molybdate. It was also controlled by neem cake insecticides and growth regulator like GA.

Further studies are required to eliminate this problem in different areas as the incidence is noticed variably in different areas.

The aerial bulbil formation is also quite common in garlic where lower temperature prevails for more periods or there is more temperature variation. It, however, does not affect much on yield or quality of bulbs and varietal variation is noticed where G-282 is seen more prone for this type of effect.

The rubberification and premature sprouting of bulbs are main physiological disorders in garlic. The reasons for these disorders are summarized as under for hill grown garlic in Tamil Nadu.

- Rubberification and premature sprouting of bulbs are noticed mostly in fields which are located in low-lying areas of watershed where there is heavy deposition of nutrients along with silt during heavy rains.
- These problems are severe in garlic fields which are more frequently irrigated than the normal requirements of garlic bulbs.
- With the application of higher levels of nitrogen, there is an increased level of pre-mature sprouting of bulbs which results in splitting and rubberification of bulbs.
- Rubberification incidence also increases when higher level of nitrogen is applied in the form of urea.
- Due to increased levels of nitrogen, in addition to the increased production of rubberized, there is an increased level of thrips incidence in leaves during the later stage of crop. The thrips lacerate leaves and cause severe damage to the crop. Through lacerated wounds by thrips, there is a severe incidence of blast disease, caused by *Botrytis allii*, when crops is 70-90 days old, which further deteriorates the quality of garlic bulbs.
- Short duration type of garlic (Mettupalayam type) is more susceptible than long duration type (Singapore type).
- Premature sprouting of bulbs is more in the crop (April-August) when there is high moisture level in soil at maturity of crop due to heavy rains.
- Delayed harvest during rainy season has increased premature sprouting and splitting of bulbs.
- Wider spacing of cloves at the time of planting increases uptake of nitrogen and water by the individual plants which increases premature sprouting and rubberification of garlic bulbs.

1. Economic part of Garlic is _____
a. bulb b. root c. umbels d. cloves
2. _____ is a frost hardy bulbous perennial erect herb.

- a. Leek b. Onion c. Garlic d. Bunching onion
3. _____ is a crop that is grown only in rabi season
- a. Tomato b. Brinjal c. Onion d. Garlic
4. The pungency in garlic is due to the presence of _____
5. In garlic _____ application at inflorescence stage enhance bulblet formation

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR PEAS

Peas - (*Pisum sativum* L.) (2n = 14) - (Hindi : Matar)

Pea (*Pisum sativum* L.), the famous plant in which G.H. Mendel worked out Mendel Laws and Genetic Principles, is a noble and aristocratic vegetable. The crop is cultivated for its tender and immature pods for use as vegetable and mature dry pods for use as a pulse. In both cases, seeds are separated and used as vegetable or pulse. Peas are highly nutritive and contain high content of digestible protein (7.2 g / 100g), Carbohydrate (15.8 g), Vitamin-C (9 mg), phosphorus (139 mg) and minerals. Tender seeds are also used in soups. Canned, frozen and dehydrated peas are very common for use during off-season. Like any legume crop, pea is an integral component of sustainable agriculture due to its soil enriching and conditioning properties.



Origin

Vavilov (1926) listed different centres of origin for pea. Area comprising Central Asia, the Near East, Abyssinia and the Mediterranean is the centre of origin based on genetic diversity. Cultivated garden pea is not seen in wild state and it might have been originated from wild field pea or other related species.

Botany

Pea is a diploid with $2n=14$. Field pea with coloured flowers belong to *Pisum arvense* and the garden pea with white flowers belong to *P. sativum*. Pea is a herbaceous annual plant with tap root system. Stem is upright, slender and usually single. Leaves are pinnately compound with the rachis terminating in a single or branched tendril. There are large stipules at base of leaf. Inflorescence is a raceme arising from axils of leaves and individual flowers are

typical papilionaceous. Gynoecium is monocarpellary with ovules (up to 13) alternately attached to placenta. Style bends at right angle to ovary and stigma is sticky. Pods are straight or curved and seeds are smooth or wrinkled.



Varieties

Pea cultivars grown in different parts of the world exhibit wide variation in height of stem, branching, pod size, seeds per pod, shelling percentage, smoothness of seeds (smooth / wrinkled) etc.

The cultivars / varieties are grouped based on various characters as given below:

Basal on maturity period

- Early types – green pods will be ready for harvest by 65 days after sowing.
- Mid season types – pods will be ready for harvest by 85-90 days after sowing.
- Late main season types – pods will be ready for harvest by 110 days after sowing

Based on height of plant

- Bush or dwarf types
- Medium tall
- Tall

Usually dwarf types are early and mid season types are medium tall. Late types are tall and require support.

A brief description of improved varieties is given below:

Developing institution	Variety	Special features
IIHR, Bangalore.	Arka Ajit	Resistant to powdery mildew and rust. Yield 10t/ha in 90 days.
	UN 53-6	A snap pea where the whole pod is edible. Yield 8-9 t/ha in 90 days.
IARI, New Delhi.	Arkel*	Early season variety introduced from England Dwarf plants bearing double pods at lower nodes and single at upper nodes. Pods 8.8 cm long and sickle shaped. Suitable for fresh market and dehydration. Susceptible to collar rot at high temperature. Yield 7.5 t/ha in 50-55 days.
	Bonneville*	Mid season variety introduced from USA. Medium tall plants bearing double pods. Pods more than 9 cm long. Yield 8.5 t/ha. Seeds green and wrinkled.
	Sylvia	Introduced edible podded variety suitable for kitchen garden. Pods curved, yellowish green without parchment.
IARI, Regional Station, Katrain	Lincoln*	Early season variety introduced from France. Medium tall plants bearing double pods of 8-9 cm length and sickle shaped. Mature seeds wrinkled. First picking 85-90 days after sowing (DAS). Yield 68-10 t/ha.
IIVAR, Varanasi.	VRP 2*	Plants 50 cm tall. Pods straight and medium sized. First harvest 55-58 DAS. Yield 10 t/ha.
	Kashi Nandini* (VRP 3)	Early maturing variety developed through pedigree selection. Plants erect and dwarf. Pods long. Tolerant to leaf miner and pod borer. Yield

		6.5 t/ha with 80 % shelling percentage.
	Kashi Shakthi* (VRP 7)	Mid season variety. Plants 80 cm tall with attractive pods. Yield 7.5 t/ha.
Tamil Nadu Agricultural University.	Ooty 1	A dwarf variety with a yield of 11.9 t/ha in 90 days. Resistant to white fly.
NDAU&T, Faizabad, UP.	NDVP 8*	Mid season variety with 10 t/ha.
	NDVP 10*	Mid season variety with 10 t/ha.
Punjab Agricultural University, Ludhiana	Punjab 88*	Early season variety developed through selection from cross between Pusa 2 x Morrasis 55. Pods dark green, long (8-10 cm) and slightly curved. Days to first harvest – 100. Yield 15 t/ha with 47% shelling percentage.
	Matar Ageta 6*	Early season dwarf variety. Tolerant to high temperature. Yield 6 t/ha with 44.67% shelling percentage. Seeds smooth and green.
CSAUA&T, Kanpur.	Azad P.2* (PRS4)	Resistant to powdery. Plants tall (130-150 cm). Straight and smooth pods. Yield 12 t/ha in 90-95 days.
	Azad P-3* (PRS 4)	Early maturing variety. Pods straight, medium size. Yield 8 t/ha.
JNKV, Jabalpur.	Jawahar Matar 1* (JM 1, GL 141)	Mid season dwarf variety with big, attractive green, 8-9 cm long pods containing 8-10 sweet green ovules.
	Jawahar Matar 2	Pods dark green, big, curved with 8-10 sweet ovules, wrinkle seeded, susceptible to powdery mildew.
	Jawahar Matar-3 (Early December*)	Early season variety developed through selection from cross between T 19 x Early Badger. First picking in 50 DAS, Pods 7 cm long, light green and round oval / ovules.

	Jawahar Matar-4* (JM 4, GL 195)	Mid season variety derived from T 19 x Little Marvel. Plants 50-60 cm tall. Pods 7 cm long, green. Mature seeds green and wrinkled.
	Jawahar Matar 15	Resistant to powdery mildew and Fusarium wilt. Plants dwarf. Yield 13 t/ha.
	Jawahar Matar 54	Powdery mildew resistant variety with big incurved pods enclosing 8-9 big wrinkled seeds. Yield 7 t/ha.
	Jawahar Peas 83*	Mid season powdery mildew resistant variety developed through double cross (Arkel x JP 829) x (46 C x JP 501). Plants dwarf. Pods big and curved with 8 green and sweet ovules. Yield 12-13 t/ha.
	Harbhajan	Early variety resembling to field pea. Susceptible to powdery mildew. Av. Yield 3 t/ha.
GBPUA&T Pantnagar	PM 2*	Early variety developed through pedigree selection from cross between. Early Badger x Pant Uphar. Pods smaller than Arkel. Yield 10 t/ha.
	Pant Uphar* (IP3)	Medium maturity, ready for harvest by 70-80 DAS. Flowers white, Pods round. Seeds wrinkled, Susceptible to powdery mildew. Resistant to stem fly. Yield 10 t/ha.
	Pant Sabji Matar 3	Early season variety with long curved pods with 8-9 ovules. Picking starts 60-75 DAS. Yield 9 t/ha.
HAU, Hisar.	Hisar Harit* (PH 1)	Developed through selection from cross between Bonneville x P 23. Pods large, sickle shaped and single or double. Yield 9 t/ha.
VPKAS, Almora	VL Matar 3*	Plants determinate. White flowers, straight and double podded. Length – 6.8 cm. First picking is 100 DAS. Yield 10 t/ha.

	VL Agethi Matar 7* (VL 7)	Early season dwarf variety. First picking in 120-125 DAS. Pods 8 cm long, light green, slightly curved. Seeds wrinkled. Yield 23-25 t/ha. with 42% shelling.
	VL 8*	Mid season variety with 10 t/ha.
	Vivek* (VL Matar 6)	Medium mature variety with straight, 6-7 cm long pods. Seeds semi wrinkled. Moderately tolerant to cold and moisture stress. Yield 11 t/ha.
TNAU, Coimbatore	Ooty-1	Dwarf variety having a yield potential of 11.9 t/ha in 90 days. Resistant to white fly.

* Varieties released / identified by AICRP (Vegetables)

In addition to the above improved varieties, cultivars like Asauji, Alaska, Meteor, Early Badger etc. are also very popular among farmers.

Climate

Pea is typically a cool season crop and thrives well in cool weather. Optimum temperature for seed germination is 22°C. Even though seeds germinate at 5°C, speed of germination is less. At higher temperature, decay of seedlings is more. Early stage of crop is tolerant to frost. But flowering and fruit development are adversely affected by frost. Optimum monthly mean temperature for growth of plants is 10-18.3°C. As temperature increases the maturity is hastened and yield is reduced. Quality of pods produced is also low at high temperature due to conversion of sugars to hemicellulose and starch.

Soil

Crop prefers well drained, loose and friable loamy soil for early crop and clayey soil for high yield. Ideal pH is 6.0-7.5 and it grows under alkaline soil. If soil is acidic, liming is recommended.

Season

In plains of North India, pea is sown from beginning of October to middle of November. Yield is drastically reduced when crop is sown after 4th December (Chaubey, 1977). Crop sown in September will be susceptible to wilt disease. In hills, pea is sown in March for summer crop and in May for autumn crop.

Sowing and seed rate

Soil is prepared to a fine tilth by disc ploughing followed by one or two harrowing. Seeds are sown in flat or raised beds by broadcasting or by dibbling at 2.5-5.0 cm depth. Early varieties are sown at a closer spacing of 30 x 5-10 cm and the seed rates is 100-120 kg/ha. Mid

season and late varieties are sown at wider spacing of 45 x 10 cm. Late varieties are sown on either edge of raised beds which are 120-150 cm wide with furrows in between. Seed rate for late varieties is 80-90 kg/ha. Overnight soaking of seeds in water or GA 3 (10 ppm) improves germination.

Manure and fertilizers

A crop yielding 4-5 tonnes of green peas removes 55 kg N, 20 kg P₂O₅ and 40 kg K₂O. High doses of N have adverse effect on nodule formation and N fixation. N at 25 kg/ha is sufficient to stimulate early growth of pea. Phosphatic fertilizer increases yield and quality by increasing N fixation and nodule formation. Potassium fertilizers also increase N fixation ability of plants and yield. In addition to 10 tonnes of farmyard manure, a fertilizer dose of 25 kg N, 70 kg P₂O₅ and 50 kg K₂O are recommended for one hectare and the entire dose is drilled at the time of sowing seeds. If fertilizers are coming in contact with seeds, there will be severe injury to seeds. Fertilizer should be applied in bands at 7-8 cm away and 2.5 cm deeper from seeds. Application of sodium molybdate @ 40 kg/ha either as pre or post emergence spray is reported to increase yield and collar rot resistance in peas.

Application of fertilizers in Tamilnadu

Apply FYM at 20 t/ha and 60 kg N, 80 kg P and 70 kg K/ha as basal and 60 kg N/ha 30 days after sowing.

Irrigation

Pea, like any legume vegetable, is sensitive to drought and excessive irrigation. Excessive irrigation immediately after sowing results in poor germination due to hard crust formation. Excessive irrigation in earlier stages increases vegetative growth. Light irrigations at 10-15 days intervals is given for pea. Flowering, fruit set and grain filling periods are critical stages and care should be taken to irrigate crop at these stages. Four irrigations at pre-bloom, pod set and fruit picking stages are recommended for variety Bonneville under Bangalore conditions.

Weed control

Care should be taken to remove weeds in early stages of crop. Lasso (alachlor) @ 0.75 kg a.i. or tribunal @ 1.5 kg a.i./ha or pendemethalin 0.5 kg a.i. / ha as pre emergence spray along with one hand weeding at 25-45 days after sowing is very effective for weed control.

Inter-culture

When plants are 15 cm high, tall varieties should be stacked with wooden sticks or twigs for trailing. A single row of stakes fixed in middle of raised bed will support both rows of plants in each bed.

Earthing up and hoeing is also important operations in peas and helps in root development and growth of plants. This is usually done after weeding and fertilizer application.

Harvesting

Since tender peas with high sugar content fetch premium price in market, care should be taken to harvest pods at correct maturity. During maturity, sugar content decreases and polysaccharides and insoluble nitrogen compounds like protein increases. Calcium migrates to seed coat and becomes tougher during ripening. Toughness of seeds is determined using Tendrometer, especially for processing purposes. Peas with low tendrometer reading is offered high price.

Many workers calculated heat units to ascertain maturity and harvesting of peas. Number of degree hours above 4.4°C required to bring a variety to maturity is calculated and it varies from variety to variety.

Peas for fresh market are harvested when they are well filled and when colour changes from dark green to light green. Usually 3-4 harvests at 10 days intervals are possible. Green pod yield varies with duration of variety and is 2.5-4.0 t/ha for early varieties, 6.0-7.5 t/ha for mid season varieties and 8.0-10.0 t/ha for late varieties. Shelling percentage ranges from 35-50. Seed yield varies from 2.0 to 2.5 t/ha. Peas after harvesting are packed in gunny bags or crates. Fresh unshelled peas can be stored for two weeks at 10°C and 90-95% RH.

Pests and Diseases

Stem fly, pea aphid, leaf miner and pod borer are major pests and wilt and root-rot, powdery mildew, rust, *Ascochyta* blight and pod rot are major diseases of pea.

1. Botanical name of peas _____
2. Origin of peas _____
3. Chromosome number of peas _____
4. _____ is an example for edible poded variety of pea
5. Peas are highly rich in _____

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR FRENCH BEANS

(Syn: Snap bean, String bean, Kidney bean, Haricot bean, Fresh bean)

(*Phaseolus vulgaris* L.) (2n = 22)

(Hindi: *Vilaiti sem*)

French bean is an important cool season legume vegetable grown for its tender pods, shelled green beans and dry beans (*Rajmah beans*). In western countries, processed pod consumption is quite high. 100 g of green pods contain 1.7g protein, 4.5 g carbohydrates, 221 I.U. vitamin - A, 11 mg vitamin-C, 50 mg calcium etc. Dry beans are rich in protein.

Origin and Taxonomy

Genus *Phaseolus* originated in New World. Following four species are under cultivation in New World:

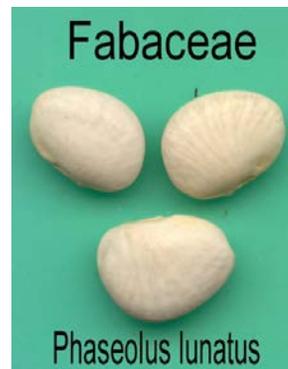
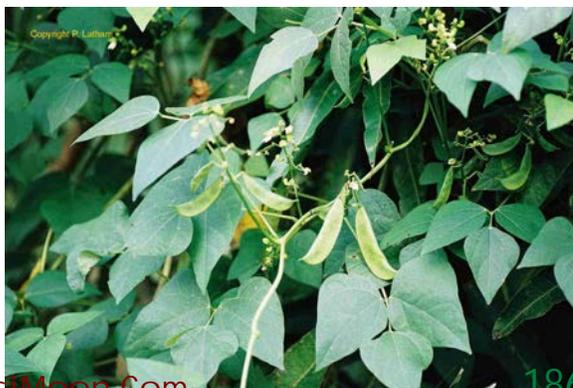
1. *Phaseolus vulgaris* – French bean
2. *P. coccineus* – Runner or Scarlet bean
3. *P. lunatus* – Lima bean, Butter bean or Madagascar bean
4. *P. acutifolius* var. *latifolius* – Tapery bean

All the given species are diploids with 2n=22 and self-pollinated except *P. coccineus*, which is cross-pollinated. French bean, the most important species under *Phaseolus*, is originated in central and South America (Kaplen, 1981).

P.vulgaris



Phaseolus coccineus





White Tepary Beans

Phaseolus acutifolius

Botany

French bean has tap root system with poor nodule formation. Leaves are trifoliate. Though a self-pollinated crop, French bean offers wide variability for plant growth (bushy / climbing), colour of pod (green / waxy coloured), cross section of pod (flat / oval / round), pliability (stringed / string less) etc.



Varieties

There are specific varieties for snap bean purpose, dry bean purpose and for processing. Processing varieties are very popular in the USA. A brief description of improved varieties is given below:

Developing institution	Variety	Special features
IIHR, Bangalore.	Arka Komal*	Introduced bushy variety from Afghanistan. Pods straight, flat, and green with large brown seeds. Good transport and keeping quality. Yield 19 t/ha and 3 t/ha seed in 65-70 days.
	Arka Subidha* (IIHR 909)	Plants bushy and photosensitive. Pods straight and oval, light green, stringless and fleshy. Yield 19 t/ha in 70 days.
IARI Regional Station, Katrain	Contender	Plants bushy with pink flowers. Pods green, round long and stringless. Tolerant to mosaic and powdery mildew. Yield 20 t/ha.
	Pusa Parvati	Developed through irradiation followed by selection from wax podded variety EC 1906. Plants bushy with pink flowers. Pod green, round long. Resistant to mosaic and powdery mildew. Yield 22-25 t/ha.
	Pusa Himalatha	Pole variety with medium sized (14 cm long) round, meaty, stringless pods with an average yield of 26 t/ha.
VPKAS, Almora	VL Boni 1*	Dwarf variety with white flowers. Pods round, light green, stringless and fleshy. First harvest 45-60 DAS. Yield 10-11 t/ha.
Tamil Nadu Agricultural University	Ooty-1	Moderately resistant to leaf spot, anthracnose and pod borer. Yield 10-11 t/ha.
	TKD1	A pole type suitable for growing in hills. Pods long, flat with low fibre. Yield 5-6 t/ha in 90-100 days.

	KKL 1 Moringa bean	A pole type suitable for growing in hills. Pods long (28 cm) with low fibre. Seeds white and flat. Yield 7 t of pods and 3 t. of grains/ha.
	YCD1	Bushy dual purpose variety suitable for <i>kharif</i> season. Pods slightly flat, 15 cm long. Seeds dark purple. Tolerant to root rot, rust, yellow mosaic and anthracnose. Yield 9.75 t. of pods or 6.3 of grains / ha in 105 days.
NDAU&T, Faizabad, UP.	NDVP 8*	Mid season variety with 10 t/ha
	NDVP 10*	Mid season variety with 10 t/ha.
CBPUA&T, Pantnagar	Pant Anupama* (UPF 191)	Plants bushy and dwarf with concentrated fruiting. Moderately resistant to bean mosaic and angular leaf spot. Yield 9 t/ha.
MPKV, Rahuri	Phule Surekha	Pods 9-10 cm long, flat, light green. Tolerant to anthracnose, yellow mosaic and wilt disease. Yield 15 t/ha.

* Varieties released / identified by AICRP (Vegetables)

In addition to the above improved varieties, cultivars like Kentucky Wonder (pole type with long, flat and stringless pods), Premier, Giant Stringless, Bountiful etc. are also very popular among farmers.

Climate

French bean is a day neutral cool season vegetable and tolerates high temperature better than peas. Optimum monthly temperature for cultivation of French bean is 15-25°C compared to 10-18°C for peas. It is sensitive to high rainfall, frost and high temperature. Pole types tolerate high rainfall better than bushy varieties

Soil

Soil requirements are same as that of pea. Ideal soil pH for growth of French bean is 5.5 – 6.0

Season

In plains of North India, French bean is sown during two seasons viz., July-September and January-February. In hills, sowing is done from March to May.

Land preparation and sowing

Land is ploughed to a fine tilth and divided into plots of convenient size. Ridges and furrows are prepared by ploughing after a basal dose application of farmyard manure. Field is irrigated once and seeds are sown under optimum moisture condition on side of ridges 2-3 days after irrigation. Spacing and seed rate vary with varieties. Early varieties are sown at a spacing of 45-60 cm x 10-15 cm and seed rate required is 80-90 kg / ha. Pole types are sown at 1.0 m apart in hills @ 3-4 plants / hill and seed rate is much less (25-30 kg/ha.).

Manure and fertilizers

French bean responds well to application of lime and fertilizers. In addition to 20-25 t. of farmyard manure, 50 kg N, 75 kg, P_2O_5 and 75 kg K_2O are recommended. Half of N along with full P and K should be applied as basal dose at the time of making ridges and furrows or one or two weeks after germination. Apply remaining dose of N, one month after first application.

Application of fertilizers in Tamil Nadu

Apply FYM 25 t/ha at the last ploughing. N 90 kg and P 125 kg/ha should be applied on one side of the ridges. For rainfed conditions of Shevaroy hills, apply as a basal dose of 62.5 kg/ha of Phosphorous as super phosphate and with another half of 62.5 kg/ha Phosphorous as FYM enriched super phosphate.

Intercultural operations

French bean is a shallow rooted crop and only light inter-cultural operations are practiced. During early stages of crop, weeding followed by fertilizer application and earthing up can be synchronized. A pre-sowing application of Fluchloralin @ 2.1 /ha checks weed growth for 20-25 days.

Water stress influences yield of French bean and crop is most sensitive at flowering and fruiting stages. 6-7 irrigations are required during growing season.

Staking is an important operation for pole types and bamboo sticks or any locally available materials should be erected when plants start vining. Individual vertical stakes and horizontal canes at 40 cm distance are erected for encouraging growth and spread of plants.

Application of plant growth regulators like PCPA (2 ppm) and NAA (5-25 ppm) has favourable effect on fruit set and yield.

Harvesting and yield

Pods are harvested at full grown stage but immature and tender. Pods are ready for harvest 7-12 days after flowering depending on varieties. In bush varieties, 2-3 harvests and in pole types 3-5 harvests are made. Quality of beans varies with harvests and best quality fruits

are obtained in initial harvests compared to later harvests. Loss of crispness during storage and in last harvest is attributed to loss of water and increase in water soluble pectin.

Seed weight is a major indicator of green bean harvest maturity. Yield of tender pods varies from 8-10 t/ha in bush varieties and 12-15 t/ha in pole types. Dry beans are harvested when majority of pods are fully ripe and colour turns yellow. Seed yield varies from 1250 to 1500 kg / ha.

Pests and diseases

Crop is affected by pests like stem fly, thrips, mites, bean beetle, bean weevil, aphids etc. Yellow mosaic, anthracnose, powdery mildew, rust, root rot and wilt and leaf spot are common diseases affecting French bean.

LIMA BEAN

(Syn: Double Bean) (*Phaseolus lunatus* L.) (2n = 22)

(Hindi : *Lobia*)



Dixie Speckled Butter Peas - *Phaseolus lunatus*



Christmas Lima Beans - *Phaseolus lunatus*



Hopi Yellow Lima Beans - "Sikyahatiko" - *Phaseolus lunatus*

Lima bean is a cool season vegetable requiring dry and cool climate with an average rainfall of 50-62.5 cm. Compared to other legumes, it is a long duration crop and is retained in field for 9 months. Lima bean is an important crop in Maharashtra.

Cultivation practices

In Maharashtra, crop is grown after sugarcane. After harvest of sugarcane, land is ploughed to fine tilth and seeds are sown in hills @ 2-3 seeds / hill at a distance of 180 x 120 cm during July. Seed rate required is 8-10 kg/ha.

When plants start vining, they are trained to trellis made with vertical bamboo poles with horizontals tied at a distance of 45 cm. Height of trellis is up to 150 cm and they are usually erected along direction of wind.

Lima bean responds well to manuring and fertilizer application. Irrigation and other timely inter-cultural operations required are same as that of other legume vegetables.

Harvesting

Plants start flowering 80-85 days after sowing and pod formation takes place one month later. First harvest is obtained four months after sowing, i.e., by November and it extends up to March. On an average, 12-14 harvests are possible at an interval of 15-16 days. Yield varies from 8-12 t/ha.

BROAD BEAN

(*Vicia faba* L.) (2n = 12, 14)

(Hindi: *Bakla*)

Broad bean, also known as faba bean or horse bean, is the only bean, sown in autumn and is grown as a winter crop in high elevations. It is a hardy plant and withstands low temperature as low as 4°C. The crop is widely cultivated in Latin America and is grown in India in a limited scale in northern states having low temperature. It tolerates salinity to a certain

extent. Broad bean is sused as tender bean, green shelled bean, and dry bean and as cattle feed.

Plants are more or less vine like and grow erect without branching to a height of 60-125 cm. Stem is square in cross section and flowers are pollinated by insects. Pods are borne in upright clusters of 5 or more in axils of leaves. Green pods grow parallel to stem. It is about 15 cm long and 2 cm wide with slightly round in cross section with 5 or more beans.



Varieties

Masterpiece White Long Pod, Masterpiece Green Long Pod, Imperial White Windsor and Imperial Green Windsor are some of the introduced varieties. Jawahar Selection 73-31 is an improved selection from Madhya Pradesh. A few selections made at Bihar are BR-1 (black seeded) and BR-2 (yellow seeded). M/s.Suttan Seeds developed a dwarf type 'Suttan White Seeded'.

Cultivation

Broad bean requires low temperature for its cultivation. Crop is tolerant to water stress due to protein accumulation. It tolerates water-logging and salinity. Seeds @ 70-100 kg/ha are sown in shallow channels spaced at 75 cm. In each channel, seeds are sown in double rows at spacing of 25 cm. Cultivation practices are similar to that of pole type pea. Plants are stacked with wooden sticks.

Tender pods are harvested at green shell stage, 3-4 months after sowing. Under favourable conditions, crop yield is 7-10 t. of green pods and 1-1.2 t. of green beans/ha.

Application of fertilizers in Tamilnadu

Apply 25 of FYM and 50 kg P and 25 kg K/ha as basal dose. 25 kg N and 25 kg of K/ha are applied between 20-25 days after sowing and application of remaining 25 kg of N is done between 40-45 days.



Anasazi Beans(*Phaseolus vulgaris*)



Bolita Beans (*Phaseolus vulgaris*)



Purple Beans (*Phaseolus vulgaris*)



Hopi Black Pinto Beans (*Phaseolus vulgaris*)



Little White Ice Beans (*Phaseolus vulgaris*)

1. Origin of French bean is _____.
2. In India, the largest area under temperate leguminous vegetable is _____.

a. Peas

b. French bean

c. Snap bean

d. Butter bean

3. For seed germination the temperature required for lima bean is _____.

4. Origin of broad bean is _____.

5. Lima bean can be grown at an elevation of _____ MSL.

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR CLUSTER BEAN

(*Cyamopsis tetragonoloba* L.) (2n = 14)

(Hindi: Guar)

Cluster bean is a drought tolerant warm season crop grown for its tender fruits for use as vegetable. Fruits are rich in food value and each 100 g contains 10.8 g carbohydrate, 3.2 protein, 1.4 g minerals, 316 IU vitamin-A and 47 mg vitamin-C. It is also used as a nutritious fodder for livestock. Mucilaginous seed flour is used for making guar gum (galactomannan) utilized in textile, paper, cosmetic and oil industries throughout the world.

Origin and botany

Diverse opinion on exact origin of cluster bean is still prevailing. Dry regions of West Africa as well as India are treated as centres of origin of cluster bean by various workers. African species, *Cyamopsis senegalensis* is the ancestor of cluster bean.



Botany

Cluster bean is an erect annual, growing to a height of up to 3 m with stiff erect branches. Stem is angled and leaves are trifoliate. Small white or purple flowers are borne on axillary racemes. Fruits are compressed, erect and 4-10 cm long. Each fruit has 5 to 12 white to grey or black coloured seeds.

Varieties

Varieties grown in India differ in height of plants. Cultivars grown in South India are vegetable types while those in North-West India are grown for seeds. There are giant and dwarf types in cluster bean. Vegetable types are mostly dwarf types with smooth appearance. Fodder types are mostly hairy.

Some of the improved varieties developed at IARI, New Delhi are :

- **Pusa Domausami** - Suitable for rainy season. Late and branching variety with 80 days to first picking. Pods smooth, light green and 10-13 cm long.
- **Pusa Sadabahar** – Suitable for summer and rainy season, non branching type. Pods green and 12-13 cm long.
- **Pusa Navbahar** – Non branching variety with pod quality of Pusa Mausmi. Developed by crossing Pusa Domausami and Pusa Sadabahar.

Sharad Bahar is a branching variety developed at NBPGR. It produces 12-14 branches with an average yield of 133 pods / plant.

Climate and soil

This hardy and drought tolerant crop comes up well during summer and rainy season in well-drained sandy loam. It cannot tolerate shade and prefers long day condition for vegetative growth and short day condition for flowering.

Land preparation and sowing

Main rainy season crop is sown during June-July and extended up to September-October. Summer crop is raised by sowing during February-March. Field is prepared to a fine tilth by ploughing and harrowing. Seeds are either broadcasted or dibbled behind country plough at a distance of 25-30 cm. Seeds are also dibbled at specified spacing of 45-60 cm x 15 cm. Seed requirement is 25-30 kg/ha.

Manure and fertilizers

Though a hardy legume, cluster bean responds to fertilizer application. In addition to 25 t. of farmyard manure, a fertilizer dose of 50:60:60 kg NPK / ha is recommended. Half N, full P and K are applied as basal dose and remaining N, 25-30 days after.

Application of fertilizers in Tamil Nadu

Apply FYM 25 t, Azospirillum 2 kg and *Phosphobacteria* 2 kg / ha, N 25, P 50 and K 25 kg/ha as basal and 25 kg N/ha 30 days after sowing.

Intercultural

The field is kept free of weeds during initial stages. Though a hardy crop, irrigation increases yield. Irrigation at flowering and fruiting stages is the most critical. For getting high yield in vegetable types, irrigation may be done at 7-10 days interval.

Stacking is also necessary to avoid lodging in tall varieties.

Harvesting and yield

Harvesting starts 40 days after sowing and pods are harvested at tender stage. A vegetable yield of 5-8 tonnes and seed yield of 0.6 to 1.0 t/ha are expected within crop duration of 120 days.

Pests and Diseases

Most of pests affecting other legume crops also attack cluster bean. Fusarium wilt, bacterial blight, powdery mildew and anthracnose are major diseases affecting the crop.

1. Among the peas and beans _____ is a hardy crop.
a. Peas b. Cluster bean c. Lablab beans d. French bean
2. Gaur gum is a product of _____.
3. Cluster bean is a _____ rooted crop.
4. Spraying of _____ @ 2000 ppm would increase the yield of cluster bean.
a. GA b. CCC c. IAA d. NAA
5. Other name for cluster bean is _____.

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR HYACINTH BEAN

(Syn: Indian bean) *Lablab purpureus* L.

(Syn: *Dolichos lablab*, *D. purpureus*) (2n = 22, 24)

(Hindi: *Sem*)

Hyacinth bean, also known as field bean or dolichos bean, is grown throughout tropical regions of Asia, Africa and America. In India, it is grown as a field crop in Tamil Nadu., Andhra Pradesh, Karnataka, Madhya Pradesh and Maharashtra. In Kerala, the photo sensitive pole types are grown in homesteads by trailing to bower for its tender fruits which are used as cooked vegetable. Dry beans are also used in various vegetable preparations; 100 g of green pods contain 6.7 g carbohydrates, 3.8g carbohydrates, 3.8 proteins, 1.8 g fibre, 210 mg calcium, 68.0 mg phosphorus, 1.7 mg iron etc.

Origin, taxonomy and botany

Hyacinth bean originated in India. Two cultivated type's viz., *Lablab purpureosus* var. *typicus* and *L. purpureus* var. *lignosus* were reported by Sivasankar et al. (1971). Former is vegetable type cultivated for its soft and edible pods and latter is the field bean cultivated for dry seeds as pulse. Both varieties are cross compatible.

L. purpureus var *typicus*



L. purpureus var *lignosus*



Hyacinth bean is a perennial herbaceous plant often grown as an annual. Pole types are photosensitive. Leaves are alternate and trifoliate. Flowers are borne in axillary racemes and are typically papilionaceous and are self-pollinated.

Flowering takes place under short day periods irrespective of planting time. Anthesis occurs from 9 a.m. to 5 p.m. (Pokle and Deshmukh, 1971). Anther dehiscence is from 5.00 a.m. to 2.00 p.m. Stigma is receptive on the day of anthesis.

Varieties

A brief description of the improved varieties is given :

Developing institution	Variety	Special features
IIHR, Bangalore	Arka Jay	Photo-insensitive bush variety developed by selection at F7 from Hebbal Avare 3 (Bush) x IIHR 99(Pole-recurrent parent). Pods long, light green slightly curved. Yield 1w t/ha in 75-80 days.
	Arka Vijay	Photo-insensitive bush variety developed by selection at F7 from Hebbal Avare 3(Bush) x Pusa Early Prolific (Pole). Pods short, dark green with characteristic aroma. Yield 12 t/ha in 75-80 days.
UAS, Bangalore.	Hebbal Avare-1	Bush and photo insensitive variety. Pods small and soft. Yield 0.8 t/ha in 90-100 days.
	Hebbal Avare-3	Bush and photo insensitive variety. Flowers white. Pods green, 2-3 seeded. Seeds brown, round and small. Yield 8-10 t/ha in 90-100 days.
	Hebbal Avare-4	Bush and photo insensitive variety. Pods soft and harvested in 5 pickings. Yield 6 t/ha.
IARI, New Delhi.	Pusa Early Prolific	Pole type. Pods flat, green, narrow, cycle shaped. Pod length 9.3 cm, width 1.5 cm, weight 3.5 g. Yield 14 t/ha in 200-215 days.
	Pusa Sem 2	Pole type. Pods semi-flat, dark green, fleshy and stringless. Pod length 15-17 cm. Yield 13-22 t/ha in 200-215 days. Tolerant to anthracnose, yellow bean mosaic virus, aphids, pod borers and frost.
	Pusa Sem 3	Pole type. Pods flat, green, fleshy and stringless. Pod length 15 cm. Yield 17-27 t/ha in 200-215 days. Tolerant to anthracnose,

		yellow bean mosaic virus, aphids, pod borers and frost.
KKVP, Dapoli	Wal Konkan 1	Bushy, photo-insensitive, resistant to yellow mosaic virus. Yield 9-10 t/ha in 110-115 days.
	Konkan Bhushan (DPLD 1)	Bushy, photo-insensitive, resistant to yellow mosaic virus. Yield 9-10 t/ha in 110-115 days.
Tamil Nadu Agricultural University	CO.1	Pole type. Pods green, fleshy with slow fibre development. Pod weight 9.7 g. Yield 18-20 t/ha in 160-180 days.
	CO.2	Pole type. Pods, flat, green with purple margin. Pod length 9.3 cm, width 2.1 cm, weight 6.17 g. Yield 11.8 t/ha in 210-220 days.
	CO.3	Pole type. Pods fleshy, green with purple tinge. Pod length 10.6 cm, width 4.8 cm, weight 11.77 g. Seeds black. Yield 10.0 t/ha in 230 days.
	CO.4	Pole type. Pods deep purple throughout and fleshy. Pod length 10.2 cm, width 3.3 cm, weight 7.43 g. Seeds black. Yield 13.5 t/ha in 215-220 days.
	CO.5	Pole type. Pods long, narrow, light green to white in colour, tubular, curved with serrated margin. Pod length 13.4 cm, breadth 1.5 cm, weight 5.26 g. Seeds chocolate brown. Yield 6-7 t/ha in 235 days.
	CO.6	Bush variety. Selected from DL 3169 x CO.5. Pods slightly curved and bloated. Yield 12 t/ha in 240 days.
	CO.7	Bush variety. Selected form DL 3169 x CO.5. Pods long, succulent, flat, greenish white and broad. Yield 12 t/ha in 240 days.
	CO.8	Bush variety. Pods green tubular and fleshy.

		Yield 6-8 t/ha in 120 days.
	CO.9	Bush variety. Pods and grains are used. Yield 7-8 t/ha in 120 days.
	CO.10	Bush variety. Induced mutant from CO.6 by gamma ray (24 krad). Pods greenish white, tubular and curved. Yield 5-6 t/ha in 120 days.
	CO.11	Bush variety. Hybrid derivative of CO.9 x a pandal type. Compact plant type. Pods flat and light green with purple margin. Yield 9-10 t/ha.
	CO.12	Bush variety. Hybrid derivative of CO.9 x CO.4. Pods deep purple. Yield 10-12 t/ha in 110 days.
	CO.13	Bush variety. Hybrid derivative of Co.9 x a training type. Pods long green. Yield 10t/ha in 110-120 days
CSAUA&T, Kanpur.	Rajani	Pole type. Pods narrow oval in cross section, shining green. Pod length 10.4 cm, width 1.2 cm, weight 1.78 g. Yield 7-8 t/ha in 200-210 days.
	KDB 403	Pole type. Pods long, narrow, shining green. Pod length 12.9 cm, width 1.2 cm, weight 2.0 g. Yield 5-6 t/ha in 180-210 days.
	KDB 405	Pole type. Pods medium long, narrow, dark green band in the middle and borders light green. Pod length 9.6 cm, width 1.3 cm, weight 1.1 g. Yield 3-4 t/ha in 180-200 days.
MPKV, Akola	Dasarawal	Pole type. Pods dirty green with purple tinge at both borders. Pod length 7.8 cm, width 2.0 cm, weight 3.2 g. Yield 7-8 t/ha.
	Deepaliwal	Pole type. Pods extra long (18.4 cm), white, not smooth due to bulging at each seed. Pod width 2.7 cm, weight 1.5 g. Yield 6-8 t/ha in 200-210

		days.
JNKV, Jabalpur.	JDL. 79	Pole type. Pods flat, broad, whitish green with parrot green boarder along the line of seed attachment. Pod length 11.8 cm, width 3.6 cm, weight 1.5 g. Yield 5.6 t/ha in 200 days.
	JDL 53	Pole type. Pods flat, small, narrow, dull whitish green with purple tinge along the boarder. Pod length 7.2 cm, width 1.8 cm, weight 3.75 g. Yield 10-12 t/ha in 200-220 days.

Cultivation practices

Prepare land to fine tilth, and sow seeds during July-August with onset of monsoon. In South and Central India, it is grown as a mixed crop with ragi and sorghum. Seeds are dibbled at a spacing of 1.0 m in between ragi or sorghum. After harvest of ear heads of ragi of sorghum, dolichos bean plants are allowed to twine and spread on their stalk. Plants start flowering and fruiting by November-December and continue up to late spring. Later vines are cut along with sorghum straw and given to cattle as a nutritious feed. As a pure crop, dolichos bean is sown at a spacing of 1.0 x 0.75 m @ 3-4 seeds / hill and later thinning is done retaining only 2 plants. Seed rate for pure crop is 50-60 kg/ha.

Pole types are usually sown in backyards of homesteads. Take pits of 45-60 cm diameter during June-July and full with green leaves and wet cow dung. Allow manure to decompose properly for 2-3 weeks. Cover pits with top soil and sow 3-4 seeds in a pit. Erect a bower with bamboo poles over an area of 4.0 x 4.0 m keeping pit at the centre. Allow plants to climb on bower by erecting one or two long twigs in pits. Apply organic manure around plants and earth up with laterite or loan soil. After cessation of rains, make a circular basin 30-35 cm away from base of plants for irrigation. Provide light irrigation daily in basin. Plants start yielding after 3 months once short days start. Thereafter daily watering and fortnightly application of organic manure are essential for protracted flowering and harvest of stringless pods over a long period.

Harvesting and yield

In bush varieties harvesting starts 50-60 days after sowing. In pole types flowering starts around three months after sowing during short days. Harvesting starts from November – December and extends up to middle of March in Kerala. Pods are harvested at tender stage before it becomes fibrous. Green pod yield varies from 5 to 8 t/ha.

Pests and Diseases

Aphids, pod borer and leaf eating caterpillar are the major pests affecting dolichos bean. Among the diseases, *Cercospora* leaf spot and *Rhizoctoni* wilt are most serious.

Lab Lab or Dolichos bean

Application of fertilizers

(a) Basal dressing for bush type

Manures and fertilizers	Irrigated	Dry
FYM	12.5 t/ha	12.5 t/ha
N	25 kg/ha	12.5 kg/ha
P	50 kg/ha	25 kg/ha
K	-	-

(b) For pandal type

Apply 10 kg FYM per pit (20 t/ha) 100 g of NPK 6:12:12 mixture as basal and 10 g N per pit after 30 days. Apply 2 kg each *Azospirillum* and *Phosphobacteria* per ha at the time of sowing.

1. _____ types of lablab bean or hyacinth beans are photoinsensitive in nature.
 - a. Pole types
 - b. Bush types
 - c. Both a & b
 - d. None
2. _____ variety of lablab bean bears pods in bunches.
 - a. CO 1
 - b. CO 2
 - c. Pusa early prolific
 - d. CO 10
3. The centre of origin for lablab bean is------.
 - a. China
 - b. India
 - c. Mexico
 - d. Europe
4. Chromosome number of lablab bean is
 - a. 22
 - b. 24
 - c. Both
 - d. None
5. Lablab yellow mosaic is transmitted by------.
 - a. Aphids
 - b. Whitefly
 - c. Jassids
 - d. Mites

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR COW PEA**(Syn: Southern pea, Black eyed pea, Yard long bean)****(*Vigna unguiculata*) (2n = 22, 24)**(Hindi: *Lobia, Chouli*)

Cowpea is a typical warm season crop adapted to tropics. The crop is used in a variety of ways. Tender pods are used as vegetable and dry beans as pulse. Due to its nutritive value and soil improving properties, it is also used as a fodder, green manure and cover crop. Being a legume crop, cowpea fits well in inter-cropping system. In Kerala, it is grown as a floor crop in coconut gardens, as an inter-crop in tapioca, fringe crop in rice fields and in garden lands. The crop is an integral part of sustainable agriculture. 100 g of green tender pods contain 4.3 g protein, 2.0 g fibre, 8.0 g carbohydrates, 74 mg phosphorus, 2.5 mg iron, 13.0 mg vitamin-C, 0.9 mg minerals, etc. (Africa is considered as primary centre of origin of cowpea). Confusion prevailed in the taxonomy of cultivated cowpea and related wild species was solved to a great extent by Summerfield *et. al.* (1974) and Ng and Marechal (1985).

Taxonomy and botany

Three cultivated sub-species have been identified under the species *Vigna unguiculata* to which cowpea belongs:

1. *V. unguiculata* ssp. *Unguiculata* (dual purpose type)
2. *V. unguiculata* ssp. *Cylindrical* (Syn: *V. Unguiculata* ssp. *Catjang*, *V. Sinensis* ssp. *Catjang*) (grain type)
3. *V. Unguiculata* var. *Sesquipedalis* (vegetable type).

*Vigna unguiculata* ssp. *cylindrical**Vigna unguiculata* var. *sesquipedalis*

Some do not agree on the distinct subspecies status to each of the above three. Ng and Marechal (1985) renamed subspecies *unguiculata*, *cylidrica* and *sesquipedalis* as cultigroups. *Unguiculata*, *Biflora* and *Sesquipedalis* respectively under *V. unguiculata*.

Cultigroup *unguiculata* is most diverse of cultivated *V. unguiculata* and is widely distributed. It is commonly known as cowpea. This is prostrate, semi-erect, erect or climbing. Pods are linear, in axillary racemes. Seeds are small and kidney shaped.

Sesquipedalis, known as yard long bean or asparagus bean is used as vegetable. It is climbing or trailing. Pods are 30-90 cm long, pendulous, fleshy and tending to shrink when dry. Seeds are elongated and kidney shaped.

All the three cross each other. In a cross between *V. unguiculata* spp. *Unguiculata* ($2n=22$) and *V. Unguiculata* var. *Sesquipedalis* ($2n=24$), F_1 , had $2n=23$.

Botany

Cowpea is a diploid with $2n=2x=22$. It is a vigorously growing annual herb with strong tap root system. Growth habit ranges from erect to climbing with profuse branching. Stem is cylindrical and twisting. Inflorescence is an un-branched axillary raceme bearing several flowers at terminal end of peduncles. Length of peduncle varies from 5-60 cm.

Anthesis takes place early in morning between 6.30 and 9.00 a.m. The process of opening corolla takes 45-60 minutes. Dehiscence of anthers is much earlier and it varies from 10.0 p.m. to 00.45 a.m. For hybridization purpose, emasculation is to be done 20 hours before flower opening. Safest time for emasculation is morning hours preceding day of anthesis. Stigma becomes receptive from 12 hours before blooming to 6 hours after anthesis.

Climate

Cowpea is a warm season crop and comes up well between 21-35°C. Grain types and dual purpose types are tolerant to hardy conditions including high temperature, drought and poor soil. The climbing yard long bean prefers mild climate than grain types. Performance of varieties varies with day length, rainfall and temperature. Hence, specific varieties are to be selected for each season.

Even though, cowpea can be grown in any soil, fertile loose soil rich in humus is required for a prolonged harvest.

Varieties

Varieties and cultivars respond differently to photoperiod. Brief descriptions of improved varieties are given below:

Developing institution	Variety	Special features
IIHR, Bangalore.	IIHR 16	Developed through pedigree selection from Arka Garima x Pusa Komal. Plants erect bushy, 70-75 cm tall, photo insensitive. Pods

		green and medium long (15-18 cm). Yield 19 t/ha in 70-75 days.
	Arka Garima* (Sel 61-B)	Derived through back cross and pure line selection from TUV 762 x <i>V. unguiculate</i> var. <i>sesquipedalis</i> . Plants vigorous, bushy, with purple flowers. Pods round and thick, fleshy and stringless. Tolerant to heat and drought. Yield 18 t/ha in 90 days.
	Arka Suman	Bushy photo insensitive variety with medium long pods. Yield 15 t/ha.
	Arka Samrudhi	Bushy photo insensitive variety with medium long pods. Yield 15 t/ha.
IARI, New Delhi.	Pusa Komal * (Sel 1552)	Plants bushy, flowers in 45 days. Pods light green, 25-30 cm long. Resistant to bacterial blight. Yield 10 t/ha.
	Pusa Phalguni	Dwarf variety that matures in 60 days. Suitable for February-March sowing. Yield 5-10 t/ha.
	Pusa Barsati	Suitable for rainy season. Yield 9-9.5 t/ha.
	Pusa Dofasli	Photo insensitive. Yield 7.5-8 t/ha.
	Pusa Rituraj	Bushy variety with 22-25 cm long and thin pods. Yield 8-10 t/ha.
Kerala Agricultural University	Vyjayanthi	Trailing growth habit, long wine red coloured pods, brown seeds; Av. Length of pod 50.62 cm; Av. Fruit weight 16.17 g; No. of seeds / pod 20-22; Productivity 12.6 t/ha.
	Lola	Trailing growth habit, smooth and extra long pods; glossy light green coloured long pods with purple tip, black seeds; Av. Length of pod 53.38 cm; Av. Pod weight 22 g; No. of seeds / pod 20-22; Productivity 20.0 t/ha.
	KMV 1	Trailing growth habit, long light green pods with brown tip, Immature seeds light green, Av. Length of pod 38 cm; No. of seeds / pod 19;

		Productivity 14.2 t/ha.
	Bhagyalakshmi	Early flowering, bushy growth habit, light green medium sized pods, mottled seeds; Av. Length of pod 27.0 cm; Av. Pod weight 7.13 g; Days to first harvest 48 days; Productivity 6.48 t/ha.
	Kanakamani	Semi trailing growth habit, pod-dark green, bold seeded and medium long, reddish brown seeds; Av. Pod length 17.8 cm; Av. Pod weight 2.0 g; Seeds / pod 17; Productivity 7.0 t/ha.
	Kairali	Resistant to mosaic disease, semi trailing growth habit, pink coloured medium long pods, reddish brown seeds; Av. Length of pod 22.78 cm; Av. Pod weight 7.08 g; Days to first harvest 50, Productivity 7.13 t/ha.
	Anaswara	Semi trailing, pods-light green, bold seeded and medium long, purple flowers; Av. Pod length 28.13 cm; Av. Pod weight 12.5 g. Seeds / pod 19; Productivity 12.5 t/ha.
	Varun	Tolerant to mosaic, semi trailing growth habit, pink coloured medium long pods, reddish. Tolerant to mosaic, semi trailing growth habit, pink coloured medium long pods, reddish brown seeds; Av. Length of pod 27 cm; Av. Pod weight 11 g; Days to first harvest 50; Productivity 8.4 t/ha.
Tamil Nadu Agrl. University	CO.2	A semi spreading variety with 26 cm long pods having less fibre. Yield 9.4 t/ha.
	Vamban	Variety with long green pods. Yield 10.6 t/ha.
NDAU&T, Faizabad, UP.	Sel-2-1*	Plants 70-75 cm tall. Pods green, 25-30 cm long, black seeded. Susceptible to cercospora leaf spot and viruses.
Punjab Agrl. University,	Sel-263*	Early maturing dwarf variety with green thick and fleshy pods of 20 cm length. Resistant to

Ludhiana		mosaic and golden mosaic virus.
BCKVV, Kalyani	Bidhan Barati-1	Bushy variety resistant to cowpea mosaic and golden mosaic virus. Flowers white. Pods green, medium long (25.2 cm) borne on long stout peduncle. Yield 13.4 t/ha.
	Bidhan Barati-2	Semi determinate variety with purple flowers. Pods light green, thick medium long (25.8 cm) borne on short peduncle. Yield 15.9 t/ha.

Season

In areas where winter is mild, cowpea can be grown throughout the year. In North Indian plains, it is sown during February-March as a summer crop. In Kerala cowpea is grown throughout the year and June-July, September-October and December-January are main seasons.

Land preparation and sowing

Land is prepared to a fine tilth by 2-3 ploughing and harrowing. Field is divided into plots of convenient size and seeds of bushy varieties are dibbled at a spacing of 30 x 15 cm with 1-2 seeds per hole. For semi-trailing varieties provide a spacing of 45 x 30 cm. During rainy season, seeds are sown at the above spacing in raised beds of 90 cm width. Trailing varieties are sown at the above spacing in raised beds of 90 cm width. Trailing varieties are sown in pits of 45-60 cm diameter and 30-45 cm depth at a spacing of 2m x 2m with 3 plants / pit for trailing on bower. Trailing varieties are also grown on trellis by sowing seeds in channels at 1.50 x 0.45 spacing.

Seed rate required for various types are :

	Seed rate	Spacing
Bushy vegetable types	20-25 kg/ha	30 x 15 cm
Semi-trailing vegetable types	20-25 kg/ha	45 x 30 cm
Trailing vegetable types	4-5 kg/ha	2.0 x 2.0 m
Dual purpose (broadcasting)	60-65 kg/ha	-
Dual purpose (dibbling)	40-60 kg/ha	45 x 30 cm

In land, where cowpea is cultivated for the first time, inoculate seeds with *Rhizobium* for quick nodulation on roots and for fixing atmospheric nitrogen.

Manures and fertilizers

Kerala Agricultural University recommended a fertilizer dose of 20:30:10 kg NPK / ha along with 20 t. of farmyard manure for cowpea. Yard long bean responds well to application of fertilizers. Hence, a higher dose of 25:75:60 kg NPK/ha is also recommended in some other states. Half of N along with entire dose of P and K should be applied at the time of final land preparation. Apply remaining 15-20 days after sowing along with weeding and earthing up.

For yard long bean, apply fertilizers in several split doses at fortnightly interval for protected fruiting. Drenching cow dung slurry in basins of plants and spraying cow dung supernatant liquid is also highly beneficial for trailing types.

Apply 250 kg lime or 400 kg dolomite / ha in acidic soils at the time of land preparation.

Irrigation

Cowpea, in general, is sensitive to water logging and requires less moisture compared to other vegetables. Grain types require only 2-3 protective irrigations at flowering and pod development stages. Water requirement of vegetable types with protracted and long fruiting phase is more than that of grain types. Irrigate trailing vegetable types at 4-15 days interval depending on soil during pre-flowering phase. Hardening of plants by restricting irrigation during pre-flowering stage is advantageous for avoiding excess vegetative growth and will induce early flowering. Once plant starts flowering, provide frequent but light irrigation. Excess irrigation and frequent rains during fruiting period induces vegetative phase at the expense of fruiting.

Interculture

Climbing types are usually trailed to bowers or trellis made of bamboo poles and coir or plastic wire for harvesting maximum yield. Erect supports with wooden sticks for training plants to the bower when plants start vining. To reduce cost of production, stretching of jute wires from base to bower is also a viable practice.

Shallow cultivation and earthing up is necessary during early stages of crop to check weed growth. Fluchloralin (2 litres /ha) will effectively check weed growth for 20-25 days. Once crop is covered, weeds will naturally be under control.

Light earthing up along with fertilizer application is also highly advantageous for better growth of plants. This facilitates better root growth and prevents lodging of young seedlings.

Nipping of excess vegetative growth is a common practice for inducing flowering and fruiting in bush and semi-trailing cowpea varieties especially when there is rain during flowering and fruiting phase.

Plant growth regulators

Plant growth regulators are effective for specific purposes in yard long bean. Spraying of NAA (15 ppm), 15 and 30 days after sowing is beneficial for inducing fruit set. CCC is reported to induce tolerance to mosaic disease.

Harvesting and yield

Tender fruits are harvested after attaining full size but before they become fibrous. Yard long bean is usually harvested in alternate days and harvesting period extends up to 45 days under good management practices. In bush varieties 2-5 harvests are possible.

Yield

Bush varieties	-	4-5 t/ha
Semi-trailing varieties	-	7-8 t/ha.
Yard long bean varieties	-	15-18 t/ha

Seed yield

Bush varieties	-	750-1250 kg/ha
Semi-trailing varieties	-	1000-1500 kg/ha.
Yard long bean varieties	-	450-600 kg/ha

Pests and diseases

Vegetable cowpea varieties especially those belonging to succulent yard long bean are susceptible to a number of pests and diseases. Pea aphids, serpentine leaf miner, stem fly, thrips, pod borers, leaf roller, hairy caterpillar etc. are major pests and fusarium wilt, rhizoctonia wilt, anthracnose, powdery mildew and mosaic are serious diseases affecting cowpea.

1. Botanical name for cowpea is _____.
2. Origin of cowpea is _____.
 - a. Central Africa
 - b. India
 - c. Europe
 - d. Japan
3. The green pod yield of cowpea is _____ q/ha.
4. Anthracnose of cowpea is transmitted by _____.
5. The vector for cowpea mosaic virus is _____.
 - a. Thrips
 - b. Water
 - c. Aphids
 - d. Jassids

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR POTATO

Family: Solanaceae

Botanical Name: *Solanum tuberosum*

Chromosome Number: 2n= 48

Origin and History

The probable centre of origin of potato is in South America in the central Andean region. Evidence indicates that potatoes were cultivated for centuries by South American Indians and the tubers were used as a common article of food. The Spaniards during invasion found this economic plant worthy of introduction into Europe. The Spanish people brought potato from Peru to Spain in 1565. Sir Francis Drake probably brought them to England about 1586. Following its introduction into European agriculture, potato became an important food crop of Italy, France, and Ireland. During the famine years, the potato crop became a valuable food crop in Ireland. Potato was introduced to India from Europe in the beginning of the seventeenth century, probably by the Portuguese, who were the first to open trade routes to the east. The first mention of potato in India occurs in 'Terry's account of a banquet at Ajmer given by Asaph Khan to Sir Thomas Rao in 1615. Potato was grown in many gardens of Surat and Karnataka in about 1675. Cultivation of potato in northern hills started later than plains but became a cash crop much earlier. Cultivation of potato was beginning first in the Nilgiri hills in 1822. The spread of potato is given in Figure 1.

Nutritive value and uses

It is one of the important crops of the world. In India, it is used only as a vegetable. Sometimes it is also mixed with other vegetables. It is also used for making of chips, halwa, gulab jamun, rasgulla, murabba, kheer, guzlia and barfi etc. According to Aykroyd (1941), it contains 74.7 per cent water, 22.9 per cent sugar, .6 per cent protein, 0.1 per cent fat, 0.6 per cent mineral matters, 0.01 per cent calcium, 0.03 per cent phosphorus and 0.0007 per cent iron, while according to Macgillivray (1953), it contains 77.8 per cent water, and food value per 100g of edible portion is energy 85 calories, protein 2 g, calcium 13 mg, vitamin A 40 IU, ascorbic acid 12 mg, thiamine 0.11 mg, riboflavin 0.06 mg and niacin 1.18 mg and according to Chatfield (1949) raw potato also contains in 100 g, edible portion: Na 3 mg, K 410 mg, Ca 14 mg, Mg 27 mg, Fe 0.8 mg, Cu 0.16 mg, P 56mg, S 29 mg and Cl 35 mg. The potato tuber may contain an alkaloid (Solanine), if it is exposed to light. It is a poisonous compound but 70 per cent of it is removed when potatoes are peeled. This alkaloid may cause sickness or death both to live stock and the human beings. Nadkarni (1927) has reported the following medicinal uses of potatoes:

It is anti-scorbutic. Persons with neurotic and liver dyspepsia digest it well. It is also employed as an, diuretic and galactagogue, nervous sedative and stimulant in gout. The leaves in the form of extract are employed as an antispasmodic in chronic cough producing effects as those of optimum etc. potato grind into a paste is applied as plaster to burns caused by fire with good results. The juice of the potato is a dark colored liquid due to the presence of citric and succinic acids. Potatoes may be mealy or non-mealy. Mealy potatoes are those in which the cells, on cooking, separate from one another so that they may be piled up in loose flour with air between them instead of remaining in a solid mass with water in the small intercellular spaces. But this is absent in immature potatoes due to low quantity of starch. Mealiness and high starch are associated with high specific gravity. According to Covdon and Boussard (1897) disruption of potatoes in cooking is partly due to turgidity of tissues, the more turgid they are more easily do they fracture and permit the ready penetration of boiling water.

Area and Production

In India out of total 5335447 ha of land under vegetables, potato occupies nearly 20.79 per cent area. The area (1109000 ha) under potato, during the year 1995-96 followed percentage change of -2.30, -10.56, -5.91 and 3.70 over 1991-92, 1992-93, 1993-94 and 1994-95, respectively. Production of potato was 18843300 MT during the year 1995-96, having 26.32 per cent share in the total vegetable production. Production increased by 3.56, 1.97, 8.34 and 8.29 per cent over 1991-92, 1992-93, 1993-94 and 1994-95 respectively. The productivity of potato was 16.99 MT/ha, whereas the highest 24.4 MT/ha was of West Bengal in the country (NHB, 1998) potato is grown in almost all the states of India. It is mainly grown in the states like Uttar Pradesh, West Bengal, Punjab, Karnataka, Assam and Madhya Pradesh. The major potato producing belts in India are as given below (NHB, 1998).

- **Himachal Pradesh:** Shimla, Lahul Spiti and Mandi.
- **Punjab:** Jalandhar, Hoshiyarpur, Ludhiana and Patiala.
- **Haryana:** Ambala, Kurukshetra, Hisar and Karnal.
- **Uttar Pradesh:** Farrukhabad, Etawah, Manpuri, barabanki, Allahabad, Badaun, Moradabad, Agra, Aligarh, Mathura and Faizabad.
- **Madhya Pradesh:** Sidhi, Satana, Rewa, Sagar, Rajgarh and Tikamgarh.
- **Chhattigarh:** Sarguja and Raipur.
- **Rajasthan**
- **Gujarat:** Khera, Dissa, Baransh katha, Jamnagar, Baroda, Mehsana.
- **Orisa:** Cuttack, Dhenkamal, Puri and Sambalpur.
- **West Bengal**

- **Maharashtra:** Pune, Satana, Kolhapur and Nasik.
- **Karnataka:** Belgaum and Dharwad , Hassan, Kolar.
- **Uttaranchal:** Almora, Pilibhit and Haldwani.
- **Andhra Pradesh:** Medak and Chittoor.
- **Tamil Nadu:** Dhinikulanna and the Nilgiris
- **Assam**

Apart from India, the other major producers of potato in world are China, Russian Federal, Poland, USA, Ukraine, Germany, Netherlands and UK (NHB, 1998)

Classification, Botany and Floral Biology

Classification

The potato was first domesticated in the high plateau region of the Peruvian and Bolivian Andes and has been grown for several millennia. A total of seven cultivated species were domesticated and they remain the most important crop in the high Andean, regions, where the greatest genetic diversity of cultivated potato is concentrated (Engel, 1970). The cultivated potatoes species are as given below:

Table1. Classification and origin of the cultivated potatoes

Species	Distribution	Origin
<i>Solanum tuberosum sub sp. tuberosum</i> (2n = 48) (2n =n48)	Cosmopolitan	By artificial selection in Europe, North America and Chile from introduced clones of group 2.
<i>S. tuberosum sub sp. andigena</i> (2n = 48)	Venezuela to northern Argentina; also sporadically in central America and Mexico	From group 4 and 5 by spontaneous doubling of the chromosome number.
<i>S.chaucha</i> (2n = 36) <i>S. phuerja</i> (2n = 24)	Central Peru to northern Bolivia Venezuela to northern Bolivia	By hybridization between group 2 and 4 and 5. by selection for short tuber dormancy from group 5.
<i>S.stentomum</i> (2n=24)	Southern Peru to northern Bolivia	By natural hybridization between wild species followed by artificial selection.

<i>S.juzepczukii</i> (2n=36)	Central peru to southern Bolivia	From crosses of <i>S.acaule</i> with groups of 4 and 5
<i>S.curtilobum</i>	Central peru to southern Bolivia	Crosses of <i>S. juzepczukii</i> with group 2.

The commercial potato generally belong to two species

Solanum andigenum: it is not very common. Plants have thin and long stem, small and narrow leaflets. Flowers are produced more profusely. It has long stolons and mostly coloured deep-eyed tubers.

Solanum tuberosum: It is more common, plants have shorter and thicker stem larger and wider leaflets.

In addition to two species, there are also some important species, which shows resistant to biotic and abiotic. These species are given in Table 2.

Table 2. Potato species resistant to biotic and abiotic

Species	Utility
<i>Solanum demissum</i> Lind (2n = 72)	Resistance to late blight, virus A, virus Y
<i>S. stoloniferum</i> (2n = 48)	Resistance to virus x, frost, Colorado beetle.
<i>S. vernei</i> Bitt et., Wittm (2n = 24)	Resistant to two species of Heterodera nematode.
<i>S. multidissectum</i> Waek (2n=24)	Resistant to two species of Heterodera nematode.
<i>S. antipovczii</i> Bulk	Resistance to late blight
<i>S. curtilobum</i> jug. Et. Buk	Resistant to frost
<i>S. phureja</i> jug. Et. Buk	Non dormant type used inbreeding
<i>S. chacoense</i> bitter	Non dormant type used in breeding Tolerance to high temperature
<i>S. anomalocalyx</i> , <i>S. jamessi</i> Torr; <i>S. Saltense</i>	Resistance to early blight.

Potato can also be divided on the basis of origin and response to day length as given in Table 3.

Table 3. Classification on the Basis of origin and Response of Day Length:

Distant characters	<i>S. tuberosum</i>	<i>S. andigenum</i>
Origin	Andean region	Chile region
Day length response	Long day plants	Short day plants
Ployploidy	Many types of polyploids	Tetraploids
Distinct varieties	'Up-to-date' 'Magnum'	All the desi varieties like

	Bonum' etc	'Darjeeling', 'Red Round', 'Phulwa' and 'Gola'
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Potato can be classified into early and late varieties. They are given below in Table 4.

Table 4. Classification of potato on the Basis of Crop Duration

Character	Early potato	Late potato
Stolon length	Short	Long
Stem	Hollow	Solid
Petioles	Broader	Narrow
Stolon number	Less number	More number
Tuber colour	White	Coloured
Photoperiodism	Long day for tuber development	Short day for tuber development
Varieties	'Satha', 'Gola', Great Scot', Kufri Chandramukhi'	'Phulwa', 'Kufri Kissan', 'Kufri Safed'

Varieties/Hybrids

KUFRI ALANKAR

It is a derivatives of the cross (Kennebee x O.N .2090) x (Majestic x Ekishiraju), released in 1968 by Central Variety Release Committee for plains of Punjab, Haryana and Western Uttar Pradesh and specially suited for sandy soils. Plants are very tall, open and erect with thick and strong stem and RI) 2 colour uniformly distributed. Leaflets are rough and present in leaflets midrib of 2.3 top leaves but not in the stem base. Tubers are oblong, tapering towards and, flesh dull white eyes and medium deep to fleet. It shows slow rate of degeneration. Tubers develop crack if allowed to remain till full maturity. It is rapid bulking variety keeping quality not good. It matures 75 days in plains and 140 days in hills. The yield potential is 300 q/ha in plains and 100 a/ha in hills. This variety is having moderate field resistance to late blight with immunity to race 1 and '0' susceptible to common scab.

KUFRI ANAND

A derivative of PJ376 x PH/F 1430, released from CPRI, Shimla in 1999. plants are tall erect, vigorous, stems few, thick and



pigmented at the base. Foliage is grey-green, leaves intermediate and rachis green. Leaflets are ovate lanceolate, smooth, glossy surface with entire margin and occasionally terminal leaflets fused. Flowers are light purple in colour with moderate flowering. Anthers are orange yellow, well-developed and low pollen stain ability. Stigma is round and notched. Tubers are white, large oval long, flattened, smooth skin, fleet eyes, white flesh having red purple sprouts. It is a medium maturing variety (100-110 days) having a yield potential of 350-400 q/ha. This variety is adaptable to plains of Uttar Pradesh and neighboring states. This variety is resistant blight. The tubers are ideal in shape for French fries.

KUFRI ASHOKA

It is a wider adaptable variety released from CPIU, Shimla in 1996. It is a derivative of (EMC-I 020 x Allerfi'uii lleste Gelbe). Plants are medium tall, erect, medium compact and vigorous. Stems are few, medium thick, lightly pigmented at base with poorly developed straight wings. Foliage is green. Leaves are intermediate having green rachis. Leaflets are ovate lanceolate, smooth glassy surface with entire margin, Flowers are light red purple. This variety has profuse flowering. Anthers are orange-yellow, well- developed and medium pollen stain ability. Stigma is round shaped. Tubers are white, large, oval long, smooth skin and fleet eyes with white flesh having purple sprouts. It is an early maturing (70-80 days) having yield potential of 400 q/ha, suited in Bihar, Haryana, Punjab, Uttar Pradesh and West Bengal for cultivation. It is susceptible to late blight and not suitable for processing.

KUFRI BADSHAH

It is a cross of Kufri Jyoti and Kutri Alankar and released in 1980 by Central Sub Committee on release in varieties for Indo - gangetic plains of North India, including Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal, Madhya Pradesh and Plateau region. Plants are tall, haulms erect, 4-5 stems per plant with a tendency for branching, semi-solid, flexible, slightly



pubescent, red purple, well developed straight wings and short (about 7-8 cm) internodes. Leaves are green, medium long, prominent venation, rachis pigmented at base, disposition almost at right angles with the stem. Leaflets are broad, medium in size, slightly hairy, entire margin, ovate, glassy veins prominent, and petiole green, usually four pairs and one terminal leaflet. Tubers are mostly large to medium, oval, shining white, smooth, regular with shallow

eyes, flesh dull white, sprouts stout, thick, 1 bulbous white with light red pigmentation at the base. Stolen are thick, short and white. Flowers are scanty, white, and medium in size, fully stretching wings, pollen fertility 50-60 per cent and frequently set berries in the hills. This variety possesses medium dormancy. This variety has average keeping quality. It shows slow rate of degeneration. Tubers are tasty with good flavour. It contains 13.6 g/100 g starch and 18.6 per cent dry matter content. It matures in plains 90-100 days. It is tolerant to frost, resistant to late blight, early blight and potato virus 'X' but susceptible to soft.

KUFRI BAHAR

It is a derivative of the cross Kufri Red x Ginek and released by Central Sub-Committee on Release of Varieties in 1980 for the plains of Haryana, Punjab and Western Uttar Pradesh. Plants are tall erect, medium compact and vigorous. Stem is thick, 4-5 stems per plant, succulent, semi-solid with moderately developed wings. Leaves are open, straight with 4-5 pairs of leaflets. Leaflets are grey green, medium, dull with entire margins. Foliage is of grey green colour. Tubers are large, white, round to oval, skin smooth with medium deep eyes, flesh white. Sprouts are bulbous and red. Stolens are medium long. This variety has moderate flowering, having white flowers, medium in size and sterile. Keeping quality is average with medium dormancy. It is mid maturity variety (90-100 days). Yield is 250-300 q/ha. Resistant to late blight, early blight and potato virus 'X', 'Y' and leaf roll. It is susceptible to insect pests, drought and frost.



KUFRI CHAMATKAR

A derivative of the cross *Ekishiraju* x *Phulwa* and released in 1967 by Central Variety Released Committee for the plains of Uttar Pradesh, Madhya Pradesh, Haryana, Punjab, where one crop of long duration is raised. Plants are medium, spreading, short stolen, compact, dark green foliage, foliage prominent, very small internodes, more stems and small leaflets. Flowers are of white colour. Tubers are round and white, eyes medium deep, flesh yellow and red sprouts. Degeneration is slow and quick tuberization. It is late maturing variety, which matures 110-120 days in plains and 150 days in hills. The yield potential of this variety is 250 q/ha in plains and 75.00 q/ha in hills. It is resistant to early blight but susceptible to viruses, late blight, brown rot, charcoal rot, wilts and common scab.

KUFRI CHANDRAMUKHI

It is a derivative of the cross S.4485 X Kufri Kuber and released in 1967 in Central Variety Release Committee for the plains of Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Rajasthan, Bihar, West Bengal and Maharashtra. It also grows well in Himachal Pradesh hills and Jammu regions. Plants are medium tall with open foliage habit and free from secondary growth. Foliage is grass green



and glossy. The small leaflets are not fully expanded especially on top, notched tip on one side of leaflets. Tubers are oval, white, flesh dull white, eye fleet, and sprouts light red and pubescent. The variety has slow rate of degeneration and early bulking. It possesses good keeping quality. It is mid season variety, matures 80-90 days in plains and 120 days in hills. An average yield is 200 q/ha in plains and 75 q/ha in hills. It is susceptible to common scab, late blight, brown rot, nematodes, charcoal rot and wilts.

KUFRI CHIPSONA-1

It is a cross of MEX.750826 x MS/78- 79 and released from CPRI, Shimla in 1998. Plants are medium tall, semi erect, compact and vigorous. Stems are few, thick, slightly pigmented with poorly developed straight wings. Foliage is green, leaves, open and rachis green. Leaflet is ovate, smooth, dull surface with entire margin. Flowers are white and profuse flowering. Anthers are orange-yellow, well developed, and stigma round pinhead. Tubers are white medium to large oval, smooth skin, fleet eyes, and dull white flesh having green sprouts. It is medium maturing variety (90-110 days) having 400q/ha. It is suitable for cultivation in Bihar and Uttar Pradesh. It is resistant to late blight. The variety is highly suitable for making chips and French fries.



It is a cross of MEX.750826 x MS/78- 79 and released from CPRI, Shimla in 1998. Plants are medium tall, semi erect, compact and vigorous. Stems are few, thick, slightly pigmented with poorly developed straight wings. Foliage is green, leaves, open and rachis green. Leaflet is ovate, smooth, dull surface with entire margin. Flowers are white and profuse flowering. Anthers are orange-yellow, well developed, and stigma round pinhead. Tubers are white medium to large oval, smooth skin, fleet eyes, and dull white flesh having green sprouts. It is medium maturing variety (90-110 days) having 400q/ha. It is suitable for cultivation in Bihar and Uttar Pradesh. It is resistant to late blight. The variety is highly suitable for making chips and French fries.

KUFRI CHIPSONA-2

It is a derivative of F-6 x QB/B-92-4 and released from CPRI, Shimla in 1998. Plants are medium tall, erect open and vigorous. Stem is few, medium thick slightly pigmented with straight wings. Foliage is dark green, leaves open, rachis green, leaflet ovate lanceolate, wrinkled dull surface with slightly wavy



margin. Flowers are white and moderate in flowering. Anthers are yellow, well-developed and moderate pollen stability. Stigma is round notched. Tubers are white, medium, round oval, smooth skin, fleet eyes, and yellow flesh having reddish brown sprouts. It is medium maturing variety yielded 350 q/ha. This variety is resistant to late blight and tolerant to frost. Due to high dry matter content, low reducing sugars and low phenols, the variety is highly suitable for making chips and French Fries.

KUFRI DEWA

It is a derivative of the cross Craig's Defiance x Phulwa and released by Central Sub-Committee on Release of Varieties in-1973 for Tarai area of Uttaranchal and Shimla agro climatic conditions. It is also suitable for Bihar and Orissa. Plants are very tall open, erect and very small internodes. Leaves are semi-compact, dark green and upright. Petioles are very long having 3-6 cm towards base and devoid of leaves. Tubers are erratic round with purple splashes, eye deep and pigmented and sprout light red with white flesh. Tubers develop brown spots after harvest. It is highly susceptible to late blight, possesses good resistance to frost and drought. It matures in 120 days in plains and 165 days in hills. An average yield is 250 q/ha.

KUFRI GIRIRAJ

It is north and south India adaptable variety. It is a cross of SLB/1-132 x EX/A 680-16 and released from CPRI, Shimla in 1998. Plants are medium tall, semi-erect, medium compact and vigorous. Stems are many, medium thick, coloured at base with moderately developed straight wings. Foliage is green, leaves open and rachis green. Leaflets are ovate, smooth dull surface with entire margin. Flowers are light purple and shy flowering. Anthers are yellow, well-developed and low pollen stability. Stigma is round. Tubers are white, medium to large, oval smooth skin, fleet eyes, and white flesh and sprout light purple. The yield potential of this variety is 250 q/ha. This variety is resistant to late blight (both foliage and tubers). It is not suitable for processing.



KUFRI HIMALINI

It is a derivative of cross SLB/H-140 x SLB/Z-389 (b) Recommended by 9th workshop of the All India Coordinated Potato Improvement Project for Hilly regions (hills of Northern India and Nilgiris in South) in the country. Plants are tall, vigorous, erect, semi-close, spreading tendency at the time of maturity. It possesses 4- 5 stems, stem solid, slightly hairy, colour red purple, spreading uniformly throughout the stem, wings moderately developed and straight. Leaves are semi-close, medium to long, placement medium and rachis of green colour. Leaflets

are grey green, flat, margin entire, petiole and mid rib green, medium in size and green and foliage grey green. Tubers are medium to large, oval, slightly flattened, skin white, eyes shallow to medium deep, flesh dull white and mealy texture. Sprouts are red purple and medium thick. Flowers are profuse, persistent white, light pinkish colour on the tips of corolla wings, pollens fertile and natural berries are formed. Tubers possess medium dormancy (2-2Y2 months). Keeping quality is good and does not show shrinkage on five months storage in hills. It is highly resistant to late blight but susceptible to early blight, phoma leaf spot, brown rot, and common scab and moderately susceptible to powdery scab and leaf blotch. Planting is done in March-April as summer crop in Nilgiris in northern hills, August- September for autumn crop in the southern hills. It matures 30-140 days after planting.

KUFRI JAWAHAR

It is a derivative of Kufri Neelamani x Kufri jyoti and released from Central Potato Research Institute, Shimla in 1996. Plants are short, erect, compact and vigorous; stem few, thick, lightly pigmented at base with well-developed straight wings. Foliage is light green, leaves open, rachis green, terminal leaflet cordate, smooth dull surface with entire margin. Flowers are white moderately flowering. Anthers are orange yellow, well-developed and low pollen stability. Stigma is round and slightly notched. Tubers are creamy white, medium sized, round-oval smooth skin, eyes fleet, and pale yellow flesh having purple sprouts. It is an early maturing variety (80-90 days) yielded 400 q/ha. This variety is resistant to late blight. It is not suitable for processing. It is widely adaptable in Haryana and Punjab, plateau region of Gujarat, Karnataka and Madhya Pradesh. It is suitable for intensive cropping.

KUFRI JEEVAN

It is a derivative of the cross M-109-3 x D 698 and adopted for northwest hills of Himachal Pradesh and Uttar Pradesh. Tubers are medium, white skin, oval shaped, eyes fleet, faint red picked, flesh waxy and pale yellow. It matures 150-160 days in hills and 120 days in plains. It is resistant to wart, highly resistant to late blight and in moderately resistant to early blight.

KUFRI JYOTI

It is a derivative of the cross 3069d(4) x 2814 Q (1) and released in 1968 by the Central Variety Release Committee for Himachal Pradesh and Kumaon Hills of Uttranchal and also plains where late blight is a limiting factor. Plants are tall, compact and erect. Terminal leaflet is a cottony or



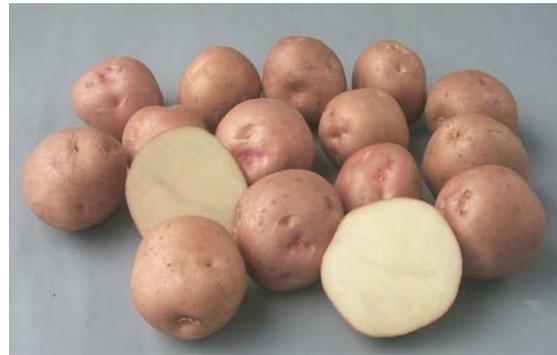
cordate and leaflet of top 2-3 leaves incurved at the base. Leaflets are broad and light green. Tubers are oval, white, eye fleet. Flesh is light white and waxy. Sprouts are blue purple and medium thick. It has good keeping quality if given proper post harvest treatment. It is field resistant to late blight with immunity to race. It is resistant to early blight and wart disease. It matures 100 days in plains and 120 days in hills. The yield potential is 200 and 150 q/ha in plains and hills, respectively.

KUFRI KHASHIGARO

It is popular variety of hilly region and a derivative of the cross Taborky x SD 698 D. It is adapted to hilly regions of Assam. Tubers are medium, attractive white, round with deep eyes and waxy, pale yellow flesh and rapid bulking. It possesses short dormancy. It gave 160 q/ha tubers in 120 days crop duration.

KUFRI LALIMA

It is a fast bulking variety and a derivative of the cross Kufri Red x CP 1362, which released in 1982 by Central Sub-Committee on Release of Varieties for the plains of Uttar Pradesh, Bihar, West Bengal, Orissa and Karnataka States. Plants are tall, vigorous, erect, compact and dark green. Stems are 4-5, stem red pigmented and prominent at internodes. Leaves are open, wide; rachis has red, pigmentation running on the central side.



Leaflets are smooth, glossy and ovate. Foliage is dark-green. Tuber is uniformly red, medium to large, round, regular, smooth with fleet to medium deep eyes. Flesh is white colour with mealy texture. Sprouts are medium thick with red colour. Mowers are numerous, persistent and blue purple coloured. Pollens are fertile, natural berry forms freely. It is susceptible to late blight wart, powdery, scab, leaf blotch, phoma leaf spot, brown rot, charcoal rot and common scab. It is susceptible to Virus 'Y'. It possesses slow rate of degeneration and medium dormancy (about 2Yz months).

KUFRI LAUVKAR

It is a derivative of cross Serkoy x Adina released in 1973 by Central sub-committee on Release of Varieties for Decan Peninsula (Maharashtra). Plants are tall, erect and thick stems, large ovate lanceolate and incurving leaflets. Foliage is dark grey



green and glossy, foliage many, large and mostly borne on rachis. Tuber is round, white, and flesh white, sprouts beet root red colour, cooking and peeling easy. Cooked flesh is white and good in taste. It has slow rate of degeneration. It is susceptible to late blight, leaf blotch; potato virus 'Y' and leaf roll. It is a variety escapes attack to tuber moth. It is susceptible to early blight. It is an early variety, which yielded 250 q/ha tubers in 75-95 days crop duration.

KUFRI MUTHU

It is a derivative of the cross 3046(1) x M-109-C and released in 1971 by Central Sub Committee on release of Varieties for Nilgiri Hills for summer and autumn seasons. Plants are tall and vigorous: Leaves are dark green and short stolens. Tubers are large, white, roundish, oval, smooth eyes medium deep and flesh white. Sprouts are of blue purple colour. The yield potential of this variety is 135 q/ha in 100 days of crop duration. It is resistant to late blight but susceptible to early blight.

KUFRI NAVEEN

It is a derivative of the cross 0-692 x, 3070d (4) and adapted to northeast hills of Assam and high altitude of Himachal Pradesh. Tubers are medium, white and oval with fleet eyes. Flesh is waxy and pale yellow. It is susceptible to early blight and to resistant to wart. It possesses high degree of field resistant/immunity to race 0, 1 and 4 of late blight.

KUFRI PUKHRAJ

It is a wider adaptable variety and a cross of Craig's Defiance x JEX/B-687, which released in 1998 from CPRI, Shimla. Plants are tall, semi-erect, medium compact and vigorous. Stems are few, medium thick, green with moderately developed straight wings. Foliage is dark grey green. Leaves are closed with large sized foliage, rachis green. Leaflets are ovate to lanceolate, smooth glossy surface with entire margin. Flowers are white and moderate in flowering, anthers orange yellow, well-developed, high pollen stability and round stigma. Tubers are white, large, oval, slightly tapered, smooth skin, fleet eyes, and yellow flesh having blue purple sprouts. It is an early maturing variety (70- 90 days). The yield potential is 400 q/ha. It is resistant to early blight and moderately resistant to late blight. This variety is suitable in Bihar, Gujarat, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Punjab, Uttar Pradesh and West Bengal. It is not suitable for processing.



KUFRI SHEETMAN

It is a derivative of the cross Craig Defiance x Phulwa, released in 1968 by Central Variety Release Committee for plains, especially frost affected areas of Punjab, Rajasthan, Haryana and Western Uttar Pradesh. Plants are tall open erect and vigorous, stem thick, firm and erect. Leaflets are rough dull green with waxy margins. Tubers are oval and white with fleet eyes. It is resistant to frost and drought. It is susceptible to late blight and leaf roll.

KUFRI SHERPA

It is a derivative of the cross Ultimus x Adina and recommended for cultivation in the hills to West Bengal State by 9th Workshop of All India Coordinated Potato Improvement Project. Plants are tall, vigorous, erect, and semi-compact with spreading pasture under wet conditions. Stems are few, highly branched, semi-solid and slightly hairy. Leaflets are rough, hairy, oval, prominent venation, yellow green, petioles short; light green and medium in size. Foliage are small in size and usually 4- 7 pairs. Foliage is light green. Tubers are medium in size, round flattened, skin smooth, medium thick, white, eyes medium deep and flesh of pale yellow colour. Sprouts are conical, blue purple and medium thick, white, eyes medium deep and flesh of pale yellow colour. Flowers are scanty, persistent, and pink in colour, regular in shape with pollen fertility of 50-60 per cent. Tuber dormancy, is medium (2-2 ½) months with good keeping quality. It matures 135 and 100 days in hill and plains, respectively and yield is 225-250q/ha. It is susceptible to frost, brown rot and leaf roll and resistant to late blight (both in foliage and tubers) and phoma leaf spot but moderately resistant to early blight and highly immune to wart.

KUFRI SINDHURI

It is derivative of the cross Kufri Kundan x Kufri Red and released by Central Variety Release Committee in 1966 for plains of Punjab, Jammu, Orissa, Bihar, Haryana, Uttar Pradesh, Madhya Pradesh and West Bengal.

Plants are tall, erect, stems thick having pigment in most part of stem. Leaf rachis is pigmented and leaves open and stiff. Leaflets are dull, basal lobe unequal, petiole slightly pigmented but not midrib. Tubers are round, light red, with medium deep eyes. Flesh is dull white. Tubers are moderate in number, skin



firm, not prone to brushing, bigger tubers having tendency to develop hollow heart. Keeping quality is good. It is late variety and matures in 120 days in plains and 165 days in hills. In plains, it yields 300 q/ha. It is slightly resistance to frost. It is Tuber Crops susceptible to late

blight, common scab charcoal rot and wilts, moderately resistant to early blight and possesses field resistance to viral disease.

KUFRI SUTLEJ

It is a derivative of Kufri Bahar x Kufri Alankar and released in 1996 from CPRI, Shimla. Plants are medium compact and vigorous. Stem are few, thick, lightly pigmented at base with moderately developed wavy wings. Foliage is grey green. Leaves are ovate-lanceolate and rachis slightly pigmented. Leaflet is ovate, smooth dull surface with entire margin. Flowers are white moderates in flowering. Anthers are orange yellow, well-developed and high pollen stability. Stigma is round and slightly notched. Tubers are white, large, oval, smooth skin, fleet eyes, and white flesh and sprouts light red. It is medium maturing (90-100 days) variety yielded 400 q/ha. This variety is moderately resistant to late blight. It is recommended for cultivation in Bihar, Haryana, Madhya Pradesh, Punjab and Uttar Pradesh. This variety has good consumer quality because of easy to cook, waxy texture, and mild flavour and free from discolouration after cooking. It possesses medium dry matter. It is not suitable for processing.

KUFRI SWARNA

It is a cross of Kufri Jyoti x (VIn) 2 (62.33.3) and released in the year of 1985 from CPRI, Shimla. Plants are tall, erect, compact and vigorous. Stem is few thick with prominent wings. Foliage is dark green, leaves open, rachis green leaflets ovate, moderately pubescent, entire margin and many follicles. Flowers are white, profuse flowering, anthers orange yellow, well-developed, low pollen stability and stigma round. Tubers are white, medium, round oval, smooth skin, fleet eyes, and white flesh having blue purple sprouts. This variety is widely adaptable for south India hills. It matures 130-135 days in summer, while 100-110 days in autumn. This variety is highly resistant to both the species of cyst (*Globodera rostochinensis* and *G. pallida*) and resistant to early and late blight. This variety is not suitable for processing.

Climatic Requirements

Potato is basically cool season crop. It grows well from sea level to snow line, where sufficient moisture and fertile soil are available. It is grown in winter in plains of India. However, in northern hills, it is grown as summer season crop. Potato is a long day plant but cultivated as ~ day plant. It requires favourable environmental conditions such as low temperature and short day conditions at the time of tuberization for rapid bulking rate. About 20°C temperature is good for tuber formation and it reduces as the temperature increases. Tuberization is badly affected at about 30°C temperature. At higher temperature, the respiration rate increases and the carbohydrates produced by photosynthesis are consumed rather than stored in tuber. High temperatures at any part of growing period affect the size of leaflets, thereby reducing the tuber formation. It grows best under long day conditions sunshine along with cooler nights are essential for reducing the spread of diseases.

Soil Conditions

Potato can be produced on a wide range of soils, ranging from sandy loam, silt loam, loam and clay soil. Soil for potato should be friable, well aerated, fairly deep and well supplied with organic matter. Well-drained sandy loam and medium loam soils are most suitable for potato cultivation. Soil structure and texture has a marked effect on the quality of the tuber. Light soil is preferred, because they tend to promote more uniform soil temperatures and make harvesting of the crop easier. Alkaline or saline soil is not suitable for potato cultivation. They are well suited to acidic soils (pH 5.0 to 6.5) as acidic conditions tend to limit scab diseases.

Planting Time

In Plains

Early Crop: Third week of September to first week of October.

Main crop: First week of October to third week of October.

Late Crop: Third week of October to first week of November

II. In Hills: Potato is planted in hills from the third week of February to second week of April. In the southern hills near Ootacamund in Nilgiris, planting is done three times in a year, i.e. in the month of February, April and September. In the plateau regions of Maharashtra, Bihar, Madhya Pradesh, potato is raised in rainy and winter seasons.. In the Mysore plateau, the summer and winter crop is planted in April-June and in October-December, respectively.

Seed Rate, Methods of Sowing and Spacing

The seed requirements for a hectare on the basis of seed size are given below:

Large size- 25-30 q/ha; Medium size- 15-20 q/ha; Small size- 10-15 q/ha; Out tubers- 8-12 q/h²:-' Potato is planted mainly by two methods:

1. Ridge and Furrow Method: In this method, the ridges are prepared. The length of the ridges depends on slope of the plot. Too long ridges and furrows are not supplied with irrigation water conveniently. The potato tubers are planted on is let into furrows.

2. Flat Bed Method: In this method, the whole plot is divided into beds of convenient length and width. The shallow furrows are opened and potato tubers are planted at recommended distance. The tubers are covered with the original soil of furrows. When the germination is completed and plants become 10 to 12 cm height, earthing should be done. Suitable plant spacing in relation to potato seed grades are given below:

Diameter of tuber from longer axis	Planting distance (row x seed)
2.5-3.5 cm	50 x 20 cm or 60 x 15 cm
3.5-5.0 cm	60 x 25 cm
5.0-6.0 cm	60 x 40 cm

Nutritional Requirements and Their Management

Soils poor in organic matter content should be supplied with 250 - 500 q/ha of farmyard manure or compost during land preparation, preferably a fortnight before planting. Potato plant is a heavy feeder. When it is grown in medium type of soils, it needs 100 to 150 kg nitrogen, 80 to 100 kg phosphorous and 80 to 100 kg potassium per hectare. Two - third to three fourth quantity of nitrogen along with whole quantity of phosphorus and potassium is applied at the time of planting. Remaining one fourth to one third nitrogen is applied 30 to 35 days after planting i.e. at the time of first earthing up or when plants become 25 to 30 cm in height either in the form of top dressing or as a foliar feeding. Spraying of essential micronutrients such as boron, zinc, copper, iron, manganese, molybdenum etc. is done when crop is showing deficiency symptoms.

Intercultural Operations

In potato crop, both types of weeds are found i.e. broad-leaved weeds as well as narrow leaved weeds-The use of weedicides in potato crop in general is not essential because earthing up operation destroy almost all weeds, if some how, weed plants are growing on ridges, they may be pulled out by hands. Pre- emergence application of nitrogen @ 1.0 kg a.i./ha or alachlor @.2.0 kg a.i./ha or post emergence application of propanil @ 1.0 kg a.i./ha may be used ill solution fom1 (800-1000 litre/ha). Care should be taken while spraying of post- emergence herbicides that they should not come in the contact to potato plants. Proper development of tubers depends upon aeration, moisture availability and proper soil temperature. Therefore, proper earthing up is necessary. Earthing should be done when the plants are 15 to 22 cm ill height. Generally earthing is done at the time of top dressing of nitrogenous fertilizers. The ridges should be high enough to cover up tubers. If necessary, a second earthing may be done after two -week of the first one. A mould board plough or a ridger may be used for earthing up in large area.

Use of Plant Growth Regulators

Soaking of potato seed tuber in CCC at 500 mg/l (Schedule and Pandita, 1986), sodium ascorbate at 100 mg/l (Murthy et al.. 1975) cytozyme at 5 per cent (Pandita and Hooda, 1979), Singh and Kaur, 1981) or foliar sprays with ethephon at 400 mg/l (Murthy and Banerjee, 1978, Pandita and Hooda, 1979 a, Sekhon and Singh, 1985), CCC at 25 mg/l or garlic acid at 10-100 mg/l(Kumar and Agarwal, 1978) increased tuber yield. Sidida Reddy (1988) also obtained higher tuber yield with foliar sprays of mixtallol at 1 or 2 mg/l.

Water Management

Before coming to the planting operation. It should be kept in mind that the sufficient soil moisture is available for satisfactory sprouting. If not then light pre-irrigation or just after planting may be given. The rate of water use is low till 30-35 days after planting; it means that the first irrigation is essentially done within 30-35 days after planting. However, when soil moisture seems insufficient for sprouting, intervals of first irrigation should be reduced. Further, irrigation is done as and when crop needs. As regards method of irrigation in potato, the furrow method is commonly followed.

Harvesting, Yield and Storage

Harvested potatoes are heaped under shade for a couple of days, so that their skin becomes hard and soil adhering with them is also separated out. Under good crop management, 350-450 quintals of marketable potatoes of good quality can be produced from one hectare land. The sorting operation is the most important, in that all cut tubers, bruised,

injured by insects-pest and disease are removed. Sorted healthy tubers are graded in to different grades based on diameter of the tubers reduce the prices in the market. Therefore, such tubers should be sorted and marked separately. Over sized tubers are great in demand for chips making. Very small sized tubers are also not remaining unsold. These tubers are purchased by poor people for making vegetable by partially Cushing them before cooking. However, both the over sized and under sized are quite unsuitable for seed purposes. Potatoes can be stored in the cold storage at the temperatures of 4 to 7°C and relative humidity.

Diseases and Pests

Diseases

Non-Viral Diseases

Early Blight (*Alternaria solani*)

The infection appears on lower leaves with necrotic spots having concentric rings. The fungus survives in the soil. In diseased plant debris. The collateral host is tomato. High moisture and low temperature are favourable for disease.

Control Measures

- (i) Follow crop rotation
- (ii) Collect and burn plant debris after harvesting
- (iii) Start sprays the crop Dithane M-45 at 0.2 per cent 30 to 35 days after planting and repeat 10 to 15 days interval
- (iv) Grow early blight tolerant varieties such as Kufri Naveen, Kufri Sindhuri and Kufri Jeevan.

Late Blight (*Phytophthora infestans*)

The infection appears at the tips or edges of the lower leaves with circular or irregular water soaked spots. White downy fungus growth appears on the underside of the leaves around the spots. Cloudy weather is conducive for very fast spread of the disease. In case of severe incidence all above ground parts may show rotting. Later the disease may spread to tubers and initiate rotting.

Control Measures

- (i) Plant only healthy disease free certified seed tubers.
- (ii) Spray the crop thoroughly with diathane M-45 (2.0 kg/ha) or diathane Z- 78 (2.5 kg/ha) or difolatan (2.5 kg/ha) well in advance to general appearance of disease. The spraying operations should remain continue at narrow interval of 5 to 6 days during cloudy weather.
- (iii) Dig out tubers when foliage is completely dry or cleaned. (iv) Grow late blight resistance varieties like Kufri Navaharl. (v) Avoid applying in excess nitrogen and irrigation.

Black Scurf (*Rhizoctonia solani*)

The infected plants killed, stem canker may also be formed. Affected plants may form aerial tubers. On tubers, black sclerotial bodies are formed. It is a soil as well as tuber borne disease.

Control Measures

- (i) Always sow certified seeds
- (ii) Treat the seed tubers with any organo mercurial fungicides containing 6 per cent mercury {agallol, aretan, emisan etc.) for about 5 to 10 minutes before the planting and also seed tubers before keeping in the cold storage.
- (iii) Dip the tubers in 1.75 per cent solution of sulfuric acid for 20 minutes.
- (iv) Apply Brassicol at 30 kg per hectare in the soil at the time of sowing.
- (v) Apply sawdust at 25 q/ha with recommended doses of nitrogen at least 15 days before sowing.

Common Scab of Potato (*Streptomyces scabies*)

It survives in soil years together and on infected tubers in cold storage. It may also spread through manure. Affected tubers show the superficial roughened areas of corky tissue, often slightly below the plane of healthy skin of tubers. Low soil moisture is favourable for proliferation of causal pathogen.

Control Measures

- (i) Obtain healthy, disease free seed tubers for planting.
- (ii) Disinfect the tubers by dipping in suspension of mercurial fungicide e.g. emisan-6 or agallol- 6 at 0.25 per cent concentration for 5 minutes,
- (iii) Plant the tubers shallow.
- (IV) Keep the soil wet during tuberization.
- (v) Follow crop rotation with non-host crops including beets, carrot etc.
- (VI) Maintain soil pH 5.0 to 5.3.

Black Leg or Soft Rot (*Erwinia spp.*)

It is caused by different species of bacteria. The base of shoots develops a blackened shriveled cortex and its growth is stunted. Leaflets become reddish in colour at the tips, branches become stiffened and more upright than normal. The affected haulms are jet black in colour at the soil level. The tubers become watery and upon rotting give off offensive sulphurous odour.

Control Measures:

- (i) Obtain healthy seed tubers for planting.
- (ii) Avoid planting of cut seed potato.
- (iii) Avoid planting too early and too late in the season.
- (iv) Collect and destroy affected plants as and when seen in the field.

- (v) Avoid injury to tubers during harvesting, transit and storage.
- (vi) Wash the tubers with chlorinated water before storage.
- (vii) Keep the stores well ventilated, dry and cool.

Bacterial Brown Rot or Wilt Disease (*Pseudomonas solanacearum*)

Affected plants show dwarfing and bronze discolouration of the leaflets. When affected stem or tubers cut across, the browning of the xylem vessel is seen, and upon squeezing, the whitish bacterial ooze may come out.

Control Measures

- (i) Obtain healthy, disease free seed tubers for planting.
- (ii) Collect and destroy infected plants.
- (iii) Avoid flowing rain or irrigation water from diseased field to healthy one.
- (iv) Disinfect cutting knife with a suitable bactericide solution, whenever diseased tubers are cut.
- (v) Follow crop rotation with non-host crops such as maize, soybean and red top grass for at least three years in the field,
- (vi) Reduce the application of organic manure (it promotes activity of bacteria) but apply high doses of inorganic fertilizers (decrease the activity).
- (vii) Treat the seed tubers in 0.02 per cent streptomycin for 30 minutes after giving five mm deep cut.

Charcoal Rot (*Macrophomina phaseoli*)

The roots of the affected plants become brown in colour. The rotting starts on the stem portion. The skin of the stem becomes ash coloured. The dark lesions appear at the lenticels of the tubers and also round the stem end of tuber. Charcoal rot is common during the hot and dry months in late season crops.

Control Measures

- (i) Obtain disease free seed tubers for planting. Hill potatoes are nearly free from this pathogen.
- (ii) Grow early maturing varieties such as Kufri Alankar or Kufri Chandramukhi.
- (iii) Irrigate crop at regular intervals.
- (iv) Seed tubers may be treated with aguarol-6 or aretan at 0.25 per cent solution before storage. The treated tubers should not be eaten.

Wart Disease of Potato (*Synchytrium endobioticum*)

It is caused by the fungus. Affected plants show warty out growth protuberances on stems, stolons and tubers. The roots are not affected. The wart consists of distorted,

proliferated-branched structures grown together into a mass of hyper parasitic tissue. It is difficult to control once it has been established in a field.

Control Measures

- (i) Avoid growing potatoes in known wart-affected soil.
- (ii) Obtain disease free seed tubers for planting. (iii) Soil treatment with 5 per cent formalin is effective but very costly. (iv) Grow wart tolerance varieties like Kufri Sherpa, Kufri Jyoti, Kufri Jeevan and Kufri Muthu.

Viral Diseases

Leaf Roll

A virus known as potato leaf roll virus, potato virus 1, solanum virus 14 or Corium solani Holmes causes it. Transmission of virus in nature occurs through infected tubers and through insect, an aphid (*Myzus persicae*). Affected plants become dwarf, more upright than normal, the leaves are rolled, especially the lower one. They are thick and leathery.

Mosaic Disease

Potato crop is affected by mainly three types of mosaic.

Type of mosaic	Caused viruses
Mild mosaic	Potato Latent virus, Potato Virus X, Potato Mottle Virus, Solanum Virus-I
Rugose mosaic	Potato Virus X and Potato Virus Y
Cinkle of potato	Potato Virus X and Potato Virus A

Control Measures of Potato Viral Diseases

- (i) Plant only certified seed tubers
- (ii) Apply anyone of the systemic insecticides like thimet, temik or furadan in the furrow at 10 kg per hectare at the time of planting
- (iii) Uproot affected plants along with complete root system and mother tuber, and destroy them
- (iv) Spray the crop with metasystox at 0.1 per cent to control aphid population
- (v) Remove haulms in the first week of January, when aphid population build up is very fast.

Phytoplasma Diseases

Potato Witches Broom

Infected plants develop many axillary and basal shoots giving 'witches broom' appearance and develop small, pigmented tubers. These tubers sprout even attached to infected plants (Nagaich et al., 1974). The disease is transmitted by grafting and leafhopper

(*Orosius albicinctus*). Tuber transmission is also very high. The pathogen can infect tomato, brinjal, *Datura fastuosa*, *D. metel*, *Nicandra physaloides*, *Vinca rosea* and *Calendula officinalis*. This disease can be controlled by hot water treatment of 'witches broom' affected tubers at 50 °C for 10 minutes, causes degeneration of pathogen and plants developed from such tubers did not develop symptoms upto 6 to 7 weeks.

Purple Top of Potato

The typical symptoms are purple pigmentation and rolling of basal parts of leaflets of young top leaves. The affected plants are stunted have many axillary shoots with aerial tubers. Root system is poorly developed (Nagaich and Giri, 1973). It causes phloem fluorescence. The disease is transmitted by grafting and leafhoppers (*Alebroides nigrocutellatus*, *Orosius albicinctus* (and *Serianthe equata*), Tuber transmission is also common but the extent varies with age of plants, the host range of pathogen includes tomato, tobacco, brinjal, clove, *Datura stramonium*, *Calendula officinalis*, *Cyphomandra betacea* etc, *Phyalis floridana*, *Vinca rosea*, Oxytetracycline, benlate, cycloheximide etc. are highly effective and causes 70 to 96 per cent remission of symptoms.

Marginal Falvescence of Potato

Flavescence or chlorosis along the margins of leaflets of upper leaves and small, narrow leaflets are prominent symptoms, affected plants are stunted and produce clusters of small tubers, which have shorter dormancy and produce hairy sprouts. It causes phloem fluorescence (Nagaich and Giri, 1973). The disease is transmitted by grafting and hopper, *Seriana equata* the disease can infect other hosts like, tomato, tobacco, brinjal, *calendula officinalis*, *physalis floridana*, *vinca rosea*, and *cyphomandra betacea*. Treatment of affected plants with antiemoebic + benlate or benlate + BP causes remission upto 80 per cent.

Potato Phyllody

The disease is characterized by extreme hairiness and roughing of leaves and stems. Chlorotic leaves develop small leaflets but enlarged petioles. Infected plants develop several naked androecia as small yellow "rosettes" and axillary aerial tubers Phyllod flowers are enlarged and have cupped calyx and corolla (Khurana et al 1983). It has wide host range and includes *Dianthus barbatus*, *Pisum sativum*, *Lycopersicon chilense*, *Phyalis floridana*, *Solanum nigrum* and *Daucus carota*. The pathogen can be eliminated by subjecting infected tubers to hot water treatment at 50 °C for 10-15 minutes.

Pests

Cut Worms (*Agrotis* spp, *Euxoa* spp)

They cut the sprouts at ground level. They feed only at night. They also attack tubers and make holes, thereby reducing market prices.

Control Measures

- (i) Spray the crop with dursban 20 EC at 2.5 ml per litre of water or drench the plants, where the damage is noticed.
- (ii) Apply phorate 10 G granules at 10 kg I per hectare on soil around the plants and rake the soil thereafter.
- (iii) Use only well rotten farmyard manure.

Epilachna Beetle

Both the adults and larvae of this beetle feed on skeletonization of leaves.

Control Measures

- (i) Pick up the eggs, larvae and adults by hands.
- (ii) Spray the crop with carbaryl at 0.1 per cent.
- (iii) Dust the crop with sevin dust at 30 kg per hectare.

Leaf Eating Caterpillars (*Spilosoma obliqua*, *Spodoptera exigua*):

Both the caterpillars cause damage by feeding potato leaves.

Control Measures

- (i) Spray the crop with thiodon 35 EC or endocel at 0.15 per cent
- (ii) Making border around the field with carbaryl dust would be effective control.

Aphids (*Myzus persicae*)

Aphids sucks the sap from leaves. Affected plants become weak, leaves become yellow and curl downwards. Aphid secretes honeydew, which gives rise to sooty mould and other fungal diseases.

Control Measures

- (i) Spray the crop with rogor or metasystox or nuvacron or monocil at 1 ml per liter of water, and repeat the spray 10 to 12 days interval
- (ii) Apply thimate 10 G granules at 10 kg per hectare in furrows at the time of planting.
- (iii) Cut the haulms in the first week of January to check the transmission of virus through seed potatoes.

Jassids

They are slender wedge shaped green hopping insects. They are diagonally. They suck sap from under surface of leaves causing yellowing, curling and later burning of leaves called 'hopper bums'

Control Measures

- (i) Spray the crop with metasystox at 0.1 per cent.
- (ii) Apply thimet 10 g granules at 10 kg per hectare in furrows at the time of planting.

Potato Tuber Moth (*Phthorimaea operculella*)

It is major pest of potato in storage. It can also attack in the field. It bores and makes tunnel into the potato tubers.

Control Measures

- (i) Sow healthy insect free potato tubers.
- (ii) Use only well rotten farmyard manure.
- (iii) Do earthing carefully, so that tuber is not exposed in the field to ovipositing female moths
- (iv) Spray the crop with carbaryl or nuvacron or monocil at 0.1 per cent.
- (v) Disinfect the go down with Malathion at 0.05 per cent before storing potatoes.
- (vi) Sort out all affected tubers before storage.

Golden Nematode (*Globodera rostochiensis*, *Heterodera rostochiensis*)

It is also known as potato root ell worm or potato cyst nematode. The infected plants produced additional rootlets near the soil surface. Later, outer leaves become prematurely yellow and die.

Control Measures

- (i) Keep the infested area in quarantine to prevent the spread
- (ii) Avoid growing tomato or brinjal in infested soil.
- (iii) Follow crop rotation excluding solanaceous crop.
- (iv) Treat the soil with DD at the rate of 90 gallons per hectare.
- (v) Avoid the soil seed tubers brought from infested area.

Root Knot Nematodes (*Meloidogne incognita* and *M. javanica*)

Affected plants are stunted, sickly and may show premature and sudden drying. Tiny galls are formed on tubers. The nematodes survive as egg masses in diseased root and tuber in soil.

Control Measures

Similar control measures as described in tomato.





1. _____ is an example of an edible stolon
 - a. Potato
 - b. Carrot
 - c. Cut tuber
 - d. All the above
2. Which of the following is the order in which the potato tuber develop?
 - a. Initiation, tuberization and maturation
 - b. Tuberization, initiation and maturation
 - c. Initiation, maturation and tuberization
 - d. None
3. A vegetable that produces 'haulm' is
 - a. Groundnut
 - b. Potato
 - c. Sweet potato
 - d. Tapioca
4. Which of the following is the latest variety released which is suitable for chipping
 - a. Kufri Chandramuki
 - b. Kufri Chipsona 2
 - c. Kufri Chipsona 3
 - d. Kufri Dewa
5. Alkaloid present in potato
 - a. Tomatine
 - b. Solanin
 - c. Salosidine
 - d. Sinigrin

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR SWEET POTATO

Ipomoea batatas L. (2n = 90)

(Hindi: *Shakarkand*, *Mitha alu*) Family: Convolvulaceae

Sweet potato is cultivated for its sweet root tubers. It is mainly used for human food after boiling or steaming, baking or frying and also as animal feed. Since roots contain 16% starch and 4% sugar, it is used for production of industrial starch, syrup and alcohol.

Origin and distribution

Sweet potato is a native of tropical America. It is an important tuber crop in tropical and sub-tropical countries like Africa, China and India. In India, it is grown mainly in Andhra Pradesh, Assam, Bihar, Tamil Nadu and Orissa.

Climate

Sweet potato requires well drained fertile soil rich in humus. Sandy loam soils with clay sub soil are ideal for tuber production. In heavy soils, tuber size is reduced. Ideal soil pH is below 5.2, liming is necessary.

Botany

Sweet potato is a hexaploid species with 90 somatic chromosomes. It is a perennial herb with trailing vines and with a cluster of a few medium sized tubers. For cultivation purpose, it is treated as an annual with duration of 90 to 120 days. Though plants produce viable seeds, highly heterozygous nature of the crop results in a heterogeneous population. Hence stem cuttings are used for propagation purpose.

Sweet potato has an extensive fibrous root system both at stem cuttings and at nodes touching soil. Some roots act as storage organs for storing reserve food. Storage roots may be fusiform, spindle or globular in shape and surface is smooth. Skin has white, red or light copper colour. Flesh may be white or with different combinations of orange and red.

Leaves are simple, alternate and stipulate. They vary in size and shape, occasionally in same plant. Shape varies from ovate to cordate, hastate or deeply lobed and may change on ageing. Leaf shape is an important character for identifying clones.

All clones do not flower and in flowering ones, duration and initiation of flowering vary. Flowers are axillary and borne solitary or in simple cymes. Flowers are bisexual. Corolla is attractive and funnel shaped formed by fusion of five petals. Anthesis starts before dawn and closes by 9-11 a.m. Pollination is entomophilous. Fruit is a capsule with false septa. Seed coat is hard and impervious to water. Hence, scarification is required for promoting germination.



Varieties

Sweet potato varieties differ in shape, size and colour of leaves, tubers and nature of tuber flesh. A number of local cultivars like Badrakali chuvala, Chakkaravalli, Anakomban and Kottaram chuvala are grown in Kerala. The Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram developed quite a good number of varieties and a brief description of them is given below:

Varsha: A semi-spreading hybrid with reddish purple skin, light yellow flesh and excellent cooking quality; yield 18-22 t/ha in 120-125 days.

Sree Nandini: A spreading variety with light cream skin, white flesh and good cooking quality; yield 20-25 t/ha in 100-105 days.

Sree Vardhini: A semi-spreading variety with purple skin, light orange flesh and high carotene content (1200 I.U.); yield 20-25 t/ha in 100-105 days. Tolerant to Feathery mottle virus.

Sree Ratna: A spreading variety with purple skin, orange flesh and excellent cooking quality; yield 20-26 t/ha in 90-105 days.

Sree Bhadra: A semi-spreading variety with light pink skin and cream flesh; resistant to root knot nematode; yield 20-27 t/ha on 90-95 days.

Sree Arun: A spreading variety with pink skin, cream flesh and good cooking quality; yield 20-28 t/ha in 90-100 days.

Sree Varun: A spreading variety with cream skin, cream flesh and good cooking quality; yield 20-28 t/ha in 90-100 days.

The Kerala Agricultural University developed an improved variety, Kanjangad, yielding 12.39 t/ha. Purple coloured and spindle shaped tubers have yellow soft flesh. It is tolerant to shade and weevil incidence.

IARI, New Delhi released two improved varieties viz., Pusa Safed, and Pusa Sunheri.

Pusa Safed: A white skinned variety with white flesh

Pusa Sunheri: A brown skinned variety with yellow flesh rich in carotene; boiled flesh is attractively orange yellow.

Acharya Ranga Agricultural University, Hyderabad developed following improved varieties:

Cross-4: Yield 20-30 t/ha in 90-105 days; highly susceptible to weevil infestation.

Rajendra Shakarkand-5: Yield 30 t/ha in 105-120 days; resistant to *Fusarium* wilt and *Cercospora* leaf spot disease.

Kalmegh: A short duration variety (90 days) yielding 26 t/ha.

Tamil Nadu Agricultural University has developed two varieties viz., Co.1 and CO.2 yielding 26 t/ha and 32 t/ha, in 135 days and 110-115 days, respectively.

Raising nursery

Sweet potato is mainly propagated by vine cuttings of 25-30 cm length. Cuttings for planting are multiplied in two nurseries – primary and secondary. Tubers in primary nursery are planted three months ahead of planting. A nursery area of 10m² is required to raise vines for planting one hectare. Ridges are prepared at 60 cm apart and tubers of 125-150 g weight are planted and irrigate as and when required. Clip off vines to a length of 20-30 cm at 40-45 days after sowing tubers for planting in secondary nursery.

A 500 m² secondary nursery is required to plant cuttings obtained from 100 m². Plant the cuttings at 25 cm apart in ridges taken at a spacing of 60 cm. 5 kg urea may be applied at 15-30 days after planting in nursery. Clip off cuttings in 20-30 cm length after 45 days from middle and top portion of vines. Cut vines are stored with intact leaves in shade for two days prior to planting in main field.

Preparation of main field and planting

Vines are planted during June-July for a rainfed crop. Crop. Under irrigated conditions, plant during October-November in upland and during January-February in low lands for summer crop. Main field is prepared by making ridges of 25-30 cm high at 60 cm apart after thorough ploughing. 20-30 cm long vines are buried horizontally with 2-3 nodes below soil, leaving the remaining portion above soil.

Manures and fertilizers

Apply 5 tonnes of farmyard manure / ha at the time of preparation of ridges. A fertilizer dose of 50:25:50 kg NPK / ha is recommended, of which 50% of N, full P and K to be applied as basal dose. Remaining 50% of N is applied one month after along with weeding and earthing up.

Irrigation

During *rabi* and hot seasons, 12-14 irrigations are required at an interval of 10 days for heavy yield.

Harvest

Harvesting is done by digging out tuber with pick-axe when leaves turn yellow in colour. Tubers are cleaned and packed in gunny bags for marketing.

Yield: 6-9 t/ha for rainfed crop & 12-15 t/ha under average management.

Storage

Red skinned varieties store better than white skinned varieties. Tubers are stored better at 15°C and 85% RH. Tubers can also be stored for 2-3 months in a pit covered with straw.

Pests and diseases

Sweet potato weevil (*Cylas formicarius*) is the most important pest causing severe damage to the crop. Adult weevil makes puncturing on vines and tubers. Grubs bore and feed by making tunnels. Even slightly damaged tubers are unsuitable for consumption due to bitterness. Yield loss is up to 100% in severe cases. On an average, 20-55% tuber loss occurs. Integrated pest management practices recommended for control include dipping vine cuttings in Fenthion or Fenitrothion or Monocrotophos (0.05%) solution for 10 minutes before planting. Reridging the crop two months after planting, installing synthetic sex pheromone traps @ 1 trap / 100 m² area to collect and kill the male weevils and destroying crop residues after harvest by burning are recommended control measures.

1. Sweet potato is also known as _____
 a. Spanish potato b. Indian potato c. Chinese potato d. Potato beans
2. Sweet potato belongs to _____ family
 a. Suphorbiaceae b. Convolvulaceae c. Umbelliferae d. Fabaceae
3. Sweet potato is propagated by _____
 a. Terminal stem cutting b. Tuber c. Grafting d. Air layering
4. _____ is the major producer of sweet potato
 a. India b. China c. Canada d. Egypt
5. The yellow flesh of sweet potato contains high amount of _____
 a. Calcium b. Boron c. Carotene d. Niacin

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR TAPIOCA

Cassava: (Syn: Tapioca) *Manihot esculenta* (Crantz)

(2n = 2x = 36)

(Hindi: *Mravuli*)

Family: *Euphorbiaceae*

Cassava is the most important starchy root crop grown in the tropics and is mainly cultivated in southern peninsular India. Introduced during seventeenth century by Portuguese, the crop played a significant role to overcome food shortage among the low income group of people in Kerala. Underground tuber is rich in starch and mainly consumed after cooking. Processed products like chips, sago and vermicelli made of tapioca are also popular in the country. Being easily digestible, it forms an important ingredient in poultry and cattle-feeds. It is also widely used for production of industrial alcohol, starch and glucose.

Origin and distribution

Cassava is not known in wild state. North-Eastern Brazil is the centre of origin. Portuguese distributed the crop from Brazil to countries like Indonesia, Singapore, Malaysia and India.

Nigeria is the major growing country in world accounting for 50% of area and production. In India crop is cultivated in southern peninsular region, particularly Kerala, Tamil Nadu and Andhra Pradesh contributing 93% of area and 98% of production in the country. Kerala accounts for nearly 50% of total area under cassava in India and is mainly grown as rainfed crop.

Botany

Cassava belongs to family Euphorbiaceae and is diploid (2n=36). Polyploids with 2n=54 and 72 are also available. It is a perennial shrub producing 5-10 cylindrical tubers per plant. Being a member of family Euphorbiaceae, it produces latex. The stem is woody and variously branched. Two distinct types are present – one without branching at the top and the other with spreading nature. Leaves are palmately lobed with 5-9 lobes. Cassava is monoecious in nature and cross-pollinated. Female flowers are a few in numbers and are borne in the base of inflorescence and male flowers are borne above. Female flowers open about 10 days before male flower anthesis. Stigma is receptive from 6.30 a.m. and continues up to 2.30 p.m.

Plants when raised from seeds produce typical tap root system. Since crop is mainly propagated by vegetative means by stem cuttings, numerous adventitious roots develop, of which a few develop into tubers. Tubers are composed of a thin peridium, while a few develop into tubers. Tubers are composed of a thin peridium, white or purple cortex known as rind and

central massive flesh rich in starch (25-40%). Bitterness often encountered in a few varieties and at certain stage is due to a bitter principle cyanogenic glucoside (HCN).



Varieties

Varieties differ in colour of rind and flesh, size of tubers, colour of stem, leaf and petiole, branching pattern, duration of crop and resistance to mosaic disease. High amount of cross-pollination results in heterozygous nature. Vegetative method of propagation resulted in development of a number of polyploidy varieties and hybrids. Most of the crop improvement works on cassava are done at the Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram. Important varieties developed at CTCRI are given below:

H-97: This erect branching hybrid, developed by crossing Manjavella Local with a Brazilian Local, is characterized by the light sepia colour of emerging leaf with brown tubers; yield 25-35 t/ha in 10 months.

H-165: This is a non-branching hybrid with mature leaves showing drooping nature; tubers are relatively short with cream coloured rind; yield 33-38 t/ha in 8-9 months.

H-226: This semi-branching hybrid having characteristic green coloured leaves; tuber rind is light purple and skin is cream with purple patches; susceptible to cassava mosaic disease (CMD); yield 30-35 t/ha in 10 months.

Sree Sahya: This is a multiple hybrid involving five parents. It is non-branching with dark brown petiole and spiny prominent stipular mark; tubers are long and rind is cream coloured; yield 35-40t/ha in 10-11 months.

Sree Vaisakham: This is a semi-branching hybrid with slightly yellow fleshed tubers which remains yellow even after cooking; carotene content is 466 IU / 100 g; tuber rind is cream and skin is brown coloured; yield is 35-38 t/ha in 10 months.

Sree Prakash: This is a short, non-branching, early maturing (7-8 months) variety developed by clonal selection; highly tolerant to *Cercospora* leaf spot; yield 35-40 t/ha in 7-8 months.

Sree Harsha: This is a triploid clone developed by crossing a diploid with an induced tetraploid clone of 'Sree Sahya'; plants are stout, erect and non-branching with tubers of good cooking quality and high starch content (38-41%); yield 35-40 t/ha in 7-8 months.

Sree Jaya: This is a short-duration (6 months) clonal selection suitable for low land cultivation as a rotation crop in paddy-based inter-cropping system; tubers are with brown skin and purple rind and have good cooking quality; yield 26-30 t/ha; susceptible to CMD.

Sree Vijaya: This is also a short-duration (6-7 months) clonal selection suitable for low land cultivated as a rotation crop in a paddy-based inter-cropping system; tubers are with cream coloured rind and light yellow flesh due to high carotene; susceptible to mite and scale insect; yield 25-28 t/ha in 7 months.

M-4: This is a non-branching variety with excellent cooking quality; susceptible to mites; yield 18-23 t/ha in 10 months.

Sree Rekha: Erect branching variety with excellent cooking quality; susceptible to mites; yield 18-23 t/ha in 10 months.

Sree Prabha: Semi-spreading variety with good taste and quality; yield 35-40 t/ha in 10 months.

Three varieties viz., Nidhi, Kalpaka and Vellayani Hraswa were developed by Kerala Agricultural University.

Nidhi: Yield (25.1 t/ha), tolerant to mosaic, short duration (5-6 months) grayish white stem, petiole white with red shade, skin light pink.

Kalpaka (KMC-1: Yield (28.4 t/ha), short duration (6 months), non branching stem, pink tuber rind.

Vellayani Hraswa: High yield (44.01 t/ha), short duration (5-6 months), pink tuber rind, excellent cooking quality.

Tamil Nadu Agricultural University also developed three varieties viz., CO-1, CO-2 and CO-3.

CO-1: A clonal selection with tubers having whitish brown skin, creamy rind and 35% starch; yield 30 t/ha in 8-9 months.

CO-2: A branching variety with tubers having brown skin, creamy white rind and 34.6% starch; yield 35 t/ha in 8-9 months; suitable for consumption and industry.

CO-3 : A branching variety having tubers with brown skin and 35.6% starch; yield 42.6 t/ha in 8 months.

Co (Tp) 4: Selection from Me501, Yield 50 t/h, Starch 40 %, Field tolerant to Red

Spider mite and scales

CTCRI CO (Tp) 5: Seedling selection, Released during 2007, Yield

Potential 30t/ha, Starch content 26%,Resistant to CMD, Duration 10 months, Suitable to irrigated conditions

Climate

Cassava is a tropical crop tolerant to drought and cannot withstand frost. It is grown in altitudes up to 2000 m, but performance is better in lower altitudes. Though crop can be grown even in semi-arid conditions, growth and productivity are better in warm humid climate with well distributed rainfall.

Soil

Cassava grows on all types of soils, but saline, alkaline and ill-drained soils are not suitable. Crop is mainly grown in laterite soils to loam in Kerala and black and red soils in Tamil Nadu.

Season of planting and preparation of sets

As an irrigated crop, cassava can be planted during any part of year, but December-January planting is better. As a rainfed crop, planting is done during April-May before onset of South-West Monsoon and during September-October coinciding with North East monsoon.

Stem cuttings, usually called as sets, for planting are taken from disease free stakes of 8-10 months maturity having a thickness of 2-3 cm diameter. Discard woody basal portion and tender top portion of stem. Prepare sets of 15-20 cm length with a smooth circular cut at the base and slanting cut at top for easy identification of base and top. The circular cut at base ensures uniform callus formation and root initiation. Sets prepared from stem stored for 15 days with leaves give better sprouting.

Land preparation

Land is ploughed or dug properly for loosening soil to a depth of 20-25 cm. Depending on texture of soil and slope of land, mounds or ridges or raised beds are prepared. Mounds of 25-30 cm height are prepared in poorly drained soils. Ridges of 25-30 cm length are made in slopy land for a rainfed crop and in leveled for irrigated crop. Ridges are taken across the slope. Flat raised beds are taken in level lands having good drainage. Since cassava mosaic disease is a serious problem, care should be taken to select disease-free stakes for preparation of sets. Raising sets initially in raised beds by planting very close (400 sets / m²), rouging out diseased plants and uprooting disease-free sets for planting at 3 weeks age ensure disease-free seedlings.

Planting

Sets 25 – 30 cm length are planted vertically in beds, mounds or ridges to a depth of 5 cm. Care should be taken to avoid planting of sets inverted. Spacing depends on branching pattern of varieties. Normally erect and non-branching varieties are planted at 75 x 75 cm and branching or semi-branching varieties at 90 x 90 cm. In case, sets are dried after planting, 5% of stakes may be planted as reserve in field, separately at a closer spacing of 4 x 4 cm for gap filling after 20-25 days.

Manures and fertilizers

Cassava is a heavy feeder and crop is to be adequately manured for getting high yield. Apply 125 tonnes of farmyard manure / ha as basal dose. For high yielding varieties, a fertilizer dose of 50 kg N, 50 kg P₂O₅ and 50 kg K₂O / ha is recommended at the time of land preparation. If planting of sets is done during hot condition, basal dose of fertilizers and manures may be postponed to one month after planting. This will avoid attack of termites and drying up of sets. Apply second dose of fertilizer i.e., 50 kg N and 50 kg K₂O, 45-50 days after planting along with weeding and earthing up. In short duration varieties, fertilizer dose can be reduced to 75:50:75 kg NPK/ha.

Interculture

Pinching off excess sprouts emerging from sets is necessary in cassava cultivation. This may be done 30-45 days after planting. As sprouts from top buds are more vigorous than those emerging from lower nodes, retain only two sprouts from top portion, that too on opposite sides of set.

Inter-culture operations are aimed at removing weeds in early stages of crop and to improve physical condition of sets for proper tuber development. First inter-culture operation

may be done sufficiently deep at 45-60 days after planting and a shallow inter-culture by way of weeding or earthing up may be given one month after the first.

Cassava is grown mainly as a rainfed crop in Kerala and irrigated crop in Tamil Nadu. Irrigating crop at 25% available moisture depletion level, could double tuber yield compared to irrigated crop.

Harvesting and yield

The crop is ready for harvesting in 10-11 months after planting. Short duration varieties can be harvested in 6-7 months. Delayed harvest results in deterioration of quality of tubers. Harvesting is usually done by uprooting plants gently by holding stem. After harvesting, stack stems vertically in well aerated place for use in subsequent planting.

Yield is 25-30 t/ha for short duration varieties and 30-40 t/ha for other varieties.

Intercropping

As cassava is widely spaced, intercropping with short duration crops like ground nut, French bean and bush cowpea will utilize light and water more effectively and give an additional income of Rs.3000-3500/ha within 3-3½ months. It adds organic manure to soil and controls weeds. Intercrops are to be adequately manured for avoiding competition with main crop.

Pests

- Two groups of spider mites occur during dry season from January to May. One group *Tetranychus cinnabarinus* and *T. neocaledonicus* feed on under surface of leaves causing elongated streaks, chlorosis and withering of leaves. In severe cases, it covers the upper surface also. The other group *Eutetranychus orientalis* and *Oligonychus biharensis* feed on upper surface of leaves causing depletion of chlorophyll, resulting in typical rusted leathery appearance. Curling of leaves starting from margins is also noticed. Water spray at run-off level, spraying neem oil or dimethoate (0.05%) is effective for control of mites.
- Scale insect (*Anoidomytilus albus*) attack stem when stacked and occasionally in field causing drying. Storing of stem in vertical position and spraying dimethoate (0.05%) will be effective for control of insect.
- Termites (*Odontotermes obesus*) and white grubs (*Leucopholis coneophora*) infest roots causing drying up of plants. In severe cases, follow soil application of insecticides.

Diseases

- Cassava Mosaic Disease is the most serious problem of cassava cultivation in Kerala and is caused by Gemini virus. Infested plants show reduction in leaf size and stunted growth, curling and typical mosaic pattern. Though quality is not reduced, yield

reduction is considerable. Field sanitation, selection of disease free stem for planting, timely rouging, control of vector (white fly – *Bemisia tabaci*), growing tolerant varieties like H-97, H-165, Sree Vaisakham and Sree Sathya are recommended for reducing disease incidence.

Tuber rot caused by *Phytophthora dreschleri*: This is more in ill-drained soils; infected tubers show brown discolouration of internal tissues and become rotten and emit foul smell. Remove infected tubers and apply *Trichoderma* spp in the soil.

1. Tapioca belongs to the _____ family
 - a. Solanaceae
 - b. Euphorbiaceae
 - c. Convolvaceae
 - d. Composital
2. The average productivity of tapioca in India is _____ t/ha
 - a. 15
 - b. 19
 - c. 22
 - d. 25
3. _____ is the major country growing cassava
 - a. Brazil
 - b. Mexico
 - c. India
 - d. Nigeria
4. Native of tapioca is
 - a. India
 - b. Brazil
 - c. Nigeria
 - d. India
5. Tapioca is _____ crop
 - a. Long day
 - b. Short day
 - c. Photo insensitive
 - d. None

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR COLACASIA AND TARO

Colocasia esculenta

Colocasia is a crop of tropical and sub-tropical regions and requires a warm humid climate. Under rainfed conditions, it requires a fairly well distributed rainfall around 120-150 cm during the growth period. Well-drained soil is suitable for uniform development of tubers.

Season

Rainfed crop: May-June to Oct-Nov

Irrigated crop: Throughout the year

Varieties

Sree Rashmi and Sree Pallavi are two improved varieties

Seeds and sowing

Use side tubers each of 25-35 g for planting. About 37,000 side tubers weighing about 1200 kg are required to plant one hectare. Plough or dig the land to a depth of 20-25 cm and bring to a fine tilth. Make ridges 60 cm apart. Plant the side corms at a spacing of 45 cm on the ridges.

Manuring

Apply cattle manure or compost @ 12 t/ha as basal dressing, while preparing the ridges for planting. A fertilizer dose of 80:25:100 kg of N: P₂O₅:K₂O per ha is recommended. Full dose of P₂O₅ and half dose of N and K₂O should be applied within a week after sprouting and the remaining half dose of N and K₂O one month after the first application along with weeding and earthing up.

After cultivation

Inter-cultivation is essential in colocasia. Weeding, light hoeing and earthing up are required at 30-45 days and 60-75 days after planting. The leafy parts may be smothered about one month before harvest so as to enhance tuber development.

Irrigation

Ensure sufficient moisture in the soil at the time of planting. For uniform sprouting, irrigate just after planting and one week later. Subsequent irrigation may be given at 12-15 days intervals, depending on the moisture retention capacity of the soil. The irrigation should be stopped 3-4 weeks before harvest. About 9-12 irrigations are required for the crop till harvest. In the case of rainfed crop, if there is prolonged drought, supplementary irrigation is required.

Mulching

Soon after planting, cover the ridges with suitable mulching materials for retention of moisture and to control weeds.

Plant protection

Colocasia blight can be controlled by spraying ziram, zineb, mancozeb or copper oxychloride formulations at 2 g/l of water (1 kg/ha). For controlling serious infestation of aphids, apply dimethoate or monocrotophos at 0.05%. Leaf feeders can be controlled by applying Malathion or carbaryl or endosulfan.

Harvesting

Colocasia becomes ready for harvest five to six months after planting. The mother corms and side tubers are separated after harvest.

Storage of seed material

The side tubers to be used as planting materials are usually separated from the mother corm and stored. Keep seed tuber in sand spread over the floor to avoid rotting.



1. _____ is the botanical name for Taro
2. Taro belongs to the family _____
3. Rich source of _____ is present in Taro
4. Taro is originated from _____
5. In Taro the mode of pollination is _____

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR YAMS**Amorphophallus****(Syn: Elephant foot yam) *Amorphophallus paeoniifolius*****(Syn: *A. campanulatus* (Roxb.) Blume) (2n = 28)**(Hindi: *Suran, Zamikand*) Family: Araceae

Elephant foot yam is a remunerative and profitable stem tuber crop. The crop is gaining popularity due to its shade tolerance, easiness in cultivation, high productivity, less incidence of pests and diseases, steady demand and reasonably good price. Tubers are mainly used as vegetable after thorough cooking. Chips are made of starch-rich tubers. Tender stem and leaves are also used for vegetable purpose. Tubers contain 18.0% starch, 1-5% protein and upto 2% fat. Leaves contain 2-3% protein, 3% carbohydrates and 4-7% crude fibre. Tubers and leaves are quite acrid due to high content of oxalates. Acridity is usually removed by boiling fairly for a long time. Cultivation of elephant foot yam is limited to India, Philippines, Sri Lanka and South East Asia.

Unlike other tubers, *Amorphophallus* roots have many medicinal uses and are widely prescribed by Ayurvedic physicians. *Amorphophallus* corm is a good source of phyto-aestrogens and is effective alternate of complementary to conventional hormone replacement thereby for symptoms associated with menopause and chronic degenerative diseases in women.

Botany

Cultivated species *A. paeoniifolius* is a robust herbaceous plant 1.0 – 1.5 m tall. Large dissected tripartite leaves constitute the luxuriant outspreading crown-like foliage, borne on a fairly thick single upright “stem”. The aerial “pseudostem” which is round with characteristic irregular blotches is botanically a leaf petiole.

Though crop is perennial due to underground stem, it is treated as an annual with duration of 8-9 months. It is usually harvested when top becomes yellow and withers (8-9 months after planting). It flowers once in 1-3 years. Inflorescence consists of a bell-shaped spathe surrounding a central yellow spadix and is borne on a very short stalk. It appears almost at ground level. Although wild species flower and set seeds profusely, cultivated species fail to set seeds under normal condition due to extreme protogyny coupled with delay in opening of spathe.



Amorphophallus paeonifolius

Climate and soil

Amorphophallus is a tropical / subtropical crop and hence thrives well under warm humid climate with a mean annual temperature of 30-35°C and a well distributed rain of 1000-1500 mm spread over a period of 6-8 months. It grows well on a variety of soils. Well drained sandy loam or sandy clay loam with near neutral soil reaction is ideal for the crop. Soil should be rich in organic matter with adequate amount of available plant nutrients.

Varieties

Sree Padma – Developed at CTCRI, Thiruvannthapuram; yield 42 t/ha

Gajendra – Developed at APAU, Hyderabad.

Propagation

Amorphophallus is propagated through corm. Corms harvested during November are stored in well ventilated rooms. Before planting during February, the corm is cut into sets of 750-100 g. each bearing a portion of central bud. Cut corms are smeared with cow dung slurry

or wood ash and allowed to dry in partial shade. Rapid seed corm production technique suggests use of cormels and mini sett transplants of 100 g size for planting at a closer spacing of 45 x 30 cm.

Cultivation practices

After one or two ploughings, pits of size 60 x 60 x 45 cm are made at a spacing of 90 x 90 cm during February. For harvesting small to medium sized tubers, distance between pits is reduced to 60 x 60 cm. Pits are half filled with top soil and well dried farmyard manure @ 2.0-2.5 kg/pit and wood ash. Planting material is placed vertically in the pit. After compacting the planted tubers, pits are covered with organic mulches like green leaves or paddy straw. Apply fertilizer @ 40 kg N, 60 kg P₂O₅ and 50 kg K₂O / ha 45 days after plating along with mulching and application of cow dung or compost after receipt of rains. This is followed by digging interspaces and light earthing up. Top dressing is done with 40 kg N, 50 kg K₂O again one month after, along with shallow intercultural operations like weeding, light digging and earthing up.

Amorphophallus is mainly grown as a rainfed crop. During periods of late receipt of monsoon, a light irrigation is given during early stages of crop. Crop is susceptible to water stagnation.

Mulching immediately after planting is the most important operation in *Amorphophallus*. It not only conserves soil moisture and regulates soil temperature, but also suppresses weed growth.

A plant usually produces a single “stem”. In case of more numbers, it is advisable to remove it retaining only one healthy one.

Pests and diseases

Amorphophallus is free from major pests and diseases except collar rot caused by *Sclerotium rolfsii*. Water logging, poor drainage and mechanical injury at the collar region favour disease incidence. Disease can be managed by use of disease-free planting material, removal of infected plants, improving drainage, application of neem cake in soil, use of bio-control agents like *Trichoderma* and drenching soil with captan 0.2%.

Harvest and yield

Underground corms are harvested with pick axe or by digging when the top is completely withered and fallen. Crop will be ready for harvest in 8-9 months after planting. However on better market price, tubers can be harvested six month onwards. Average yield is 30 - 40 t/ha.

1. Sree Padma is a variety of
a. Yam bean b. Chinese potato c. Greater yam d. Elephant foot yam
2. The edible portion of yam is the under ground modified _____
a. *A. campanulatus* b. *A. oncophyllus* c. *A. riveri*, d. All the above
3. The maturity indices for harvest of elephant foot yam is _____
a. Cracking of soil b. Drooping of the leaves
c. Yellowing and drying of leaves d. All the above
4. The total crop duration of Elephant foot yam is _____ months after planting
a. 4-5 b. 6-7 c. 9-10 d. None
5. The origin of elephant foot yam is _____
a. Europe b. India c. China d. Japan

YAMS

Plants belonging to genus *Dioscorea* of family Dioscoreaceae under Monocotyledons are commonly known as yams. *Dioscorea alata* (greater yam) and *D. esculenta* (lesser yam) are main yams of India. Another species, *D. rotundata* (white yam or African yam), which is under extensive cultivation in Western Africa, recently introduced to India is becoming popular. All species are typical tropical crops grown for carbohydrate rich underground tubers. They form staple food in many parts of Western Africa. In *D. alata*, tubers are peeled, cooked and used as vegetable. *D. esculenta* is consumed after boiling and peeling.

Dioscorea alata



Dioscorea esculenta



Botany

Yam tuber is neither a root structure nor a stem, but may have its origin as a hypocotyls structure. Tuber grows from a small conical structure located at base of stem. In all yams, tubers are renewed annually. Tubers may be single or two or three. *D. esculenta* produces a large number of small and spindle shaped tubers. *D. bulbifera* and *D.alata* produces a large number of small and spindle shaped tubers. *D. bulbifera* and *D.alata* produce aerial bulbs called bulbils from axils of leaves. Whole tubers or pieces of tubers with stem are used for planting in yams. Bulbils can also used for propagation.

Stem is weak and climbs on trees by twining. In *D. rotundata* stem remains erect upto one metre height. Leaves are simple. All species are dioecious. Fruits are dehiscent tri-locular capsules. Seeds are small and dispersed by wind. Even though all the species have seed dormancy for three months, *D. alata* does not exhibit seed dormancy. In *D. alata*, majority of male clones are tetraploids ($2n = 40$) and majority of females have higher ploidy level ($2n=60$ or 80).

Varieties

Improved varieties developed at Central Tuber Crops Research Institute (CTCRI), Sreekrayam, Thiruvananthapuram in Kerala are given below:

Greater yam

(*Dioscorea alata*)

(Hindi: *Ratula*) ($2n = 20, 30, 40-80$)

Sree Keerthi: Tubers are conical with brown skin and white flesh having 20-22% starch. It yields 25-30 t/ha in 9-10 months.

Sree Roopa: Tubers are digitate in shape with black skin and white flesh. Productivity is 25-30 t/ha in 9-10 months.

Sree Shilpa: Tubers are swollen, oval and smooth with black skin and white flesh. Yield is 28 t/ha in 8 months.

Indu: Indu is a high yielding (39.39 t/ha) variety developed by Kerala Agricultural University. Tubers are digitate with brownish black skin and white to pale flesh.

White yam (*D. rotundata*)

Sree Subhna: Tubers are cylindrical with brown and partially hairy skin and white flesh. Yield is 35-40 t/ha in 9-10 months.

Sree Priya: It produces 2-3 tubers having smooth surface and good cooking quality. Yield is 35-40 t/ha in 9-10 months.

Sree Dhanya: This is a dwarf and bush variety with spineless stem and tubers containing 23.3% starch.

Propagation and time of planting

In greater yam and white yam, tuber pieces of 250-300 g size are used as planting material. For this, tubers are cut longitudinally with a portion of stem end and allowed to dry under partial shade after dipping in cow dung slurry. Planting is usually done during March-April.

Plough / dig land to a depth of 15-20 cm. Take pits of 45 cm³ at a distance of 1 m. Apply 1½ kg compost or well rotten cattle manure in the pit and fill up to ¾ with top soil. Plant tubers and mulch with dry leaves. Approximately 1800-2700 kg seed material is required to plant one hectare.

Manuring

Apply cattle manure or compost @ 10 t/ha as basal dressing before planting. A fertilizer dose of 80 kg N, 60 kg P₂O₅ and 80 kg K₂O per hectare in two split doses is needed for yams. Half dose of N, full dose of phosphorus and half dose of potash are to be applied within a week after sprouting. Remaining nitrogen and potash may be applied one month after the first application. Top dressing of fertilizers should be followed by weeding and earthing up.

Interculture

Vines are allowed to trail on shrubs or trees or props for high productivity. Tubers are harvested in 9-10 months when leaves turn yellow in colour. Harvesting is done by digging surrounding area and exposing tubers.

Lesser Yam (*D. esculenta*) (2n = 40, 60, 90, 100)

Hindi: (Suthni)

Sree Latha: Tubers are oblong to fusiform in shape with creamy white flesh and greyish brown skin covered with thin hairs. It yields 20-25 t/ha in 8-9 months. Tubers have 18.4% starch content.

Sree Kala: Tuber is sweet, round and smooth. Yield is 20-25 t/ha in 8-9 months.

Cultivation of lesser yam is different from that of greater yam or white yam. Plough / dig the land thoroughly and make small mounds at a distance of 70 cm after incorporating compost or well rotten cow dung. Plant whole tubers of 100-150 g. Manuring and other cultivation practices are similar to that of greater yam. Trailing is necessary to expose leaves to sunlight. It is done within 15 days after sprouting by coir rope attached to artificial supports in open area. Lesser yam is harvested in 8-9 months after planting. Harvesting is done by digging out tubers carefully.

Scale insect is a serious pest of yam and is usually controlled by dipping planting material in monocrotophos (0.05%).

1. Yams are _____ plants
 - a. Monococious
 - b. Dioecious
 - c. Shade loving
 - d. Perfect flowers
2. The basic chromosome number of *Dioscorea* is _____
 - a. 10
 - b. 20
 - c. 30
 - d. 40
3. _____ covers the major cropped area in Asia
 - a. *D. alata*
 - b. *D. esculenta*
 - c. *D. rotundata*
 - d. *D. cayenensis*
4. Sree Shilpa is _____ of *D. alata*
 - a. Hybrid
 - b. Variety
 - c. OP variety
 - d. Introduction
5. Among the yams, _____ doesn't require staking
 - a. *D. rotundata*
 - b. *D. alata*
 - c. *D. esculenta*
 - d. *D. bulbifera*

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR CARROT

CARROT - (*Daucus carota* L.)

(2n – 2 x 18)

(Hindi – Gajar)

Family: Apiaceae

Carrot is an ancient cool season root vegetable. Roots are used for making soups, stews, curries, pies, pickles and for salad purposes. Sweet preparation 'gajar halwa' prepared out of carrot is delicious and popular. Roots are also canned. Carrot roots are rich sources of α and β carotenes (1890 μ g/100g) and contain sucrose 10 times that of glucose or fructose. Carrot leaves are a good source of leaf protein. It is used as fodder and for preparation of poultry feeds.

Carrot has many medicinal properties. It increases quantity of urine and helps in elimination of uric acid. It has cooling effect and is beneficial for people suffering from gall stones, constipation and heat troubles.

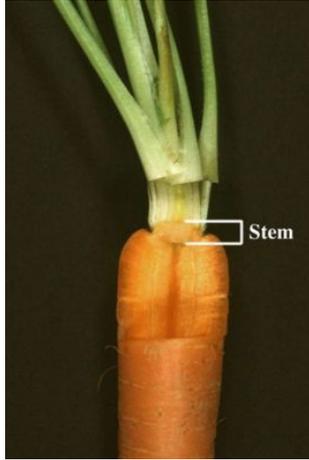
Purple and black carrots are used for preparation of a beverage called 'kanji' which is a good appetizer. In France, essential oil separated from seeds is used for flavouring liquors and all kinds of food substitutes.

Origin

According to Mackevic (1929), Afghanistan is the primary centre of origin of carrot since a large diversity for morphological and root characters occur. Considerable variability for root also exists in India, indicating India also as a centre of origin. Root colour varies from absolutely colourless through light lemon light orange, deep orange, light purple, deep purple to almost black.

Botany

Carrot is an annual or biennial herb with an erect or branched stem (30-120 cm high) arising from a thick fleshy root. Leaves are pinnate. Edible portion is the fleshy tap root composed of an outer cortex (phloem) and inner core (xylem). Inflorescence is compound umbel and is produced during second phase. Anthesis in a single umbel is completed in 7-9 days. Individual flowers are bisexual with white or yellow petals. The so-called carrot seed is actually a fruit, an indehiscent mericarp, which consists of a single seed. Two mericarps pair to form a single rhizocarp, the real carrot fruit which develops from a two-loculed ovary.



Root development

In most cultivars, the root first grows in length and then increases its diameter. By 12-16 days after sowing, the tap root reaches its optimum length. Shape and size of roots are influenced by several factors. Varietal characters, un-decomposed organic matter, any obstruction to its downward growth etc. are a few factors causing cracking, forking and branching of roots. Temperature also influences shape of root. Variety Chantney produces longer and more slender roots at 18°C, while they were shorter and thicker at 24°C. High temperature and irregular water supply cause deep depression on roots causing rough root

surface. Excessive irrigation after drought results in white corky outgrowth where side roots may develop.

Temperature has significant influence on colour and development of roots. A temperature range of 15.5 – 21.1°C is the best for colour development. Carotene content decreases above 21.1°C and below 15.5°C. Usually the young roots are yellowish in colour which changes to whitish yellow, light yellow, dark yellow, orange or orange red as a result of accumulation of carotenoids pigments. Carotene accumulation takes place first in old phloem cells followed by old xylem vessels and finally to centre core.

Cultivars / Varieties

Varieties with long, orange coloured and smooth roots are preferred in India. Many varieties, both indigenous and exotic, differing in temperature requirement, length, size, shape and colour of roots and duration of crop are grown in India. Varieties are also classified into temperate and tropical types.

- a. Temperate or European or biennial types require a low temperature of 4-8°C for flowering. They do not produce seeds in plains of India, e.g., Nantes, Half long, Early Nantes, Pusa Yamadagini and Ooty 1.
- b. Tropical or Asiatic or oriental or annual types which do not require low temperature for flowering and they produce seeds in plains of North India. E.g., Pusa Kesar, Pusa Meghali.

A brief description of important varieties is given below:

Tropical varieties

Pusa Kesar: Evolved at IARI, New Delhi by selection from a cross between Local Red and Nantes Half Long. Roots are scarlet in colour sufficiently red coloured central core compared to yellow or white core in Local; roots stay one month more than the Local red without bolting; contains high carotene (38 mg/100 g).

Pusa Meghali: Selection made at IARI, New Delhi by crossing Pusa Kesar and Nantes. It has long orange coloured tapering roots with self coloured roots.

Hisar Gairic: Roots long (18.5 cm), tapering, light brick red in colour, less fibrous with thin self colouring core. Yield 25-30 t/ha.

European varieties

Nantes Half Long: The variety commonly known as Nantes is evolved at IARI Regional Station, Katrain; roots are small, slim, rough, sweet, cylindrical and stumpy with abrupt tail; the core is small and self coloured; yield is 15-20 t/ha in 90-110 days.

Early Nantes: Roots almost cylindrical terminating abruptly in small thin tail, 12-15 cm long, orange flesh with self coloured core; duration 90-100 days.

Chantenay: Suitable for canning and storage; roots are reddish orange with a length of 11.5 – 15.0 cm.

Chaman: Developed at SKUA&T, Srinagar; roots long, cylindrical and semi blunt; tolerant to cracking; yields 25-27 t/ha.

Pusa Yamadagini: Developed at IARI Regional Station, Katrain; roots 15-16 cm long, orange with self coloured core, slightly tapering and semi-stumpy with medium top; 9-10 t/ha in 90-100 days.

Ooty-1: Developed at Horticultural Research Station (TNAU), Udthagamandalam: roots are 25 cm long with deep orange colour; yield 45-50 t/ha in 100-110 days.

Zino: Introduced from Germany in the Nilgiris hills of Tamil Nadu by the State Department of Horticulture; roots deep orange with self coloured core; duration 110-120 days.

Imported varieties like Danvers and Emperor are also popular in the country. Gold King Indian Kuroda, Nebora and Super Kuroda are a few of the carrot varieties marketed by private seed industry.

Climate

Climatic and soil factors have great influence on shape and colour development of roots. Carrot is grown as a spring summer and autumn crop in hills and as a winter crop in plains of North India. Ideal temperature for germination of seeds is 7.2-23.9°C, while for root growth and development it is 18.3-23.9°C. Tropical types produce roots even at a temperature of 25°C.

European types require a low temperature of 4.8-10.0°C for 4-6 weeks at any time during development of roots or after they mature either in storage or in field. Seed stalk formation takes place only when plants are subjected to a subsequent temperature of 12.2 – 21.1°C.

Soil

Deep and well drained friable soils are essential for proper root development. For early crop, sandy loam and for heavy yield, silt loam is preferred. Long rooted cultivars perform the best in light soil. In heavy soils, short stump rooted varieties having round and heart-shaped roots are preferred. In hard soils, roots will be rough and coarse. The ideal soil pH is 6.6 – 7.1

Land preparation and sowing

Soil is ploughed to a fine tilth. Utmost care should be taken to remove clods, stones etc. Land is then made to ridges and furrows at 30-45 cm apart in small plots of convenient size for

irrigation. Seeds are sown on ridges or on flat beds either by dibbling in lines or by broadcasting. Seeds are first rubbed to remove fine hairs and mixed with fine sand before sowing to facilitate even distribution. For sowing in lines, a small furrow of about 1.5 cm deep is made at top or on either sides of ridges with finger or with sharp end of a stick. Seeds mixed with sand are dropped in furrow by hand and is covered lightly with soil. Seed rate varies from 6 to 10 kg/ha depending on variety and sowing. Seedlings should be thinned to a plant to plant distance of 5-8 cm, soon after they are established. Otherwise, over crowding leads to deformed roots.

It is advisable to give light irrigation immediately after sowing or to soak seeds in water for 12-24 hours before sowing to hasten germination.

Manuring

In addition to 20-25 tonnes of farmyard manure, a fertilizer dose of 40-50 kg N, 40-50 kg P_2O_5 and 80-100 kg K_2O is recommended for the crop, of which entire dose of farmyard manure, half N and full P and K are to be applied as basal dose at the time of final land preparation. Remaining dose of N can be applied at the time of first hoeing.

Interculture

Carrot seeds take about a week to germinate and initial growth of seedlings is rather slow. First irrigation should be given immediately after sowing followed by another 4-6 days after. Soil should be kept moist by frequent light irrigation for proper growth of roots. Excessive irrigation, that too towards the last stage, should be avoided as it may result in excessive vegetative growth.

Since seedlings grow very slowly care should be taken to remove weed growth during initial stages.

Carrot roots do not come up like that of radish and hence, earthing up is not required. Soil should be hoed frequently to allow proper aeration and to prevent discolouration of crown.

Harvest

Roots grown on ridges are usually harvested after loosening soil with a spade and by pulling out roots by grasping top. In flat ground, top is removed close to ground and roots are dug out with a spade. A light irrigation is usually given before harvesting for easy uprooting.

Yield varies with season, climate, varieties etc. Tropical types yield 20-30 t/ha. and European types yield 10-15 t/ha.

Harvested roots are put in mulberry basket and dipped in flowering water for washing. Roots are then partially dried, trimmed and graded before sending to distant markets.

Trimming, grading etc. are done at a cool place. Fresh Carrot roots can be stored for 3-4 days under ordinary conditions and for six months at 0°C and 93-98% RH.

Seed production

Tropical annual types produce seeds in plains and temperate biennial types in hills. Both root to seed and seed to seed methods are recommended for carrot seed production. Seed to seed method is followed to get more seed yield. Root to seed method is followed to get quality seeds. However, in this method, high incidence of root rot is noticed. To check root rot in transplanted crop, planting roots without cutting is recommended.

Carrot is a cross-pollinated crop due to protandry and pollination is done by honey bees. Being a cross-pollinated crop, allow an isolation distance of 1000 m from other varieties. Opening of umbel starts from periphery and completed within 6-7 days. Seed yield is 500-600 kg/ha.

Pests and diseases

Pests and diseases are not major problems in cultivation of carrots. Among pests, carrot rust fly (*Psila rosae*) maggots burrow into roots resulting in unmarketable roots. **Lycus** bug damages seed crop and reduces viability and germination of seeds. Seed treatment with insecticides controls this pest.

Among diseases, *Cercocpora leaf spot and root rot caused by Fusarium oxysporum* adversely affect stand of crop. Watery soft rot caused by *Sclerotinia sclerotianum* occurs in storage.

Physiological disorders

Cavity spot - This is primarily caused by calcium deficiency induced by excess potassium. Symptoms appear as a cavity in cortex.



Carrot splitting – Splitting or cracking of roots is a major problem in carrot cultivation. Though this is a genetic character, other factors are also influencing cracking. Excess nitrogen and its untimely application promote cracking.



1. The mode of cross pollination in carrot is due to the presence of _____ flower.
 - a. Protogynous
 - b. Protandrous
 - c. Dichogamy
 - d. Duodichogamy
2. Carrot was first introduced in India from _____
 - a. Persia
 - b. Sri Lanka
 - c. Paris
 - d. Japan
3. Cavity spot of carrot is due to the deficiency of _____
 - a. Boron
 - b. Zinc
 - c. Calcium
 - d. Iron
4. Aster yellow is a disease of _____
 - a. Tomato
 - b. Carrot
 - c. Onion
 - d. Beetroot
5. Carrot root is a modification of
 - a. Adventitious roots
 - b. Tap root
 - c. Runner
 - d. Sucker

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR RADISH

(*Raphanus sativus* L.) (2n = 2x = 18)

(Hindi: Mooli) Family: Brassicaceae

Radish is grown for its tender tuberous roots which are eaten raw as salad or as cooked vegetable. It has a unique pungent flavour. It is also used in *Parathas* which are taken with curd for breakfast in north India. It has a cooling effect, prevents constipation and increases appetite and is more nutritious when cooked with leaves. Young leaves are also cooked as vegetable. It is recommended for patients suffering from piles, liver troubles, jaundice etc. Juice of fresh leaves is used as diuretic and laxative. Radish is a good source of vitamin-C and minerals.

Rat-tail radish (*R. sativus* var. *caudatus*), which is similar to common radish, is grown for its long slender pods which are used as salad or cooked vegetable. It will not produce fleshy root as in radish.



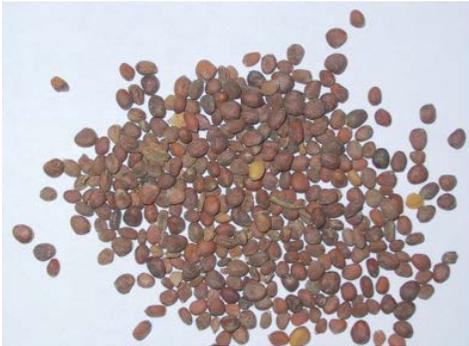
Origin

Radish is originated in Europe and Asia. It is believed to have originated from *Raphanus raphanistrum*, which is widely distributed as a weed crop in Europe.

Botany

Radish is an annual or biennial depending on the ecotype / cultivar. The rosette leaves are lyrate, pinnatifid and vary in size from 10 cm to 15 cm in small rooted cultivars to 45 cm in large rooted cultivars. Edible portion develops from both the primary root and hypocotyls. Inflorescence is of racemose type with white flowers. Fruit is a silique. Seeds are yellowish when mature and turn reddish brown with age. Radish is cross-pollinated due to sporophytic self incompatibility. Pollination is by honey bees and flies. Stigma receptivity is maintained up

to 4 days after anthesis. Selfing is by bud pollination. Flower buds are pollinated two days prior to opening of flower by collecting pollen grains of previously bagged flowers of the same plant.



Varieties

Radish varieties vary in shape, sized and skin colour of roots and duration of cop. The varieties can be divided into three groups – European or temperate types. Asiatic or tropical types and Indian types. Temperate types are of small size, with excellent quality and mainly used for salad purpose. Tropical types are more pungent than temperate types and have large

roots. An indigenous type, Jaunpuri Giant, cultivated Jaunpur in Uttar Pradesh, has roots of 75-90 cm length, 50-60 cm girth and weight up to 5-15 kg.

A brief description of improved varieties is given below:

Asiatic varieties		
Pusa Deshi	:	Roots are pure white, pungent, 30-35 cm long, tapering with green stem end; suitable for sowing in middle of August to middle of October in North Indian Plains.
Pusa Chetki	:	Suitable for sowing in hotter months, i.e., from March to August when no other variety is available in North Indian Plains; roots medium long, stumpy, pure white and medium pungent; duration 40-45 days.
Pusa Reshmi	:	Roots mildly pungent, 30-35 cm long, white with green shoulder; duration 55-60 days.
Japanese White	:	Developed at IARI Regional Station, Katrain by introduction; roots 20-30 cm long, cylindrical, mildly pungent and white with green shoulder; yield 15-30 t/ha in 60-65 days; suitable for sowing between October to December in plains and September in hills.
Punjab Safed	:	Developed at PAU, Ludhiana; roots white, tapering, 30-40 cm long, mild in taste, free from forking.
Punjab Pasand	:	Roots are long white and semi stumped. Suitable for sowing in October-November.
Punjab Agethi	:	Developed at Punjab Agricultural University, Ludhiana; roots medium long, red skinned at top and white skinned at lower half, the most suitable for sowing from April to August.
Kalyanpur No.-1	:	Roots 22-23 cm long, white with green shoulder and tapering.
Arka Nishant	:	Roots long, marble white with mild pungency; resistant to pithiness, premature bolting, root branching and forking.
CO.1	:	Roots milky white, 23 cm long and cylindrical; yield 9-10 t/ha in 45 days.
European varieties :		

Pusa Himani	:	Developed at IARI Regional Station, Katrain; Roots white, 30-35 cm long, sweet flavoured; suitable for growing throughout the year except winter months in hills; yield 32 t/ha in 60-65 days.
White Icicle	:	Developed at IARI Regional Station, Katrain; roots pure white, thin, icicle-shaped, straight and tapered; duration 30 days.
Scarlet Globe	:	Roots bright red, round, small, flesh white, takes 25-30 days from sowing to harvest.
Scarlet Long	:	Roots long, tapering with red skin and white flesh.
Kashi Sweta	:	A selection made from Chetki population at IIVR, Varanasi; roots 25-30 cm long, straight and tapering with pointed tip; yield 45 t/ha in 30-35 days.

Climate

Ideal temperature for growth and development of quality roots in radish is 10-15.5°C. Though it can tolerate high temperature, roots develop pungency under hot weather. Hence, it should be harvested when roots are small and tender during hot periods.

Soil

Being a root crop, radish requires loose and friable soil, rich in organic matter.

Land preparation and sowing

In plains of North India, radish can be grown throughout the year. Since temperate radish tolerates frost, it is successfully grown between September and January in plains. Tropical types are sown from middle of September onwards. If sowing is done later than November, it bolts earlier.

Land is ploughed to a fine tilth and ridges of 25 cm height and furrows are prepared at 30-45 cm distance. Seeds are sown continuously in ridges. Spacing depends on type of varieties. Indian tropical cultivars take longer time and grow larger. Distance between two rows is kept at 45 cm and seeds are sown continuously on ridges. Later they are thinned to keep a distance of 6-8 cm in a row. European types will be ready in 25-30 days and are sown at a closer spacing of 5-10 cm x 3 cm. Accordingly, seed rate varies from 10.0 kg for large varieties to 12.0 kg for temperate European types. For round cultivars, sow seeds on soil surface and put a layer of soil above it. Seeds of large cultivars are sown 1.5-3.0 cm deep. Usually seeds are sown in phased manner to get continuous supply of roots.

Hafeez and Hudson (1967) narrated beneficial effects of hardening radish seeds by subjecting them to 2 cycles of wetting and drying in which they are allowed to absorb water equivalent to 25% of weight and after dried at 2.2°C.

Irrigation

Radish requires plenty of water from sowing to harvest. For rapid germination and subsequent production of roots, soil should be moist and loose. So irrigate immediately after sowing. If irrigation is restricted, roots will be tougher and pungent, making it unfit for marketing.

Inter-culture

In radish, the epicotyl's grows up and develops into root tubers. As it grows in size, there is a tendency to bulge out. These roots are to be covered by way of one earthing up, which will take care of weeds also.

Harvesting

Depending up on the cultivar, roots will be ready for harvest in 25-55 days after sowing. If harvesting is delayed, roots will become bitter and pithy. Harvesting is done manually. A light irrigation is given before pulling out roots. After harvesting, roots are washed, made into bundles and marketed along with a few leaves.

Yield

European varieties yield 5-7 t/ha while in Indian cultivars, it varies from 15-20 t/ha. Radish roots can be stored for 2-3 days under room temperature without impairing quality. Roots can be stored for about 2 months at 0°C and 90-95% RH.

Seed production

Seeds of European varieties are produced in hills and tropical types in plains. As it belongs to family Cruciferae, it is cross-pollinated and pollination is done by bees. Hence, provide isolation distance as in cabbage or cauliflower. Wild mustard, wild turnip and wild radish should also be removed from field. Roots left *in situ*, without harvesting, produce maximum quantity of seeds. One additional earthing up is required during flowering and fruiting stages to prevent lodging of plants. For producing quality seeds, roots are pulled out and true-to-type roots alone are replanted. Usual practice is to remove ½ to ¾ of lower root portion before planting. However, it reduces yield considerably. Hence, replanting roots with minimum injury is advisable for high yield. Seed yield varies from 600-800 kg/ha.

Pests and diseases

A few of the important diseases of radish are *Alternaria* blight, white rust and radish mosaic.

Alternaria blight: It is caused by *Alternaria rapham*. Symptoms and control measures already discussed under Cole-crops.

White rust (*Albugo candida*): It produces white powdery substance in patches on under-surface of leaves. Disease symptoms appear on leaves and flowering shoots, which become deformed and produce malformed flowers. Use of resistant cultivars like Arka Nishant and regular sprayings with mancozeb (0.2-0.3%) are recommended.

Among pests, aphids, (*Myzus persicae* and *Brevicoryne brassicae*) are the most serious ones.

-
1. Chromosome number of radish is _____
 2. Radish mosaic virus is transmitted by _____
 3. The mode of pollination for radish is _____
 4. Arka Nishant, a variety of radish is resistant to _____
 5. Among the following _____ is a short duration root crop
 - a. Radish
 - b. Elephant foot yam
 - c. Beet root
 - d. Tapioca

ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR TURNIP
(*Brassica rapa*)

Turnip (*Brassica rapa*) is grown in temperate, subtropical and tropical regions of India. It is extensively cultivated in Bihar, Haryana, Himachal Pradesh, Punjab and Tamil Nadu.



Climate and soil

Cool and moist climate is most favourable for growing turnip. However, it can also be grown where summers are mild. The roots develop best flavour, texture, and size at a temperature of 10°–15°C. The short day length and cool weather favour proper development of roots. The long day and high temperature induce early bolting even without adequate development of roots. In hot weather, roots become fibrous, tough and more pungent. The Asiatic types can tolerate high temperature, while temperate types are quick-growing and flourish well under cool weather.

Turnip can be grown in all kinds of soils but it grows well in loam soil having sufficient humus. The well-drained, sandy loam soil is ideal for its cultivation. The extremely light sandy

soil or too heavy soils should be avoided. In such soils either the plant growth is hampered or forked or defective roots are formed which are unfit for market.

Varieties

Turnip varieties are divided into 2 groups- Asiatic or tropical types and European or temperate. These can further be classified on the basis of root shape as well as skin and flesh colour. The varieties recommended for cultivation are:

Early Milan Red Top

Its roots are deep flat with purplish red top and white underneath. The flesh is pure white, well grained, crisp and mildly pungent. The top is very small with 4–6 sessile leaves. It is an extra early and very high yielding variety.

Golden Ball

Its roots are perfectly globe shaped, medium sized and smooth. It has bright, creamy yellow skin and pale amber coloured flesh of fine texture and flavour. The top is small, erect with cut leaves.

Punjab Safed 4

An early maturing variety, commonly grown in Punjab and Haryana. The roots are pure white, round, medium-sized with mild taste.

Purple Top White Globe

It is a heavy-yielder and large-rooted variety. The roots are nearly round, upper part purplish, lower portion is creamy. The flesh is white, firm, crisp and mildly sweet flavoured. Top is small, erect with cut leaves. It is suitable for growing during cooler months.



Pusa Chandrima

Its roots are medium to large, nearly flattened globe to globular, smooth, pure white skin with fine grains. The flesh is sweet and tender. Top medium and leaves not so deeply cut. It is an early maturing (50–60 days), heavy cropper with an average yield of 400q/ha. It is suitable for sowing from October to December in plains.

Pusa Kanchan

It is a selection from the cross of Asiatic (Local Red Round) and European (Golden Ball) varieties. It contains good qualities of both the parents. The roots look just like the Local Red Round. The skin is red, flesh is creamy yellow with excellent flavour and taste. The leaf top is shorter than the Local Red Round. It becomes ready for harvesting in about 10 days later than

the local parent. Its roots can be kept for a longer time than Local Red Round in field without becoming spongy.

Pusa Swarnima

The roots are flattish round with creamy-yellow skin and pale amber coloured flesh of fine texture and flavour. Its top is medium; leaf blade is not so deeply cut. It is suitable for growing from June to October in hills and October to December in plains. It matures in 65–70 days.

Pusa Sweti

Attractive, white roots of Pusa Sweti mature 45–50 days after sowing. A very early maturing variety, it is suited for October sowing in plains.

Snow Ball

This variety is an early temperate type with medium sized small top. Its leaves are erect, cut and medium green. The roots are round, smooth with pure white skin. The flesh is white, fine grained, sweet and tender.

Cultivation

The method of land preparation for turnip is the same as for radish. Asiatic turnips are sown from July to September, whereas European types from October–December in northern plains of India. In hills, sowing time is usually from July–September. Its seeds are sown directly either in lines or on ridges. Normally, flat beds are used for sowing turnip but sowing in low lying area or during the rainy season should be done on ridges. Seeds are sown on ridges or rows 30cm apart while a spacing of 5–7cm is kept within the row. The seeds are sown 1.5cm deep. Seeds can be mixed with sand or ash to facilitate uniform sowing. Generally thinning is done 10–15 days after germination. The plants are spaced 10–15cm apart within rows. Bold seeds germinate better than the medium ones. About 90–95% seeds germinate. Seeds remain viable for 4–5 years under good storage conditions. Seeds take 4–6 days to germinate.

Manuring and fertilization

The quantity of manures and fertilizers to be applied depends upon climate, fertility status, pH level and texture of the soil. The proper time of application is equally important to facilitate optimum intake of plant nutrients for good harvest. Different doses of NPK have been recommended for various agroclimatic zones of India. However, a basal dose of 20–25 tonnes/ha of farmyard manure should be applied at the time of land preparation. This is supplemented by applying 70–100kg of N and 50kg/ha each of P and K. The complete dose of P, K and half of N should be applied before sowing. Phosphatic and potassic fertilizers are

applied 7–8cm deep before sowing. The remaining half of N is given in 2 split doses: first at the time of root formation and the second during development of root knobs.

Micronutrient requirement is almost similar to that of radish. Intake of B, Ca and Mo is more in turnip. Therefore, deficiency of these micronutrients is overcome by spraying 1kg/ha of Micnef MS-24 one or two times depending upon the requirement. It helps to control hollow-stem, pith formation and brown heart in turnip.

Irrigation

Irrigation requirement of turnip is similar to that of radish. This is generally irrigated at 8–15 days interval depending upon weather conditions. The increase in moisture stress drastically affects its yield. Therefore, optimum required moisture is maintained by irrigating the crop at proper time.

Interculture

About 2–3 hoeings are done to keep the crop weed-free and to conserve moisture. The earthing-up is done during second and third hoeings after top dressing of nitrogenous fertilizers to produce better quality roots. Usually 2–3 weedings are done till the crop is harvested. However, at the latter stage of crop growth, the fully developed leaves also restrict the weeds. The pre-emergence application of herbicide, Tok E-25 (Nitrofen) @ 2kg/ha effectively controls the weeds.

Seed production

The method of raising seed crop as well as the techniques of seed production is the same as for radish. The Asiatic turnips produce seed in plains, whereas European ones in hills only. The selected roots are used to prepare the stecklings by pruning the root tip from the base and leave one-third of crown after trimming off the top. These stecklings are transplanted 60cm × 60cm apart in the hills and 45cm × 35cm apart in the plains. An isolation distance of 1,000–1,600m should be kept from Chinese cabbage, mustard and other turnips to avoid contamination by crossing with these crops. Application of 84kg of N, 50kg/ha each of P and K results into good seed yield in turnip. When 70% of the pods turn light yellow, they should be harvested immediately to avoid shattering and damage by birds. On an average, seed yield of 5–6q/ha is obtained.

Harvesting and postharvest management

The fully developed tender roots of turnip are uprooted on attaining the marketable size. Normally the roots are harvested when they are 5–10cm in diameter depending upon the variety. The roots become tough and fibrous if harvesting is delayed. The harvesting should be done in

the evening. The yield of turnip varies with varieties as well as growing season. On an average it yields 200–400q/ha.

Its harvested roots along with the green tops are properly washed to remove the adhered soil. The side roots are trimmed off. These are sent to the market in baskets either along with green tops or after cutting them off near the surface of the crown. After removing old and diseased leaves the foliage is made into bunches for marketing. The roots are sorted into different grades according to colour, shape and size to give an attractive appearance in the market. Then these are immediately transported to the market and disposed off. The roots can be stored safely for 2–3 days under cool and moist conditions. However, it can be stored for 8–16 weeks at 0°C with 90–95% relative humidity.



Physiological disorder

Whip tail is caused due to deficiency of Mo. This is more common in acidic soils. Young leaves become narrow, cupped, showing chlorotic mottling especially around the margin, develop deep patches which ultimately affect the root growth. The affected plants are removed from the field during thinning. Further appearance of this disorder can be controlled by liming the soil and bringing the pH to 6.5. However, it is controlled by the application of 1.2kg/ha of sodium or ammonium molybdate.

1. Example of an extra early variety of turnip
 - a. Pusa Swarnima
 - b. Pusa Kanchan
 - c. Early Milam Red Top
 - d. Purple Top White Globe
2. _____ variety of turnip is a cross between Asiatic and European types
 - a. Pusa Kanchan
 - b. Pusa Chandrima
 - c. Pusa Swarnima
 - d. Pusa Sweti
3. Isolation distance practiced in seed production of turnip
 - a. 700-1000 m
 - b. 1000-1200 m
 - c. 500-700 m
 - d. 1000-1600 m
4. Deficiency of Molybdenum in turnip is called _____
 - a. Sponginess
 - b. Witches broom
 - c. Internal breakdown
 - d. Whip tail

5. Cross pollination in turnip is due to
- a. Monoecy
 - b. Male sterility
 - c. Sporophytic self incompatibility
 - d. Gametophytic self incompatibility

**ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR
BEET ROOT**

(Syn: Garden beet) (*Beta vulgaris* L.) (2n = 2x = 18)

(Hindi : *Chukandar*) Family : Chenopodiaceae

Beet root is a popular root crop grown for its fleshy roots which are used as cooked vegetable, salad and for pickling and canning. Young plants along with tender leaves are also used as pot herbs. It is very popular in USA. Beet root is a rich source of protein (1.7 g/100 g/100 g), carbohydrates (88 mg), calcium (200 mg), phosphorus (55 mg) and vitamin C (88 mg). Leaves are rich in iron (3.1 mg), vitamin A (2100 I.U.), thiamine (110 µ g) and ascorbic acid (50 mg/ 100 g).

Origin

Beet root originated from *Beta vulgaris* L. ssp. *maritima* by hybridization with *B. patula*. Crop has site of origin probably in Europe. Earlier types were with long roots like that of carrot. Beet root, sugar beet and palak belong to species *B. vulgaris* and are cross compatible.



Botany

Beet root is a biennial, producing a fleshy elongated hypocotyls and a rosette of leaves in first year and flowers in second year. Upper portion of fleshy root develops from hypocotyls and basal part from tap root. Concentric rings seen in cross section of root are as a result of alternate formation of vascular tissues and storage parenchyma tissues. Root skin colour varies from orange red to dark purple red. Colour of beet root is due to presence of red violet pigments of β cyanins and a yellow pigment, β xanthin. It has extensive tap root system and tap root grows as deep as 3m.

Rosette leaves develop in a close spiral, with older ones on outside. Inflorescence which normally develops in second year is a spike and bears numerous sessile flowers in clusters of 3-4. Flowers are bisexual, small, inconspicuous without corolla, but with green calyx. It produces abundant pollen and is wind pollinated. All breeding, works are to be conducted under pollen proof conditions using filtered air.



Fruits are mostly aggregates formed by cohesion of 2 or more fruits and held together by swollen perianth (calyx) base forming an irregular dry cork like body called as 'seed ball' or the so called seed. If there is a single flower, a single germ seed alone will develop in the seed'. True seeds are small, kidney shaped and brown. Attempts to breed varieties with monogerm seeds are in progress since thinning is a costly and essential operation in beet root cultivation.

Varieties

A few of the improved varieties popular in India are:

Detroit Dark Red: Roots perfectly round with smooth uniform deep red skin; flesh dark blood red with light red zoning; heavy yielder with a duration of 80-100 days.

Crimson Globe: It produces round to flat round roots. Outer skin is medium red and flesh is crimson red without zonations; duration 55-60 days.

Early Wonder: Roots flat globular with dark red skin and dark red flesh and light red zoning.

Ooty-1: This TNAU variety has round roots with blood red flesh colour; yields 28 t/ha in 120 days; it sets seeds under Nilgiris conditions.

Crosby Egyptian: Roots flat globe with dark purplish red flesh; duration 55-60 days; produces white zoning under warm weather.

Madhur, Ruby Queen and Ruby Red are a few of the varieties marketed by private seed industry.

Climate

Beet root is hardy to low temperature and prefers cool climate. Though it grows in warm weather, development of colour, texture, sugar content etc. of roots is the best under cool weather. High temperature causes zoning *i.e.*, appearance of alternate light and dark red concentric rings in the root. Extreme low temperature of 4.5-10.0°C for 15 days will results in bolting. It requires abundant sunshine for development of storage roots.

Soil

Deep well drained loam or sandy loams is the best for beet root cultivation. Heavy clayey soils result in poor germination and stand of crop due to formation of a soil crust after rains or irrigation. Roots may be misshaped and will not develop properly in heavy soils. Beet root is highly sensitive to soil acidity and the ideal pH is 6-7. Beet root is one of a few vegetables which can be successfully grown in saline soils.

Land preparation and sowing

Being a cool season crop, beet root is raised during winter in plains and as a spring-summer crop in hills by March-April. In plains, sowing is practiced during September-November.

Land is ploughed to a fine tilth by thorough ploughing making it loose and friable. Clods are to be removed completely. Apply well decomposed farmyard manure at the time of final ploughing. Flat beds or ridges and furrows are prepared. Water-soaked 'seed balls' which contain 2-6 seeds are drilled 2.5 cm deep in rows at spacing of 45-60 x 8-10 cm. 5-6 kg of seeds is required for one hectare. Staggered sowing at 1-2 weeks interval ensures steady supply of roots during the season.

Manures and fertilizers

On sandy soils, organic manure @ 25 t/ha is recommended. For an average soil, 60-70 kg N, 100-120 kg P and 60-70 kg K/ha is recommended. Entire farmyard manure, half of N and full P and K should be applied basal at the time of land preparation prior to sowing and remaining at 30-45 days after sowing. Nitrate sources of N are preferred to ammonium sources. Beets have a relatively high boron requirement and its deficiency causes internal breakdown as black rot or dry rot.

Aftercare

Thinning is an essential operation when more than one seedling germinates from each seed. Moist soil is essential for seed germination and for further growth. Usually 5-6 irrigations are usually given during summer and three irrigations during winter in North Indian plains.

Field is usually kept weed free by light hoeing at early stage of crop. Swollen roots are also to be covered with soil by earthing up.

Harvesting

Medium sized tubers are of great demand and tubers are harvested after attaining a diameter of 3-5 cm. Harvesting is done 8-10 weeks after sowing by pulling the top with hand. Later tops are removed, graded and marketed. In European countries, where small sized bunches are in demand, tubers are tied in bundles of 4-6 with their tops. Over matured and oversized tubers become woody and crack. Yield varies from 25 to 30t/ha and the tuber stores well at 0°C and 90% RH.

Seed production

Unlike other root crops, annual tropical types do not exist in beet root. All cultivars in beet root are temperate biennial types and seed production is possible in hills 1400 m above mean sea level. A low temperature of 4.4 to 7.7°C for 6-8 weeks is required for flowers to initiate. Usual method of seed production is root to seed method. In this method, seeds are sown in July and well developed roots are dug out during November-December. After selection of root tubers, top is trimmed without injuring crown. Then whole tubers of selected plants are transplanted at a spacing of 60 x 45-60 cm in well prepared fields and irrigated. Harvesting is

done during June-July. Cross pollination is due to self incompatibility. Being a cross pollinated crop, that too wind pollinated, provide an isolation distance of 1000 m for certified seed production and 1600 m for breeder and nucleus seed production. Average seed yield is 2.0 t/ha.

Pests and diseases

Insect pests like leaf miners, web worms, semi loopers; fungal diseases like *Cercospora* leaf spot and downy mildew and viral diseases cause damage in beet root cultivation.

OTHER ROOT CROPS

Minor root crops which are under cultivation in specific areas of the country are rutabaga (*Brassica napobrassica*), parsnip (*Pastinaca sativa*), horse radish (*Armoracia rusticana*), salsify, chervil, celeriac etc.

1. Family of beetroot is
 - a. Cruciferae
 - b. Chenopodiaceae
 - c. Umbelliferae
 - d. Clauciaceae
2. Colour of beetroot is due to
 - a. β cyanin & β xanthin
 - b. β carotene & xanthophylls
 - c. Anthocyanium
 - d. β carotene & β cyanin
3. Inflorescence of beetroot is
 - a. Raceme
 - b. Panicle
 - c. Cyme
 - d. Spike
4. _____ is an essential operation in beetroot
 - a. Mulching
 - b. Desuckuing
 - c. Thinning
 - d. Pinching
5. Storage temperature of beetroot is
 - a. 0^o
 - b. 5^oC
 - c. 7^oC
 - d. 15^oC

**ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR
AMARANTHUS, PALAK AND GOGU**

AMARANTHUS - *Amaranthus* spp. (2n = 32, 34, 64) - (Hindi: *Chaulai*)

Family: Amaranthaceae

Amaranth is the most common leaf vegetable grown in Kerala and Tamil Nadu. Leaves and succulent stem are good sources of iron (38.5 mg/100g), calcium (350-400 mg/100g), vitamin A and vitamin C. Absorption of calcium from amaranth is however poor. The iron availability is only about 15.2 – 53.6% of total iron. High oxalate content (1-2%) and nitrate (1.8-8.8 g/ kg dry matter) levels are reported from leaves of various species. Short duration, quick response to manures and fertilizers, high yield, easiness in cultivation and availability of diverse types suited to specific agro-climatic situations make it a favourite crop of farmers to fit in any cropping systems. Both leaf and grain types play a vital role to combat malnutrition of poor people.

Origin and distribution

Centres of diversity for amaranth are Central and South America, India, South East Asia with secondary centres of diversity in West and East Africa. Leaf amaranth is a native of India.

Taxonomists recognize two sections in *Amaranthus*, viz., *Amaranthus* and *Blitopsis*, Section *Amaranthus*, includes important grain types where the inflorescence is terminal. Section *Blitopsis* includes leaf types and flowers are borne in clusters in leaf axils.

Majority of leaf cultivars grown in India belong to *Amaranthus tricolor*. Major species found in India are:

<i>A. tricolor</i> (Syn) <i>A. gangeticus</i> ,	
<i>A. mangostanus</i> , <i>A. polygonoides</i>	cultivated - leaf type
<i>A dubius</i>	cultivated -leaf type
<i>A. blitum</i> (Syn: <i>A. lividus</i>)	cultivated - leaf type
<i>A. tristis</i>	wild - leaf type
<i>A. viridis</i>	wild - leaf type
<i>A. spinosus</i>	cultivated - grain type
<i>A. cruentus</i>	cultivated - grain type
<i>A. caudatus</i>	cultivated - grain type



A. tricolor



A. viridis



A. tristis



A. blitum



A. dubius



A. spinosus



A. cruentus



A. caudatus

Botany

Amaranth is an annual herb with erect growth and scarce to profuse branching habit. Stem is succulent and green or purple or mixed shades of these two. Leaf is simple, alternate, with obovate to lanceolate shape. Leaf colour is green or red or with different shades of above. Flowers are borne terminally and in axils of leaves in clusters. Basic unit of inflorescence is called as glomerule. Flowers are small, unisexual and monoecious. Most of cultivated types are monoecious. Proportion of male and female flowers varies in an inflorescence. Each glomerule consists of a staminate flower and a number of pistillate flowers. The extent of cross pollination is governed by proportion of male and female flowers in an inflorescence and position of inflorescence in plant. Percentage of male flowers in a glomerule is 0.5 in grain types and 10.25 in leaf types. According to Pal and Khoshoo (1978), leaf amaranths are predominantly self pollinated due to presence of a large number of male flowers per glomerule, terminal inflorescence and development of axillary glomerules. Grain types favour cross pollination.

Stigma of pistillate flower is receptive several days prior to opening of staminate flowers in an inflorescence. Wind help in transfer of pollen grains from male flowers of a glomerule / inflorescence / plant to another glomerule / inflorescence / plant. But grain species with colorful inflorescence are occasionally visited by bees (Khoshoo and Pal, 1970).

Chromosome number varies with species in amaranth. The diploid species have $2n=32$ or 34. *A. tricolor* is with $2n=34$ white *A. cruentus* and *A. tristis* have $2n=32$. The tetraploid species, *A. dubius* has $2n=64$.

Varieties

Cultivated leaf amaranth varieties and cultivars differ in size, shape and colour of leaves and stem, position of inflorescence etc. and belong to different species. A brief description of improved varieties developed by different Research Institutes is given below:

1) Tamil Nadu Agricultural University, Coimbatore-3

CO.1 (<i>A. dubius</i>)	This tetraploid variety was developed by selection from ("local germplasm. Stem and leaves are dark green; leaf-stem ratio is 2.0; inflorescence terminal and axillary; lacks initial vigour but makes rapid growth after 30 days; suitable for late harvest; resistant to <i>Rhizoctonia</i> leaf blight; green yield 8.0 t/ha; seed yield 1.5 t/ha.
CO.2 (<i>A. tricolor</i>)	Stem and leaves green, leaves lanceolate and slightly elongate, leaf-stem ratio 1.8; suited for early harvest; yield 10.78 t/ha.
CO.3 (<i>A. tristis</i>)	This is specifically suited for clipping of tender greens and is locally known as 'Araikeera' in Tamil. Leaves are small and green; stem is slender and tender. First clipping is possible in 20 days after sowing. Nearly 10 clippings can be taken over a period of 90 days. Due to very high leaf-stem ratio, cooking quality and taste are excellent. Special care is required in land preparation for the variety.
CO.4 (<i>A. hypochondriacus</i>)	This grain type makes rapid vegetative growth within a period of 20-25 days. Plants are dwarf; grain yield 2.0-2.5 t/ha in 80-90 days.
CO.5 (<i>A. tricolor</i>)	Leaves double coloured with Green and pink and is free from fibre. It gives a rosette growth in early stages and first harvest is possible in 25 days; yield 40 t/ha in 55 days.

Sirukeerai (*A. polygonoides*) is a traditional cultivar in Tamil Nadu, suited for uprooting at 25 days after sowing; leaves are small, ovate with blunt bifurcated tip and have long petiole; collar region is dark pink and at leaf axil a miniature branch initiates.

2) IARI, New Delhi

Pusa Chotti Chaulai (*A. blitum*): Plants dwarf with succulent, small and green leaves; responds well to cutting.

Pusa Badi Chaulai (*A. tricolor*): Plants tall and stem thick with large green leaves; responds to cutting.

Pusa Kirti (*A. blitum*): Green leaved variety with green and thick stem; leaf lamina broad ovate; ready for harvest in 30-35 days and extends up to 70-85 days; yield 55 t/ha; specifically suited for summer.

Pusa Kiran (*A. tricolor*): This is developed by natural crossing between *A. tricolor* and *A. tristis* and has more characteristics of *A. tricolor*. Leaves are glossy green with broad ovate lamina; leaf-stem ratio is 1.0:4.6; yield 35 t/ha in 70-75 days; suited for *kharif* season.

Pusa Lal Chaulai (*A. tricolor*): Upper surface of leaves are deep red and lower surface purplish red; yield 45-49 t/ha in 4 harvests.

3) IIHR, Bangalore

Arka Suguana (*A. tricolor*): A multicut variety with broad green leaves. First picking starts in 24 days after sowing and continue up to 90 days. Moderately resistant to white rust. Yield 17-18 t/ha.

Ark Arunima (*A. tricolor*): A multicult variety with broad dark purple leaves. First picking starts in 30 days after sowing and two subsequent cuttings at 10-12 days interval. Yield 27 t/ha.

Climate and Soil

Amaranthus is widely distributed in both tropical and sub tropical regions. Leaf amaranth is a warm season crop adapted to hot humid climatic conditions. It is grown throughout the year in tropics and in autumn, spring and summer seasons in temperate regions. Most of leaf types are day neutral in habit but differ in their day length requirements and respond differently to changes in photo and thermoperiodism. Grain types, *A. caudatus*, *A. cruentus* and *A. edulis* are short day species while *A. hypochondriacus* is day neutral.

Amaranth comes up well in well drained loamy soil rich in organic matter. The ideal is pH is 5.5-7.5 but there are types which can come up in soils with pH as high as 10.0. Red amaranth requires bright sunlight for colour development.

Land preparation and sowing

Amaranth is harvested by pulling out and by frequent clippings (multicut). Cultivation practices differ according to method of harvest, duration, growth pattern of variety, etc.

Land is prepared to a fine tilth by thorough ploughing and harrowing. Well decomposed and powdered organic matter @ 20-25 t/ha is incorporated with the soil at the time of final ploughing.

Direct sowing

For direct sowing, field is divided into small plots of about 3.0-3.6 m long and 1.5-1.8 m width with irrigation channels running between every two plots. In case of irrigation by pot watering, reduce width of plots to 90-100 cm. Amaranth seeds, being small in size, are mixed with fine sand and sown uniformly by broadcasting. The seeds are covered either by raking up soil and by covering with a thin layer of sand or soil. This is followed by a light irrigation. Soil is kept moist by frequent irrigation. Grown up seedlings are selectively pulled out at 30 days after sowing and marketed in small bundles along with roots. Seed rate for direct sowing is 2.0-2.5 kg/ha.

After first pulling, urea is broadcasted in beds and irrigated for quick growth of remaining seedlings so that second pulling out is possible 10-15 days after first pulling. This is repeated so that final pulling is over by 55-60 days after sowing.

Transplanted method

This is mainly practiced for multi-cut varieties. The land, after thorough ploughing and leveling, is made into shallow trenches / basins of 50-60 cm width and convenient length. Well decomposed farmyard manure is applied in trenches and thoroughly incorporated in soil by digging. 20-25 days old seedlings, already raised in nursery, are transplanted in trenches at 20-25 x 10-15 cm spacing. Seed requirement for transplanted crop is only 500 g/ha.

Manures and fertilizers

Amaranth is a heavy feeder and high yielding crop. 20-25 tonnes of FYM and 50:25:20 kg NPK / ha are recommended as basal dose. Under pulling out method, 20 kg N should be top dressed twice during subsequent pulling out of seedlings. For clipping varieties, a still higher dose of 75:25:25 is advisable. Apply N after every clipping or cutting. Foliar spray of 1% urea or diluted cow urine at every harvest is good for promoting further growth and for high yield.

Irrigation

Grain amaranth is a drought tolerant crop, but leaf amaranth requires frequent irrigation to keep soil moist. Frequency of irrigation depends on soil.

Interculture

Amaranth is a short duration and shallow rooted crop. Provide light hoeing to prevent soil crust formation after irrigation and to keep soil loose. Field also should be kept weed-free, especially during initial stages.

Harvesting

Amaranth is harvested early in the morning by pulling out or by clipping. In the first method, grown up plants are pulled out at 30, 45 and 55 days after sowing, along with roots, washed and sent to market in small bundles.

In multi-cut method, first clipping or cutting is done 25-35 days after sowing. Subsequent cuttings are made at weekly intervals in Chhotti Chaulai and 10 days intervals in Badi Chaulai.

Bolting

Premature flowering or bolting is a serious problem in cultivation of amaranth. Quality and yield are deteriorated after flowering. Bolting is usually associated with planting of short day varieties during November-December, deficiency of nitrogen, extreme high temperature and poor soil aeration. Practices like raising of crop at ideal time depending on locality, frequent application of nitrogen fertilizers and manures and keeping soil loose by light hoeing prolong flowering.

Seed production

Provide an isolation distance of 400 m for foundation and 200 m for certified seed production in amaranth. For seed production, seedlings are transplanted at a wider spacing of 3-45 x 30 cm. Crop may be left for seed production after making one or two cuttings for vegetable harvests. Inflorescence is harvested when glumes turn brown in colour and seeds turn black. Spikes are initially dried in sun to 15% moisture. After drying, inflorescence is threshed with pliable bamboo sticks for separation of seeds. Seeds are then winnowed and sieved through 2 mm sieve. Seeds are finally dried to 7% moisture and stored. Seed rate varies from 450 kg to 500 kg/ha.

Pests and diseases

Leaf blight and white rust are major problems in amaranth cultivation.

Leaf blight (*Rhizoctonia spp.*)

Leaf blight disease is the most severe during rainy season under warm and humid conditions. Symptoms include appearance of white and irregular spots on leaf lamina making the produce unmarketable.

The package suggested for control of leaf blight is given below:

- Sow resistant green amaranth variety, CO-1 during rainy season
- Avoid splash irrigation
- Spray Mancozeb @ 4g/1 of cow dung supernatant as fine droplets. Cover plants thoroughly so that spray solution reaches under surfaces of leaves also.

SPINACH BEET / INDIAN SPINACH

Beta vulgaris var. bengalensis

Spinach beet is one of the most common leafy vegetables of tropical and sub tropical regions. The popular palak growing states include Uttar Pradesh, West Bengal, Maharashtra and Gujarat. However, Palak is not very popular in South India. It is primarily used as potherb. It is a rich Source of vitamin A and C and also contains appreciable amount of protein, calcium and iron. The leaves contain low oxalic acid.



Origin and taxonomy

Spinach beet is most probably a native of Indo Chinese region. It was known in China as early as 647 AD. Spinach beet, swiss chard and garden beet has a chromosome number $2n=2x=18$, indicates their close relationship. Leaves of this crop might have been first used in Bengal and hence it is known as *Beta vulgaris var. bengalensis*

The basic methods employed for the development of palak include introduction, selection especially mass selection and hybridization. Mass selection is also employed for the maintenance of cultivars. The best individual plants are selected on the, basis of their phenotypic performance and their seeds are composited for raising the following generation of large number of plants are selected to avoid inbreeding depression.

Varieties

Punjab Green: This cultivar was developed by Punjab Agricultural University, Ludhiana, through selection. Its plants are semi-erect; foliage is shining dark green, thick, long and broad. The leaves are succulent and free from sourness. There is mild purple pigment on the stem. It is ready for first cutting 30 days after sowing. Its average yield is 3 tonnes/ha. It is slow bolter.

Pusa Jyoti: This cultivar was developed by the Indian Agricultural Research Institute, New Delhi by polyploidization of the culture as a result of induced mutagenesis using All Green as a

source material. It has very big leaves with dark colour. Leaves are thick, tender, succulent and crisp. The plants are very vigorous, quick growing and regenerate quickly after each cutting. It yields about 50 tonnes /ha in 6-8 cuttings.

HS 23: This cultivar was developed by Haryana Agricultural University, Hissar, Harayana through selection. It produces dark green, large, thick, tender and juicy leaves. It is a quick growing cultivar and is ready for first cutting 30 days after sowing. A total of 6-8 cuttings at two weeks interval can be obtained.

Ooty 1: It was developed at Horticultural Research Station, Ooty of Tamil Nadu Agricultural University through selection from an introduction from Himachal Pradesh. Leaves are green with a length of 40-50 cm and breadth of 8-10cm. The crop comes to first harvest 45 days after sowing. Subsequent harvests can be done once in 15 days for 4 times. The yield is 1.5 tonnes/ha/cutting.

All Green: It was developed at the Indian Agricultural Research Institute, New Delhi It produces green tender leaves and gives about 6-7 cuttings at 15-20 days interval. It yields about 12 tonnes/ha.

Pusa Harit: This cultivar was developed by hybridization between sugar beet and local palak at IARI Regional Station, Katrain, HP. It produces thick, green, large and slightly crinkled leaves. It is a heavy yielder and has very late bolting habit as it has low chilling requirement.

Jobner Green: This was developed at Jobner campus of University of Udaipur by selection from a spontaneous mutation detected from a local collection, Sl. No 5. It produces green, large, thick and tender leaves with strong flavour having entire margin. It is a high yielder and gives an average yield of 30 tonnes/ha.

Pusa Bharati: It is the latest variety at the Indian Agricultural Research Institute, New Delhi. It produces green, tender leaves. It has higher vitamin C content and beta carotene than Pusa Jyoti. It is very high yielder and gives an average yield of 50 tonnes/ha.

Climate and soil

Although spinach beet is a winter season crop, it can be growth throughout the year under mild temperature conditions. It can tolerate frost better than other vegetables. It can also tolerate warm weather but high temperature leads to premature bolting without giving economic yield. Palak can be grown on any type of soil possessing good fertility and drainage but sandy loam soil is most suitable. Although, Palak can tolerate slightly alkaline soil; high yields of better quality greens are produced in neutral soils having a pH of 7.0.

Sowing and spacing

The main sowing season in plains is from last week of August to second week of

November. In places with mild climate, it may grow throughout the year. In hilly regions, palak is sown from March-May. To improve germination, seeds are soaked in water overnight before sowing.

Sowing can be done either by broadcast method or by line sowing. Line sowing is more desirable as it facilitates weeding, hoeing and harvesting. Line spacing is maintained at 20cm and thinning is done to maintain plant spacing within lines at about 5cm. Seed rate varies with the crop season. For winter crop, use 10-15kg seed/ha and for summer crop 25-30kg/ha seed is required.

Manuring and fertilizer requirement

As palak is a leafy vegetable, it requires more nitrogen for crown growth. It is better to apply fertilizers based on the soil analysis. In the absence of soil test, PAU recommends 25 tonnes of farmyard manure, along with 87.5kg N and 30kg P₂O₅/ha. Apply whole of farmyard manure and P₂O₅ and half of N at the time of soil preparation. The remaining half N may be applied in two split doses, one after each cutting followed by a light irrigation

Irrigation

In case of insufficient soil moisture, apply first irrigation immediately after sowing. Subsequent irrigations may be given at an interval of 4-6 days during summer and 10-12 days during winter. However, rainy season crop does not require much irrigation.

Interculture and weeding

Hand weeding is still a common practice to control weed. Generally 2-3 hoeing cum hand weeding are required to control weed. It also helps to loosen soil for proper aeration.

Harvesting

The crop will be ready for harvesting in about 3-4 weeks after sowing. Subsequent cuttings should be taken at an interval of 20-25 days depending upon variety and season. During summer, only one harvesting is recommended. Harvesting is not done early in the morning because there is dew on the crop. After harvesting it is washed, trimmed, graded and bunched before marketing.

1. Anti nutritious factor in amaranthus

- a. Oxalate b. Protein inhibitor c. Sinigrin d. Cyanide

2. Example for grain amaranth

- a. *Amaranthus spinosus* b. *A. cruentus* c. *A. caudatus* d. All the above

3. The species of CO 1 Amaranth is

- a. *A. viridis* b. *A. dubius* c. *A. tristis* d. *A. hypochondrius*

4. Chromosome number of palak is

- a. 21 b. 22 c. 18 d. 24

5. Palak variety Pusa Jyoti is evolved through _____ method of breeding

- a. Mutation b. selection c. polyploidy d. Hybridization

**ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR
DRUMSTICK, COCCINEA AND CURRY LEAF**

DRUMSTICK

(*Moringa olerifra* Lam.) (2n = 22)

(Hindi : Seeng, Sahgan) Family : Moringaceae

Drumstick is grown for its nutrient rich tender, but full grown pods, leaves and flowers which are used for culinary preparations. Fruits are rich in vitamin C (120 mg/100g), carotene (110 mg), phosphorus (110 mg) and minerals like magnesium (28 mg), potassium (259 mg), sulphur (137 mg), chlorine (423 mg) etc. The crop is grown in homesteads for family uses or cultivated commercially for market. Tender leaves and flowers are comparable to that of colocasia in vitamins and minerals and have great role for combating malnutrition of urban and rural masses. Certain morigna types principally grown for its foliage are reported from West Indies. Drumstick roots are good substitute for horse radish. Root, bark and seed have many industrial uses also.

Origin and distribution

Originated in South West India, drumstick became a popular vegetable in South Indian states. The crop is widely distributed in India, Sri Lanka, Pakistan, Singapore, Malaysia, Cuba, Jamaica and Egypt.

Botany

Drumstick is a small or medium sized perennial tree of about 10 m height with fragile and corky stem. The leaves are usually tri-pinnate with elliptic leaflets. Pods are pendulous and length ranges from 20 cm to 100 cm. Seeds are trigonous with wings on angles.



Flowers are produced on current season growth on large and erect panicles or monocladiol cyme. Flowers were yellowish creamy white and sweet smelling. Individual flowers are bisexual, zygomorphic and pedicellate.

Calyx and corolla consist of five sepals and petals. Androecium also has five stamens alternating with five stamindodes. Gynoecium has a superior, one celled and three carpelled ovary containing many ovules on parietal placentation. Stigma is truncate.

Flowering in drumstick varies from place to place and is greatly influenced by rain, temperature, humidity, wind, soil temperature, soil moisture etc. Under South Indian condition, one or two distinct peak periods of flowering noticed. Peak period of flowering in central parts of Kerala is December-January while in southern part it is February-March and

July-August with maximum flowering in February-March. Under Coimbatore and Bangalore conditions, flowering seasons are March-May and July-September respectively. Anthesis continues throughout the day. Two anthesis peaks i.e., 2.00 p.m and 4.00 a.m. are noticed at Thiruvannthapuram. In most parts of Tamil Nadu, flowering is from 4.30 a.m. to 6.30 p.m.

In southern part of Kerala, stigma becomes receptive one day prior to flower opening and continues with maximum receptivity on the day of opening and a sudden decline thereafter.



Varieties / cultivars

A number of local cultivars are known by the place of their cultivation. Details of local cultivars are given:

- **Jaffna moringa** - a perennial type which bears 60-90 cm long pods with soft flesh and good taste.
- **Chavakacheri murunga** - a perennial type producing 90-120 cm long pods.
- **Chemmuringa** - This perennial type flowers throughout year and bears red tipped fruits.
- **Yazhpanam murunga** – same as Jaffna type
- **Pal muringai** – Pods having thicker pulp and better taste
- **Puna murunga** – Thinner fruits.
- **Kodikal murunga** – produces short pods of 15-20 cm long and is used as support for betel vine plants. Propagated by seeds.

There are only a few named varieties and the details are given below:

KM-1 (Kudumianmalai 1) – Bushy variety propagated through seeds. Plants come to bear 6 months after planting and can be rationed for 2-3 years. Productivity 400-500 fruits / year. Developed at Anna Pannai, Kudumianmalai of Pudukottai.

PKM – 1 – This “seed moringa”, propagated through seeds is developed at Horticultural Research Station, TNAU, Periyakulam. Plants grow to a height of 4-6 m and come to flower in 90-100 days after planting. The first harvest starts 160-170 days after planting and on an average each tree bears 200-225 fruits / year. Pods are 65-70 cm long with 6.3 cm girth and 150 g weight. Fruits are green coloured and highly pulpy.



PKM 2 – This “seed moringa”, propagated through seeds, is also developed at Horticultural Research Station, TNAU, Periyakulam. Pods are extra long (125-130 cm), pulpy and suitable for homestreads.

Dhanraj – This is also an annual drumstick propagated through seeds and is evolved at KRC College of agriculture, UAS, Arabhavi, Karnataka.

Crop improvement programmes in the Department of Olericulture, Kerala Agricultural University, Vellanikkara resulted in the development of three promising perennial drumstick clones viz., MO 70, MO 95 and MO 44 and one annual seed drumstick, AD 4.



Climate and soil

Drumstick is predominantly a crop of dry and arid tracts. However intensive cultivation with good irrigation and systematic cultural practices will give good yield especially for annual type. The plant put forth luxuriant growth at 25-30°C. Higher temperature results in heavy flower shedding. Crop is also injured severely by frost. Though the crop comes up well in all types of soil, performance is better in sandy loam rich in organic matter. A pH range of 6.0 – 6.72 is most ideal.

Propagation

Perennial types are propagated through limb cutting of 90-100 cm length and 5-8 cm diameter. Annual types are propagated by seeds. Average seed weight is 0.288 g and 10 g contain 35 seeds. Seeds @ 625 g/ ha can be either sown in pits or transplanted after raising seedlings in polythene bags. Transplanting of seedlings can be made one month after sowing. It is always advisable to raise a few plants additionally in polythene bags for purpose of gap filling. Time of sowing of seeds for annual seed drumstick or planting of limb cuttings varies from region to region depending on receipt of monsoon.

Land preparation

Field is ploughed 3-4 times. Apply FYM @ 20 t ha⁻¹ at last ploughing. Take pits of size 45 x 45 x 45 cm at a spacing of 6.0 x 6.0 m for perennial types and 2.5 x 2.5 m for annual types, apply 10 kg FYM and fill up pits.

Interculture and manuring

To facilitate side branches, shoot may be nipped off when the seedlings are at 75 cm height. Apply 100 g Urea, 100 g Super phosphate and 50 gm MOP and irrigate heavily. Top dress plants with 100 g Urea again 3 months after first application. Provide light irrigation for early emergence of seedlings for annual type.

After harvest of main crop, annual types are cut back to one meter height from ground level for rationing. These rationed plants develop new shoots and start bearing four to five months after rationing. Likewise about three ratoon crops can be taken. At each and every ratoon crop, plants are supplied with N, P and K nutrients as already mentioned along with 20-35 kg of FYM and irrigate.

CURRY LEAF

Murraya koenigii

Rutaceae

Curry leaf (*Murraya koenigii*) is an important perennial tree vegetable. Its leaves are used mainly to improve the taste and flavour of foods. Leaves are slightly pungent and retain their flavour even after drying. Ground curry leaf with mature coconut kernel and spices forms an excellent preserve. It grows wild in the foothills and plains of the Himalayas from Kumaon to Sikkim. In south India, especially in Tamil Nadu, Kerala and Karnataka, at least one curry leaf plant is found in each homestead. Recently it has gained importance as a commercial crop. It is cultivated commercially in Tamil Nadu and Karnataka. It is also cultivated in West Bengal, Assam and Deccan Plateau.

Climate and soil

Curry leaf can be cultivated in a wide range of soils. Red sandy loam soil is ideal for its cultivation. It can tolerate temperature up to 37°C. But below 16°C, its growth is affected.

Varieties

There are 2 improved varieties of curry leaf - DWD 1 and DWD 2. Both of these have a good aroma. They have an oil content of 5.22% and 4.09% respectively. They are mainly cultivated in Karnataka. DWD 1 is sensitive to winter season. During winter its growth is poor, whereas DWD 2 is winter insensitive. It gives higher yield than DWD 1. 'Senkaampu' is a local cultivar grown in many parts of Tamil Nadu.

Cultivation

Propagation

Curry leaf is mainly propagated through seeds. For raising seedlings, well-ripe fruits are collected from high-yielding plants. The seeds are sown either in nursery or polybags filled with a mixture of 1:1:1 sand, soil and farmyard manure. Seeds germinate in 3 weeks. One-year-old seedlings are planted in the main field.

It can also be propagated by root suckers. There are a number of root suckers near its plants. They are separated from the main plant during rainy season and planted immediately in the main field.

Planting

Planting in the main field is done during the monsoon season. The main field is ploughed thoroughly. Pits of 30cm × 30cm size are dug at a spacing of 4m × 4m. Farmyard manure @ 10kg/pit is applied.

Manuring and fertilization

Usually curry leaf plant is not given inorganic fertilizers. But for higher yields, its plant may be given 10kg farmyard manure and NPK @ 60:80:40g/plant/year. The fertilizers may be applied at the onset of the monsoon.

Aftercare

The pit should be irrigated if there is no rain. The plant should be irrigated at 3-day intervals, if there are no rains. The field should be kept weed free. The plants should be trained and pruned to maintain a height of 1m. Their terminal buds are removed to encourage lateral branching. A minimum of 5–6 branches are kept per plant.

Harvesting and Post-harvest management

Curry leaves are picked 15 months after planting. Commercial harvest can be started from 3 year old plants. With good management, normal yield can be obtained up to the age of 20–25 years. The leaves can be harvested at two and a half to three months intervals, the average yield being 20–25 tonnes/ha.

***Coccinia grandis* (L.) Voigt.**

Syn: *Coccinia indica* and *C. cordifolia*

The ivy gourd, *Coccinia grandis* (L.) Voigt, is commonly known as *kundru* or *tondli*. It is a climbing perennial having small (4-5 cm long and 1-2cm in diameter) ovoid or elliptical. The fruits are smooth and bright green with stripes which become scarlet red on ripening. The roots are long and tuberous. The leaves have five lobes with serrated margin.

The ivy gourd is cultivated in India, tropical Africa, Malaysia and other south east Asian countries, and China. In India it is widely grown in southern; eastern and western regions, mainly in Tamil Nadu, Karnataka, Kerala, Maharashtra, Gujarat, Andhra Pradesh and West Bengal.

It has about 30 species, occurring mostly in Africa. Only one species- *Coccinia grandis* (L.) Voigt. - is cultivated. It is a perennial found naturally in India and tropical Africa. A monoecious species is cultivated and the species, *C. abyssinica* is grown in Ethiopia for its edible tuberous roots. In India *C. grandis* (L.) Voigt. (*Coccinia indica* Wight & Am.) is distributed in northern plains and terai regions, extending to peninsular region.



Origin and distribution

About 30 species of the genus *Coccinia* occur wild in Africa. The cultivated species, *C. grandis* (L) is found growing in nature in the tropics of India and southeastern Asia besides Africa. It was domesticated in India and Southeast Asia. In India, the ivy gourd, known as "bimba" It has been recorded in the Mahabharat period.

The ivy gourd is a diploid with $2n=24$. Extensive studies on karyotype and chromosome biology have revealed a pair of heteromorphic chromosomes in the male plant. There is a large chromosome in the male plant and two x chromosomes in the female plant. The male plant has 22 autosomes with a pair of XY chromosomes and the female plant with 22 autosomes and a pair of chromosomes. Polyploidy does not affect dioecism and male is always heterogametic with Y chromosomes

Genetics and Breeding

There are no reports on genetics and breeding of ivy gourd. Almost all the present day cultivars ivy gourd have been developed by farmers as clonal selections, mainly from seedling progenies spontaneous mutations. The fruits of the different varieties vary in shape, size and stripe pattern. There are also few types in which plants with male flowers are absent and the fruits produced on the female plants are parthenocarpic. Some types having bitter fruit, not suitable for human consumption, are also found occasionally.

Area and production

The data on area and production of ivy gourd are not available.

Uses

The immature fruits are cooked and used in sambar or fried. The tender shoots are also eaten. Leaves, stems and roots have medicinal uses in ayurvedic and native systems for treatment of skin diseases, bronchitis and diabetes and also for lowering blood sugar levels.

Production Technology

Climate

The ivy gourd grows best in warm and humid climate. The optimum temperature requirement is 20 - 30 degree celsius. In southern region, it continues to produce fruits almost throughout the year but the peak seasons of fruiting are summer and rainy seasons. In the northern plains the plants remain dormant during winter and produce fruits only once

in a year.

Soil

The most suitable soil for growing ivy gourd is well drained sandy loam. Heavy clay is to be avoided. The best soil pH is 6.5. The crop does not grow well in acidic and alkaline soils.

Planting

The ivy gourd is vegetatively propagated by stem cutting. Semi hardwood cuttings, 15-20 cm long and 1.5-2.0 cm thick, having 5-6 leaves on each cutting, are used for planting. Two to three cuttings are planted, about 5-6 cm. deep, in each basin of 60 cm. diameter. The distance between the basins is 1.5-2.0 metre. The planting is done in June-July or February-March. The plant population in a field should have female and male plants in a ratio of 10: 1. The plants are perennial, replanting is advocated after every 4-5 years. The vines are trailed on bowers or bamboo pandals of 1.25-1.50 m. height. The dimensions vary according to the requirement.

Manures and Fertilizers

About 20 tonnes of FYM are applied at the time of basin preparation and planting. The fertilizer requirements are 60-80 kg N, 40-60 kg P and 40 kg K per hectare. Both manures and fertilizers are applied every year before fruiting starts. The plants start fruiting in 10-12 weeks after planting. The vines are pruned back after the fruiting is completed, leaving 60-75 cm long vines. In N plants are pruned twice in a year, in September and April. About 8-10 mm thick is pruned back to two buds. Every year after pruning about 3-5 kg. FYM is applied to each plant.

Interculture

Weeding and light hoeing are done during the early stages of vine growth.

Irrigation

The plants require light irrigation at 10-12 days interval during summer. Watering may not be necessary in rainy season. The soil should have adequate moisture during flowering and water logging is harmful to the plants.

Yield

The flowering starts after 50-60 days of planting. The average yield is about 10-15 tonnes per hectare.

Storage

The immature fruits after harvesting can be stored at room temperature for about a week.

1. Perennial moringa is commercially propagated through

- a. Seeds b. air layering c. limb cutting d. tissue culture

2. Mode of pollination in moringa
 - a. Autogamy
 - b. Allogamy
 - c. Gaitenogamy
 - d. Cross pollination
3. Curry leaf can be propagated through
 - a. Runners
 - b. off shoots
 - c. cuttings
 - d. root suckers
4. Coccinia exhibits
 - a. Dioecy
 - b. Parthenocarpy
 - c. both a & b
 - d. None of the above
5. Curry leaf belongs to the family
 - a. Myrtaceae
 - b. Rutaceae
 - c. Polygonaceae
 - d. Apocyanaceae

IMPORTANCE AND PLANNING OF ORNAMENTAL GARDENS

History and development of gardening in India

It is believed that the gardening in India is as old as its culture. Five to six thousand years before Christ, gardening was in vogue. It is understood that Indians were the first to choose gardening as the proper atmosphere for meditation. Gardening has been mentioned in classical literature of India. Asokavana of Ramayana was believed to be established with trees, shrubs, ponds, etc. The use of 'brindavan' (landscaped city) and 'Raja-vanam' (large park where kings go for hunting) did find very frequent mention in ancient literature. Many trees were considered, 'sacred' to Hinduism e.g. *Ficus religiosa*, *Saraca indica*, *Aegle marmelos* and *Mimusops elengi*. During Buddha's period (about 563 B.C.) gardening received further encouragement. Gardening is considered as a source of peace and solitude. Imitation of nature and improvement over nature were considered as a primary goal in these types of gardening. King Asoka could be considered as the Father of road side avenue planting as he was the first king to order planting of road side avenue trees in India. From 6 to 10th Century gardening received a great deal of encouragement from Indian kings.

During the time of King Somadeva (11th Century) and King Hamira (13th Century) gardening developed into a fine art. The 'Vanas' and 'Ashrams' gave way to gardens established by kings and nobles and gardening became virtually a monopoly of the feudals. The period between the beginning of the 14th Century to the end of 16th Century showed sudden change in the style of gardening due to influence of Moghul emperors who ruled India during these centuries. King Feroze Shah and King Baber brought with them the finest art of gardening from their country and the Mogul style gardens were established in Delhi, Hyderabad, Agra, Kashmir, Lahore and Pinjore. Some of these gardens are still famous to this day, e.g.

1. Garden at Fatepur Sikri (U.P.) by King Akbar
2. Moghul garden at Pinjore (Punjab) by King Fadaikhan
3. Shalimar Bagh at Lahore by Shah Jahan
4. Taj Mahal garden in Agra.

These Mogul gardens had a distinct style. They were laid out near river, or rivulets, slope of a hill or river bank. The garden may be square or rectangular and paths running parallel to water courses. Running water is the life and soul of the garden and the water channels are paved with tiles of brilliant blue colour to reflect the sky and give the impression of depth. On either side of the central channel or sheet of water were planted with flowering shrubs, trees, scented flowers like rose and jasmine. All the mogul gardens had high wall surrounding them.

During the 16th Century when British came to India they introduced the styles of gardening of England and continental Europe. The first style developed by the British was the formal or symmetrical style of gardening. By 18th Century, this style became monotonous and then informal style or natural gardens began to develop. The modern gardens, developed during 19th and 20th Centuries, involved the combinations of the formal and informal styles. The important features in English gardens are lawn, rockery, mixed borders of herbaceous perennials, annuals, shrubs, etc. Lal Bagh at Bangalore, Government Botanic Garden at Ooty, Sims park at Coonoor and Bryant part at Kodaikanal are examples of gardens established in British style.

Importance of gardening

The importance of gardening is realised by every individuals now in the globe. The gardens serve the purpose of public recreation and education. They serve to refresh the body and the mind. They are virtually a retreat for the public from the harsh strains and stresses of public life. Gardens have become essential to modern civilization. Home gardening is an integral part of family life and it lends itself for the family to relax and enjoy the nature and beauty of garden. It also helps to develop some useful hobby and the 'skill' in flower and dry arrangements. In the recent years, landscape architecture has come to play a vital role in the developments of home, public institutions, public places like bus stand, railway stations, towns and cities. Landscaping the roadsides on cities and towns is also given much importance in tropical countries like India as they provide shade and beauty to that area. In foreign countries landscaping of homes and public buildings is an important art and there are professional and qualified landscape architects who do the job. This field of gardening is slowly gaining momentum in our country especially in big cities. The government has also established many parks and a few Botanic gardens in our country. In most of the big cities and towns, Agri-Horticultural societies have been established with the sole objective of promoting horticulture, more particularly gardening. These societies organize annual flower shows and garden competition to have healthy competition among the public to develop gardening.

Scope of ornamental gardening and landscaping

Gardening which was only an art and science in the earlier days has now emerged as a huge industry. With the importance and need of gardening in improving and conserving the environment being strongly felt now, the concept of landscaping and gardening is growing rapidly. Ornamental gardening and landscaping has expanded as a multi-faceted industry encompassing activities such as propagating and rearing ornamental plants, landscaping, production of growing media, pots and other accessories, etc., generating huge employment

opportunities and simultaneously promoting activities that would improve the environment.

Planning of gardening

- **Land:** Analyzing the soil for the suitability of planting is the most important beginning to start a thriving garden. After testing the soil, enrich it with the required nutrients.
- **Plants:** Some forehand knowledge about plants like, which are hardy plants, which are for hedging, flowering, shade giving plants etc. Then the knowledge about the plants suited for dry gardens, clay soils and acid soils will help in planning good gardens. The selection of plant and styles of garden should be in such a way that it should look green and variety show that is going to last for a long time. This can be achieved by using wide range of plants from trees to shrubs, to climbing plants, flowering ones and ferns, annuals and perennials.
- **Environment:** Choose plants that are suitable to the kind of environment and climate conditions of that particular area. It would be useless and expensive to waste money on plants that will hate the environment.
- **Styles and Types:** There are several planting styles from cottage gardens to prairie gardens, from gardens for commercial purposes to those strictly for personal use. Based on the different types and styles, you can tackle the job of planting them all together in a garden, working out which ones will look best where and how they will compliment each other.
- **Cultural aspects:** Knowledge about preparation of land, fertilisation, weeding and disease and pests of plants is necessary to keep the garden productive and for proper maintenance.

1. Who is known as father of roadside avenue planting
 - a. King Babal
 - b. King Akbar
 - c. King Asoka
 - d. King Somaveda
2. Moghul garden at Pinjore was established by
 - a. King Akbar
 - b. King Fadaikhan
 - c. King Shah Jahan
 - d. King Aurangazeb
3. Example of British style of gardening
 - a. Shalimar bagh
 - b. Taj Mahal
 - c. Lal bagh
 - d. Roshnara Park
4. The Indian Botanical garden is situated at
 - a. Lucknow
 - b. Sibpur

- c. Calcutta d. New Delhi
5. National flower of Japan is
- a. Chrysanthemum b. Carnation
- c. Lotus d. Rose

TYPES AND STYLES OF ORNAMENTAL GARDENS

Types of gardens - I - formal and informal gardens

Man's eternal desire is to make his living place like that of a paradise. The geometrical design of the earlier dwellings when man came out of caves lead to orderliness as well as provided life security. But it lacked the raw nature around him inside the dwelling.

FORMAL STYLE

The gardens of Greece and Rome assured an emotional security though their Formal style. The Persian, Moorish gardens of Spain and Moghul gardens were also of the same kind and were strictly formal, symmetrical and geometrical resembling a carpet.

The Italian renaissance garden was having intricate geometric designs, sheared trees, trimmed hedges and edges to create formality.

The impact of formalism influenced the French and British gardens also in the form of **parierre**, the much divided flower beds.

The Moorish garden of Spain also had the impact of Moghul's architecture and they were formal and geometrical though Moorish gardens were exclusively meant to beautify patios of large mansions.

The key features of formal design are

- ★ Plan is made on the paper and land is selected accordingly.
- ★ The plan is symmetrical with square, rectangular and roads cut at right angles.
- ★ It had a sort of enclosure or boundary.
- ★ Flower beds also have geometric designs as in carpets.
- ★ The arrangement of trees and shrubs are necessarily geometrical and kept in shape by trimming and training.
- ★ Other features like fountains, water pools, cascades, etc. are used for further attraction.

Demerits

- ★ Formal gardens have no 'secrets' and the element of surprise is lost.
- ★ However, attractive focal points at terminal and intersecting points of paths and roads are provided to make the formal garden effective.
- ★ Present day home gardens are laid out in formal design only at the frontage.

INFORMAL STYLE

- ★ Hindu, Buddhist and Japanese garden laid no emphasis on formality.
- ★ Woodlands (vanams) and running water (streams and rivers) was the main feature around which the garden was created in natural way.
- ★ Brindavan of Lord Krishna was a woodland.

- ★ Every temple was provided with irregular shaped lotus tanks. (Latter on such tanks was given masonry boundary either rectangular or square).
- ★ Japanese developed an intensely national and naturalistic style of its own. It is in Japanese garden, the asymmetric balance has been perfected.
- ★ The impact of industrial climate drove the Britishers to opt for natural gardens latter
The further the man is isolated from nature (due to industrial revolution) the deep is the longing to go back to nature. The industrialized cities became concrete jungles with no flavour and aroma of nature and there was emptiness in human life. To avert this, natural gardens was given impetus.
- ★ The nature's projection of mountains, oceans, rivers and lakes on a larger canvas of earth's surface is informal with all its grandeur. Such grandeur is mimicked in informal gardens omitting the untamed, disastrous and violent side of nature.
- ★ Lanchlot 'capability' Brown (1716-83): She emphasized the use of coloured flower and foliage, tree form, etc. in natural style.
- ★ The cottage gardens of UK had the utility with fruits, vegetable and herb plants as well as the beauty that spans from its harmony with surrounding rural scenery.

Key feature of informal style/natural style

- ★ This style reflects naturalistic effect of total view and represents natural beauty.
- ★ It is contrast to formal style.
- ★ Plan is asymmetrical according to the land available for making the garden.
- ★ Smooth curvaceous out lines are more appropriate.
- ★ Water bodies are more irregular in shape.
- ★ Hillock are made, water falls provided, lakes and islands, cascades, rocks, shola and a rustic hutment are provided to create rural effect. Appropriately grouped plants provide living quality and they are not trimmed.

SPECIAL TYPES OF GARDENS - I - ROOF GARDEN AND VERTICAL GARDEN

Roof Garden



Roof gardening is one of the best ways towards fulfillment of this passion. Roof often are decorated with potted ornamentals, both flowering and foliage. The number of such plants may be small or large. These may be arranged systematically or carelessly. In strict sense this is not roof gardening. A roof garden is one which has close resemblance with the garden on the ground with various features, like lawn, flower bed, etc., laid out tastefully according to the principles of balance and harmony to create beauty. Main difference is in scale; the roof garden is smaller both in expansion and height.

Types

Roof top gardens may be private or cooperative in nature. When the garden is constructed on a private building, usually under single ownership, it is private in nature.

Private roof gardens may be owned by an individual or by an institution, like hotel, bank, office or other such establishments. Nowadays multistoried apartment buildings are coming up. Here, the number of owners is many and all can claim a share on the roof space. If a garden is established on the roof of such buildings, its ownership will be considered cooperative in nature.

The type of planning, gardening and problems associated with cooperative roof gardens are largely different from those of privately owned roof gardens. Under private ownership the making and maintenance of the roof garden is shaped according to the wish of the single owner, his taste, his financial ability and the type of use this garden is put to. Since, under cooperative ownership individuals vary regarding these aspects, a simpler design and management have to be worked out to suit the fancy of each individual owner.

Suitability of the roof

A roof garden puts considerable weight on the roof. The strength of the roof to bear this load is the first consideration before making a start. The best thing is to plan the engineering aspects of a new building to impart enough strength so that the load of the garden on the roof can be carried through without the danger of damage. Since the concept of gardening on the roof is comparatively new in India, this aspect had not been considered while constructing the old buildings. The planning of gardening under these two different situations will be different to a large extent.

Drainage and water proofing

In every roof, the drainage aspect is taken care of during the construction of the building. Hence, drainage should not pose a problem unless it is disturbed during garden construction. Roofs are preferably made waterproof during construction. But this water proofing takes care mainly of the rain water. But if gardening is done on the roof directly, the constantly moist soil is likely to damage the roof. Hence, arrangement for additional waterproofing should be made.

Choosing the stretch of the roof, where the construction of the building has been made with an eye for the roof gardening, the whole roof may be utilized for developing the garden. In other cases, a strip of land, 60-70 cm wide, along the side of the load bearing wall may be chosen for planting.

Planting the garden

The planning of a roof garden should nearly be similar to the one on the ground, but with limited features, like lawn, flower bed, edge, rockery, lily pool, fountain, arch, bower, lath house and the like. Other features, like statue, sundial, aquarium, mini-zoo, etc., may be added as variety. Garden lights and music set up enhance the charm of the garden. Small trees, small and medium shrubs and climbers may be grown in appropriate locations. But features like hedge, shrubbery border and big trees have little place in a roof garden.

Gardening

The soil mixture for roof garden should be prepared by mixing equal parts of garden soil and cow dung manure. Leaf mould should be a welcome alternative to cow dung for its light weight and fluffy nature. Layout of the garden should be delineated on the roof with powdered lime and the soil mixture should be spread 15-20 cm thick, leaving the paths lined with bricks. Bricks should be held together through cementing. A gap of 5mm between two bricks should be left approximately at every 50 cm length to act as drainage hole. The soil mixture of the beds should be held back from draining out through these holes by spreading a double layer of close-knit nylon screen along the inner side of the brick lining.

One kilogramme (kg) of oil cake, preferably from neem (*Azadirachta indica*), mahua (*Madhuca latifolia*) or karanj (*Pongamia pinnata*) seeds, one kg of bone meal and 0.05 m³ of small charcoal bits should be worked in every 10m² of the newly prepared beds. The pH of the soil mixture should be maintained between 6.2 and 6.8.

Enclosure

In Indian cities, sparrows, crow, squirrels, etc., often damage the leaves, flowers and berries in a roof garden. Care should be taken to keep these enemies away. Construction of an overhead framework 2.5-3.0 m high, preferably of galvanized iron pipes overlaid with nylon net, makes a durable solution of this problem. Stakes with their lower ends fixed in the roof soil and upper ends tied with the overhead iron pipes may be used to support plants of the roof garden, where necessary. To check the harmful effect of wind, which often poses serious problem for plants in the roof garden, particularly on a tall building, a wind break screen may be erected on the windward side. This screen may be prepared by training suitable climbers on a wire net stretched vertically on strong poles along the desired side.

Vertical Garden

Preparation of vertical garden

Steps

1. Build a 2 foot square by 11 inch high box from redwood, cedar, or pressure treated 2 x 6s. Screw 8 foot pressure treated 2 x 2s at the center and one corner in back, and 6 foot 2 x 2s at the other corner and 18 inches from the back on both sides.
2. Pre-drill, glue and screw 1 x 2s every 6 inches, starting at the top of the box. Extend the 1 x 2s at least an inch beyond each 2 x 2 to minimize the danger of splitting.
3. Add platforms by screwing on 3 foot 1 x 2s, then screwing on 1 x 2s laid flat to create a miniature deck.
4. Add one more 6 foot long 2 x 2 in the center at the front, and screw it to the crosspieces.
5. Add a 1 x 4 crosspiece at the top of the two longest 2 x 2s. Attach a bird house to the crosspiece.
6. Hang a bird feeder from a curved metal hanger attached to the side of the vertical garden.
7. Fill the box with good soil, then plant climbing plants and train them up the lattice. Add other plants in pots and hanging baskets.



SPECIAL TYPES OF GARDENS II - WATER GARDEN AND BOG GARDEN

Water Garden



“Planned planting of aquatic and semi aquatic plants in and around pool is known as water gardening”. The reflections of the sky and the plants on the water surface, little waves passing in parade with gems of sunbeam on their crest, the movement of fishes in water, all give us a very pleasant and happy feeling. A water garden may be large (or) small depending upon the size of the garden of which it is a part. It may be natural (or) artificial / informal (or) formal.

i) Informal pool

Those who are fortunate enough to have a shallow pond (or) a natural depression holding sufficient water and not drying up in the summer (or) over flowering too much in rains, thus maintaining more (or) less a constant level, can start their water garden conveniently in such a pool. These types of pools are informal and so more natural. The curves and bends of such pools must be graceful and artistic and merge with the natural landscape.

The base of such ponds is made impervious to water by the ‘puddling’ method. This can be achieved by importing clay and laying it to a depth of about 30-45cm at the bottom. Puddling consists of pummeling the wet clay with feet, or preferably with a rod. At this stage the clay becomes impermeable to water. The pond will be used for planting true aquatics such as lotus, water lilies, etc, where as in shallow waters near the banks bog plants are planted.

ii) Formal pool

The formal pool need not be situated in a low lying area; rather it should form a main feature of the garden and should be situated in a prominent place of the garden.

Location of pool

The pool should be far away from the tree, as they would cast their shade and drop the leaves into the pond; besides the roots may damage the walls.

Construction

Where natural water body is absent, artificial concrete pools are constructed. The wall and bottom of such pools should be at least 15 cm thick and fully waterproof. The depth should be 1m. Provision should be made for an outflow pipe laid horizontally at the bottom for completely draining out the pool. The end of the outflow pipe should run well inside the pool and fitted with a stop cock. An inlet pipe is also inserted into the pool. When the pool is filled up the excess water would get out through the open end of the vertical branch of the drain pipe. An inner concrete wall, 70cm height, is then constructed 1m away and parallel to the wall of the pond and the space between the two walls is filled with manured soil in sloppy manner.

Testing

After construction fill the pool with water and leave it for at least 4 weeks to test for any leakage and also to allow chemicals harmful to plant life and fish to dissolve out of the cement.

Planting

The bottom of the pond is filled up to a depth of 20 cm with a mixture made up of 6 parts of garden soil, 1 part of cow dung manure, 125g of bone meal should also applied per sq. meter of the bottom. The lilies and lotus are planted directly in the soil and then water is filled in just to cover the crown of the plants. More water is filled in stages as the plants make new growth. In no case should the plants be submerged. As soon as plants starts growth water level should be increased a few cm per day. This will help the growth of the young plants.

Care of the pool

Aquatic plants need very little care. However some species grow very vigorously and need trimming to avoid overcrowding and smothering of weaker species. Sometimes the water of the ponds becomes green, popularly known as '**blanket of weed**' covers the surface and side walls of the pool. Add 1kg potassium permanganate (or) 120g copper sulphate to every 24,000 litres of water.

Plants for water garden

A) Surface flowering Aquatics

Nelumbo lutea-American lotus

Nelumbo nucifera-Indian lotus

Nymphaea sp-Water lily

Victoria regia

B) Oxygenators

Elodea canadensis

Vallisneria spiralis

C) Floating plants

Eichornia crassipes

Lemna gibba

Marsh (or) Bog Garden



A pond is not an essential feature of any bog garden, but, if there is any adjacent pond, the overflow, the over flow water can be used to keep the marsh garden moist. The main criterion of a marsh garden is to keep it moist and in a swampy state all throughout. For this reason, the site of the marsh garden should be low lying where the surface drainage water will collect naturally.

The whole area intended to be developed into marsh garden is dug up to a depth of 60cm and a thin layer of clay, 10-12cm deep, is placed at the bottom to form the base of the marsh garden. Then a 12cm layer of large stones are placed over this to ensure that the water in the marsh does not become stagnant. The rest of the hollow is filled with a compost of garden loam suffer from drought and be kept sufficiently moist by a trickle of water at the same time avoiding stagnation. All parts of the marsh garden are made accessible by laying paths of rough stones (or) bricks.

Plants for marsh garden

Marsh plants can be categorized into three broad groups.

A. Plants which love 5-10cm of standing water and are termed as “**Swamp dwellers**”.

B. Plants which live on (or) a little above the waterline, with their roots standing in **water-object soil**.

C. Plants which grow above the saturated soil, but near enough to send their roots in search of water. eg., *Acorus calamus*, *Iris sp.*, *Alocasia sp.*

SPECIAL TYPES OF GARDENS III - TERRARIUM

Terrariums



A Terrarium is an arrangement of plants together in one container, often with other things like rocks, stones or miniature figures and items. Sometimes the goal of a terrarium is just to create a pleasing arrangement of plants and other times the goal is to create a miniature world. Terrarium planting is a specialized part of home gardening, but an interesting one. A great many woodland plants which prosper in their natural environments fail to grow at all in the

house due to the lack of moisture in the air. Terrariums provide this humid atmosphere and allow you to bring the forest plants home. The theory behind the terrarium is that in a closed container the moisture which the plants take up through their roots and transpire through their leaves is condensed and eventually returns to the soil again, keeping the plants watered and at the same time keeping the air within the container at a point below saturation.

History of terrariums

The bringing of the art of the terrarium is generally credited with a man called Nathaniel Bagshaw Ward. This came about with the publishing of his book called "On the Growth of Plants in Closely Glazed Cases" which he published in 1842. The second edition of this book was published in 1852 and is readily available in the public domain. In the preface to his first edition he cites an earlier reference where he wrote a letter that was published in the "Companion to the Botanical Magazine" which was published in the May, 1836 issue. He also gives credit to an author named Mr. Ellis who published an article about growing plants in closed cases in an article in "Gardeners Magazine" in September of 1839. The publication of the "On the Growth of Plants in Closely Glazed Cases" is considered to be the first substantial work that outlines the theory and keeping of terrariums.

Materials Required

It doesn't take much to set up a terrarium: fine gravel or coarse sand, charcoal chips, synthetic fabric (nylon) or screen to act as a soil separator, and potting mix appropriate to the plants used. If you wish to add a decorative touch, you can cover the soil with coloured stone, bark chips or ground cover plants.

Containers to use

The originality of a terrarium depends on the type of container you use, the plants you choose and the way you arrange them. Any glass container can serve as a terrarium, provided that it is transparent. You can recycle a large glass jar, a fish bowl or an old aquarium. Alternatively, there are some very attractive containers made of wood and glass or plastic available on the market. Terrariums do not require drain holes so, unlike other planting containers, holes are not necessary at the bottom of the container. If you are thinking of starting your own terrarium you will probably find that you have all the material and equipment you need around the house. Fish tanks, especially those that are not too big and unwieldy, make very good terrariums. All you need for them is a glass top. If you are going to start from scratch, you can build your own container using a flat, low sided box for the bottom, and fitting it with glass sides which can be taped together, and a glass top. Although the theoretical airtight terrarium would have no openings whatever, it is safer to provide the container with several drainage

holes so that you avoid the risk of over watering and rotting the roots of your plants. If you use a large brandy glass or some other container for which drainage holes cannot be provided, then you must be extra careful that there is a good layer of drainage material (pebbles, gravel, crocking, etc.) at the bottom, and that the soil is sprinkled with charcoal.

Soil mixes/ additives

Use clean, sterilized peat moss based soilless mix with vermiculite or perlite to enable the soil to hold moisture and oxygen. There should be an initial layer of gravel for drainage (one part gravel to two parts soilless mix). Add charcoal to absorb odour (one tablespoon per cup of drainage). In a small terrarium, omit the gravel and use charcoal. Soil separator can be used to keep the layer of charcoal apart from the soilless mix. Use fibre glass drapery fabric, nylon tights, sheer drapery, screening (not metal) or landscape fabric. Use sand in a desert terrarium. Sand should be bagged, washed and free of salts. Leaf mold can be used for woodland soil mixes but should be sterilized. Limestone can be used, especially for desert terrariums. Bone meal can be used in desert terrariums; do not use fertilizer in the initial planting.

Watering, ventilation and sun

When your plants are all in position, the soil should be well watered. If you can do this in the kitchen sink or in the bathtub where you can give it a thorough wetting and then allow the excess to drain out, so much the better. The frequency with which terrariums must be watered after they have been started depends on how much ventilation they are given. Although opinions vary, it has been our experience that the plants will prosper if they are kept covered during the day and the top is partially slid off at night. If this system is followed, we think you will find that your terrarium garden will need watering only once every few months. Terrarium plants need sunlight, but in limited amounts. An east or west window will do the trick, or a south facing location, if there is a glass curtain between the window and the container.

Lighting

It's important that the plants receive bright, indirect or dappled light. While direct sun will usually cook or sunburn the plants, too much shade will cause stringy growth and poor colouration. Different plants have different needs, but a good starting place is to use four fluorescent tubes for a tank that is 12-14 inches wide. The length of the tubes should be as long as the tank. 50% Gro-Lux® plant lights and 50% cool white, placed alternating across the top are used. The lights should be barely above the tank cover and the plants from 4-7 inches below the lights. Spot lights put out more heat and less light and are not recommended. Natural sunlight can be used if it is filtered through a sheer fabric, white plastic or partially shaded by other plants that do not have large, broad leaves, (too dark). Watch your plants and adjust the

light as needed. Spindly, thin and stretched growth indicates not enough light whereas pale yellow leaves with burned edges indicates too much light. For those of you with light meters: place the sensor in the tank and under the cover. When the sun or lights are illuminating the terrarium, an average candlepower runs from 500-800 using natural light, and from 400-600 using the above fluorescent lights. High Pressure Sodium and Metal Halide are usually at 600-850 foot candles. These general guidelines may need to be adjusted according to what you are growing. In any case, do not let the lighting run the terrarium temperature above 95°F.

Location

Location of the terrarium will play a part, too. If it will be in a sunny place, succulents may work best. A succulent is a water retaining plant that does well in arid conditions (e.g., jade plant, Christmas cactus, **sedum**). If the terrarium will have a lot of shade and moisture, in a bathroom for instance, then ferns and mosses will most likely be a good choice.

Terrarium tools

Some tools and terrarium supplies to plant your terrarium, especially if it has a small or narrow mouth.

- ★ **Tweezers and long sticks** can be used to dig holes, move items and support plants while they are being planted.
- ★ **A long, thin spoon** will be helpful in placing soil and drainage material in the container.
- ★ If a container with a very small opening is used, make a **funnel** from paper or aluminum foil for placing soil into the container.
- ★ **Household scissors** are handy for pruning plants before they are planted.
- ★ **An atomizer** or bulb type sprayer will be useful for spraying and watering plants in the terrarium.
- ★ **A stick with a wire loop on the end** is handy for lowering plants into large terrariums with small tops.

Terrarium-work to be done

Laying the groundwork

The way you place the soil at the bottom of the terrarium is extremely important. It should always be well drained. Start out by placing large pieces of concave crocking over each of the drainage holes to prevent the soil from leaking out. Then add an inch or so of good drainage material. Follow this with another layer of a couple of inches of a good potting mixture, such as those that can be bought in a garden supply store. It should be filled in firmly, but not tamped down too tight. The soil should be slightly damp, but not soaking wet. Then place the

plants, which should be ready nearby, by digging small holes large enough to accommodate their balls of earth in a pleasing arrangement.

Plants to grow

In addition to lichens and mosses, a good many plants which grow in the open air of your living room will prosper as well in miniature form in the terrarium.

Low light plants

Plant	Height	Comments
Swedish ivy <i>Plectranthes australis</i>	1-3"	Very durable
Bird Nest Sansevieria <i>Sansevieria trifasciata</i>	3-6"	Will survive almost anywhere
Maidenhead spleenwort <i>Asplenium trichomanes</i>	1-3"	Lays across the ground

Moderate light plants

Plant	Height	Comments
Heart leaved philodendron <i>Philodendron scandens</i>	12"+	Climber or trailer
Irish moss <i>Selaginella spp.</i>	1-3"	Excellent groundcover
Maidenhair fern <i>Adiantum cuneatum</i>	6-12"	High humidity
Miniature peperomia <i>Pilea depressa</i>	1-3"	Do not overwater
Tahitian Bridal Veil <i>Gibasis geniculata</i>	3-6"	Creeper or trailer
Parlor palm <i>Chamaedorea elegans</i>	12"+	Slow, but may become too tall
Nerve plant <i>Fittonia spp.</i>	3-6"	Pink or white
Podocarpus <i>Podocarpus macrophylla</i>	12"+	Slow growing mini-tree
Prayer plant	6-12"	Leaves fold together at night

<u>Maranta leucoreura</u>		
Spider plant <u>Chlorophytum comosum</u>	3-6"	Easily propagated
Strawberry begonia <u>Saxifraga sarmentosa</u>	3-6"	Spreads by runners
African violet <u>Saintpaulia spp.</u>	3-6"	Best to select miniature varieties
Aluminum plant <u>Pilea cadierii</u>	6-12"	Keep compact by pruning
Artillery plant <u>Pilea microphylla</u>	6-12"	Forms umbrella-like canopy
Baby tears <u>Helxine soleirolii</u>	1-3"	Excellent groundcover
Club moss <u>Lycopodium spp.</u>	3-6"	Tolerates low light
Creeping fig <u>Ficus pumila</u>	1-3"	Creeping groundcover
Dwarf natal plum <u>Carissa grandiflora nana</u>	6-12"	Prune to keep compact
Emerald ripple peperomia <u>Peperomia caperata</u>	3-6"	Do not over water
English ivy <u>Hedera helix</u>	6+"	Cut back to prevent crowding
Flame violet <u>Episcia dianthiflora</u>	3-6"	Likes humidity
Creeping Charlie <u>Pilea nummularifolia</u>	3-6"	Excellent groundcover
Earth star <u>Cryptanthus bromelioides</u>	3-6"	Nice accent plant
Miniature Begonia rex <u>Begonia rex-cultorum</u>	3-6"	Likes humidity, but not wet foliage
Golden pothos <u>Scindapsis aurea</u>	12"+	Cut back to control size

Button fern <i>Pellaea rotundifolia</i>	3-6"	Fills in any space nicely
Pitcher Plant <i>Sarracenia spp.</i>	6-12"	Carnivorous plant

Bright light plants

Plant	Height	Comments
Elephant bush <i>Portulacaria afra</i>	12"+	Desert gardens only
Haworthia <i>Haworthia spp.</i>	1-6"	Desert gardens only
Hen and chicks <i>Echeveria spp.</i>	1-3"	Desert gardens only
Jade plant <i>Crassula argentea</i>	6+"	Desert gardens only
Panda plant <i>Kalanchoe tomentosa</i>	6+"	Desert gardens only
Oxalis <i>Oxalis spp.</i>	3-6"	Shamrocks
False Aralia <i>Dizygotheca elegantissima</i>	12"+	Keep compact by pruning
Watermelon peperomia <i>Peperomia sandersii</i>	3-6"	Do not over water
Asparagus fern <i>Asparagus plumosus</i>	6-12"	Feather-like foliage
Venus fly trap <i>Dionaea muscipula</i>	1-3"	Carnivorous plant
Sundew <i>Drosera spp.</i>	1-3"	Carnivorous plant
Bloodleaf iresine <i>Iresine herbstii</i>	6-12"	Blood red foliage
Plush plant	6-12"	Desert gardens only

<u><i>Echeveria pulvinata</i></u>		
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Maintenance

Any dead leaves or rotting plants in your plant terrarium should be removed promptly with tweezers before the problem spreads to other plants. If a fungus seems to be spreading from a plant through the growing medium, remove a portion of the medium in the infected area and replace it. Apply a general fungicide to reduce spread of the disease. General maintenance required is,

1. Moisture balance

After planting an 'open' terrarium mist plants to clean them and to clean the glass walls of the container. If using a 'closed' terrarium keep the lid off until the plant foliage dries. The water in the bottom should not be more than 1 inch deep in a terrarium after planting. Once the moisture cycle is established, it is self perpetuating. Changes in light and heat are not likely to cause problems in the long run. If moisture does not appear on the glass for over a week, add some water. Most terrariums (if closed) need added water every 3 or 4 months. Open terrariums require moisture more frequently, but not as frequently as plants in pots.

2. Plant growth

Pinch back regularly to promote bushy growth. Prune woody growth to encourage compact growth. Always cut back to leaf or branch joint. Remove plants if the terrarium looks overgrown or if diseased or infested with insects.

3. Temperature

Maintain daytime temperature range of 65 - 80 degrees with a night-time temperature of ten degrees lower. A sealed terrarium is protected against sudden temperature changes, drafts or excessive dryness, as long as the environmental change does not last longer than 48 hours.

4. Light

If light conditions are not ideal, the plants will stretch or look too pale. Direct light is required for desert terrariums with no lid. Indirect strong light (east or west facing window) is excellent for tropical or woodland terrariums or up to 1.5 m away from a south facing window. Medium light is acceptable for woodland or tropical terrariums (1.5 to 4 m away from south, east or west facing windows). Low light is used for low light tropic plants (4 to 6 m away from sunny windows and 1.5 to 3 m away from north, east or west windows).

Advantages of using terrariums

- ★ Ideal environment for plants that require constant moist soil and or atmosphere.
- ★ Plants grow slowly and evenly.

- ★ An interesting alternative to using pots when space is limited.
- ★ Easily moveable.
- ★ Good for miniature specialty gardens.
- ★ Safe around children and pets.
- ★ Fun to make.

Types of terrariums

The upside down terrarium

This is a unique little terrarium that looks great. But it was quite a challenge to figure out how to do it right. Filling it with the materials like soil, stone and seeds then flipping it over real quick didn't work. The sides got dirty. All the standard terrarium making materials are used. It includes soil, seeds, spagnum moss and pearl stone for drainage. The trick is getting them in the top of the bottle or jug without getting dirt on the sides.

Apothecary jar terrariums

These jars make stylish and very attractive terrariums and they are small enough for a beginner with a large mouth for easy access. Apothecary jars make great containers for terrariums. They are attractive looking, reasonably sized and have a large mouth for easy access. If you want a good looking and easy to make terrarium this is a great way to go.

Moss terrarium

Moss terrariums have become very popular lately. Mosses could be collected from the local cemeteries, wooded areas and special note and caution about using any kind of external plant, rock or wood piece in your terrariums: Moss, Rocks, Plants, Wood pieces from the outside world can carry insects with them. Or even insect eggs that you can't see. Immediately these should not be added to any indoor plant or terrarium. First we should quarantine them in a sealed transparent container for up to a month. This way we can see if anything develops or any eggs hatch.

Hunting for Moss

- ★ Shady Spots - the moss in sunny areas was often brown and unhealthy.
- ★ Angled and slanted areas (they seemed to grow well on the sides of small hills).
- ★ This could be a water preference. On a slanted location the moss will get water only for a short period of time which is rather interesting, this leads us to believe the moss will do well with frequent but very light watering.

Desert themed terrarium

This kind of terrarium is attractive, fun to make and very hardy. Here is a complete tutorial on how to make one. A Desert themed terrarium is a fun project to make and it is

something that is relatively easy to care for. A variety of cacti and succulents which don't require a lot of water and are very tolerant of sunlight are used. This kind of terrarium can also be done in an open dish which is easier to make than in a closed container.

Carnivorous terrariums

Growing carnivorous plants in the home requires the mimicking of their natural environment so that they thrive. As carnivorous plants usually grow in extreme conditions it is more challenging to do this for carnivorous plants than for most other house plants. The majority of these plants grow in areas where the soil is extremely acidic and often very wet such as in bogs, or in soils that lack most of the nutrients that most plants need. Bright light is required by most carnivorous plants. For artificially lit terrariums use fluorescent rather than incandescent bulbs to prevent overheating.

STYLES OF GARDEN

Man was able to harmonize with the external environment *viz.*, nature in as much as he was in harmony with the internal environment *viz.*, self composed of feeling and desire. The civilization of the present and the recent past made the globe as village through its advancement in science and technology, isolated the human race from the nature externally and alienated the self internally. The nature has been exploited to the core for bodily pleasures and the self has been ignored, leading to the deterioration in the psychic, which lost righteous and reason.

To make the self to be in tune with the body and the body in tune with the nature, there has come the necessity to create artificial pleasure gardens, psychic gardens and biological gardens.

Hindu type of garden

Vanams in the earlier period served the purpose of a garden and was synonymous with garden. Vanams were the natural gardens furnished by the mother earth for the humans and animals to dwell on and inhabit in such vanams were put to various uses by the various sections of the society. Vanavasam was part of the life of Vikramaditya, Rama and Pandavas. The great sages reside only in vanams to attain spiritual bliss.

Rajavanam

Area of natural forest exclusively meant for the ruler or kings to hunt wild animals. More than hunting, it was the time spent in hunting that is relaxing in real sense. Later on four kinds of Rajavanams came into existence.

- i **Promododyan:** Private garden for king and queen exclusively. It would get attached to the forts when queen resided.

- ii **Udayan:** A vanam where the kings passed their leisure time in playing chess, enjoying dance and listening to music.
- iii **Vriksha vatika:** a vanam meant for ministers and courtiers where they made merry with courtesans.
- iv Special gardens dedicated to God with water pools studded with lotuses and lilies.

Tapovanam

It was meant for sages and hermits who would prefer to be in tune with nature and meditate to explore the self and the universal god head. Tapovanams would have the trees of spiritual significance.

- i *Guttardia speciosa* (Panneer)
- ii *Couropita guinensis* (Nagalingam)
- iii *Butea frontosa* (Vedic tree, real flame of the forest)
- iv *Caliophyllum inophyllum* (Punnai)
- v *Michelia champaca* (Sanbakam)
- vi *Ficus bengalensis*
- vii *Nauclea eadamba* (Kadambam)

Brindavanam

It means a place of eternal bliss. It is supposed to be the advanced version of tapovanam. It is a natural abode where the sages relinquish their physical body and attain radiant body (Nirvikalpa Samadhi) and the soul part of the body conjoins with the absolute. God head in eternal ecstasy. Eg: Arvind Ashram, Pondicherry; Mantralayam of Ragavendra and Ramana and Seshadri brindavans at Tiruvannamalai. Trees with showy, colourful flowers to express the absolute joy would be grown in Brindavans.

Asokavanam

It was a place or a garden where royal ladies like queens and princess relax. Asoka trees (*Saraca indica*) were grown in woodlots. The down flowing coppery leaves of *Saraca* would suggest to royal ladies that their kings would return with triumph and pacify their emotionally imbalanced heart.

Nandavanams

They are small gardens established around village temples. There the flowering shrubs whose flowers can be offered to various deities are grown for daily rituals. Eg: *Tauberana montana coronana*, *Hibiscus*, *Tecoma*, *Nerium*, *Occimum sanctum*, *jasmines*, etc.

Indus and Harappan civilization

The history of systematic gardening in India is as old as civilization of Indus and Harappan which existed between 2500 BC and 1750 BC.

- ★ Harappan pots were generally decorated with designs of tress - pipal, mango and neem.
- ★ The cult of animal and tree worship was at its peak.
- ★ The tree of pipal (*Ficus religiosa*) and banyan (*Ficus bengalensis*) served mankind and fauna in many different ways and they were considered as the symbol of fertility.

Aryavarttha period

It existed during 1600 BC. Aryavarttha means the country of lotus and sunshine. Lotus signifies the soul and the sun signifies the Godheads. The blooming lotus on the radiating sun's arms symbolizes the ultimate purpose of human life, the soul's unification with God.

- ★ They were ardent lovers of nature.
- ★ They used flowers on religious and social ceremonies.
- ★ They named the kids after the flowers. Eg: Kamal, Champagam, Madhavi, Chameli, Rukmani, Mallika.

Literature

Ramayan narrates unending list of trees, shrubs, creepers, etc. which were in use for adornment and also as seen wild in nature.

Mahabarat embodies names of various vegetation and flowers along with Kurkshetra war. In Pathu pattu, the names of 99 flowers have been mentioned at a stretch as having collected by the lady who awaited her would be who was yet to make his presence.

Kalidasa's poetic description of nature was vivid in Sakuntalam in which there was a metaphor on a twining Madhavi lata (*Hiptage madablota*) on a mango tree indicating the sweet, supple womanhood through the vine and the youthful vigour through the tree. The Megha sandesam and Regu vamsam were full of descriptions of vegetation between Ujjain and alpine Himalayas.

Very frequent references were made about flowers in folklores right from birth ceremony to the death rituals which indicates the association of flowers with social life.

Buddhist Type

Lord Buddha preached the concept of 'thoughtlessness' (Nirvana) as the only remedy for human misery caused by the desire part of the self which resides in the physical bodies a divine force.

Thoughtlessness can be achieved not by suppressing the 'desire' but by exploring the desire within.

'Exploring within' would be possible only when one's mind is detached from the senses and tries to identify the self within.

Buddhist gardens were so designed that no component will excite the senses and such gardens were established around vihars and latter came to be known as Amaravanams.

The key features are

- ★ No artificial structures would be put up in any form.
- ★ No one will pluck the flower to offer to the lord. Only the fallen flowers alone are collected and offered to the Lord.
- ★ Mostly, the trees with white and saffron coloured flowering trees were preferred and planted.
- ★ The trees shouldn't invite birds either for nesting or for eating the edible fruits as the sound of birds may disrupt the silence.
- ★ Extreme silence should be ensured in the garden so that one could enjoy meditation peacefully.
- ★ Life of Buddha had been identified with trees and flowers.
 - i. According to Hiuen, Tsang, Budha was born in 563 BC under the tree of Ashoka at Lumbini.
 - ii. He attained enlightenment under the tree of pipal at Gaya.
 - iii. He preached the first sermon of his religion under mango tree at Saranath (Varanasi).
 - iv. He entered into Samadhi in a sal grove.
- ★ During Ashoka's period, avenue planting on road was given priority (264 – 227 BC).
- ★ He wrote the messages of Buddha on stupa; in which a pipal tree, wheel and lotus were also carved.
- ★ Lotus represented the birth of Buddha, the pipal enlightenment and stupa the unification with god.

Japanese type

The entire world watched awestruck as the half century old soviet empire suddenly came unglued and is near chaotic changes today.

Slowly or less dramatically the other super power the United States also went into relative decline. While the two super powers faded, Japan's economy skyrocketed.

Now the Japan's attention has been focused in Europe and Germany in particular. In Europe power has been shifted away from London, Paris and Rome as the German's economy has outstripped all the rest. Now the nations of Europe are caught between Bonn and Berlin.



But in Japan is to continue to top in economic arena in as much as it started looking into 21st century by 1970 itself. As per the Japanese legend, 'Sanshu No Jinji' the three sacred objects given to Sun God are

Sword	Jewell	and	Mirror
implies	implies		implies
muscle power	money power		self knowledge

The success of Japan is to be attributed to the self knowledge or the knowledge of the 'self' which is inner. Self knowledge can often be used to make the other party to like your agenda for action. It can be used to punish, reward, persuade and even transform an enemy into an ally. Best of all, with the right self knowledge, one can circumvent nasty situations so as to avoid wasting force or wealth altogether.

With all modern, advanced electronic gadgets available to make the day to day life highly mechanical, the Japanese life is still undisturbed and social fabric is still vital and vibrating with human tendencies. This has been attributed to the fact that their way of life stems from internal power, the power of the self; the external developments are kept at check by the internal power of self.

The internal power of the 'self' is understood and harnessed by meditation of the body. Every individual meditates and thus the entire nation to bring out the best of human on the intellectual arena.

Japanese gardens type is nature in miniature which enables them to meditate, be in harmony with nature even while they are busy with daily routines.

History of Japanese garden cult

592-628 AD : Empress Suito: Garden style with originated with rocks, water,

- trees and plants
- 646-794 AD : Nara: Chinese influence introduced birds, animals and fishes to the above.
- 794-1185 AD : Heian: Korean architecture influence introduced an open space, pond with an island, hill and a stream of water.
- 1185-1392 : Buddhist influence through silk route. Flat gardens (Hira-niva) came into existence stones and trees were arranged on a ground adjoining vihars to bring the desired effect.
- 1603-1867 : Gardens were beautified with large lakes and islands surrounded by paths leading to the structure of the garden.

Forms of Japanese type

A) HILL GARDEN

The main features of hill garden are hills, streams and ponds along with other features

1) Ornamental water

Water is the life of the garden and necessary feature of Japanese hill gardens. It may be present in the form of big lakes with a calm tranquil surface or symbolically in the form of water basins of natural shape.

Waterfall is another means to bring the natural setting into a garden. A group of stones is raised and water is allowed to fall from it naturally. The trees are planted in front of the place where waterfalls. Wells serve a dual purpose for beauty as well as utility.

2) Islands

Islands are important feature and are located in the middle of the pond. Rocks are used for foundation of island and soil is deposited on it. Then trees are planted and stones are erected in an irregular manner to give natural touch. Islands may be connected by a bridge or left isolated.

Different islands are formed because hills, lakes and islands are complementary beauties. They are given personal touch by naming them as master island, guest island and central island.

3) Hills and hillocks

A bigger sized broad viewed hill forms the main feature (hill 1). Secondary to it, a lower hill is created adjacent to hill 1 and is called companion hill (hill 2). A lower hill 3 is projected front opposite to hill 1. Hill 4 is elegantly introduced in the foreground close to hill 3 and below hill 2. At the far end, hill 5 is to be located which could be seen from all parts of the garden.

4) Stones

The stone structures are used to depict different natural moods, ideas of spiritual and melodic. There are 5 such types of stones as described below:

- i. Status stone: A tall vertical stone bulging out towards middle and finishing at the top suggesting a human at thinking or meditating.
- ii. Low vertical stone: is rounded at the base and its top is bent resembling the bud of magnolia.
- iii. Flat stone: is a low broad stone of irregular shape with a flat top suggesting submissiveness.
- iv. Recumbent or ox stone: resembles trunk of an animal. Its long curved and bent boulder suggests an animal hiding in a bush.
- v. Arching stone: is arch like as its name indicates and suggests flexibility in thought.
- vi. The above stones can be grouped into two, three or four to give different meanings as below:
 - a) Three stones placed at the edge = long life stone of beach
 - b) Two stones on the bank of lake = Good luck stone or river

Such stones are located in ten positions in a hill garden most central (Guardian stone), opposite to the fall (companion stone), foreground centre (worshipping stone), foreground left (interviewing stone), foreground right (waiting stone), between two hills (man shadow stone), near central group of trees (cave stone), at the heart of the garden (seat of honour stone), 1st stepping stone (pedestal stone) and pair of stones near entrance (idling stones).

5) Trees

Trees are planted with certain objectives and have been given specific names.

- i. **Principal tree:** Group of trees planted at the central part of background.
- ii. **View perfecting tree:** A tree planted in the foreground of an island.
- iii. **Tree of solitude:** Group of trees with thick foliage in the background on one side.
- iv. **Cascade screening tree:** Group of bushy or leafy tree planted at the side of waterfall to hide the portion of it.
- v. **Tree of setting sun:** is planted in the west side to filter the glare of setting sun.
- vi. **Distancing tree:** Pine plants planted to give a forest look.

6) Garden lanterns

Stone and bronze lanterns were used to decorate Buddhist temples. They became the thing of beauty in gardens also. Standard lanterns or legged lanterns or stone lanterns are used in an informal manner to decorate the garden.

7) Garden pagoda

It may be in the form of stone tower or pagoda. The roof may have three, five or seven a nine or eleven separate roots.

8) Garden bridges

There are made of natural wood of stone varying in size and width. They are used to connect islands. Either single stone or many pieces have been used to make the bridges sometime, semicircular arch. Form of bridges is constructed on the special ponds to permit the passage of boats under it. The bridges are named as wooden trestle bridge, 'peeping' bridge, 'granite slat bridge' curved bracket bridge, Chinese full moon bridge, etc.

B) JAPANESE TEA GARDENS

In Japanese the tea ceremony has gained the status of national ceremony and has been intricately woven with life style. A glimpse of tea room or more sitting at tea room for a while itself is a, pleasant experience. Mat floor and wooden walls with all bamboo works. Pale brown is the colour everywhere. Two 'L' shaped benches and in front of which a sturdy but long tea poi.

No one should talk or gossip during tea ceremony. Even those who walk, conduct themselves in such a way that no noise is produced. It is really breathless silence as if one is in front of Emperor or Religious heads.

Tea is boiling in a vessel at one corner and a middle aged lady looks after the tea. The vessels are artistically made. The vessels are cleaned by with silk towel. The lady pretends as if she is cleaning the vessel since it has already been cleaned. The pretension is something like that of abhinaya bhava in Indian Bharatanatyam. Some other girl enters the room and she handles the cup and saucer. She cleans the cup and saucer and places them before the guests. The guest looks the inside as well as the outer surface very carefully. She just smiles and nodes her head towards the guest seated next. The next guest does the same careful look and passes it to the next. The process continues till all guests have a look of the cup and saucer. Such a dead slow process is the key feature of the tea ceremony as it makes one to be silent and the mind is attentive to the saucer alone. The mind is detached from the daily chores of high speed. Almost is another form of meditation to harness the power from inner self.

Then, in a tissue paper, an edible item is provided. The eatable is taken along with the tissue paper and while eating, the tissue paper hides the facial expression which is considered as unethical in Japanese life more than the taste of the stuff, the way in which it is eaten is curious to look at.

Tea is provided finally. It is green tea. The tea has to be sipped with extreme silence by the guests and after saying thanks in Japanese style, one is expected to leave.

Sometimes the tea is served outside in a garden which is called as Tea garden. Tea garden is just the nature recreated in miniature in front of the house. A path leads from garden to tea hall which is as specified by ancestors. Before one makes entry into the tea room in a garden, one should clean himself in the water kept in **unsized** granite troughs.

Such tea ceremony has been introduced into Japan by Zen-Buddhist monks. 'Zen' is a word derived from Tamil word 'Thianum'. Bodhi Dharma introduced the system of 'Thianum' (meditation) through tea ceremony. Not only the common people but also the Emperors and rulers followed the Zen. The philosophy of perseverance learnt whatever worst may happen; doing the duties meticulously; cleanliness, softness and sweetness become basic principles of Japanese society.

To attain such a mental poise, tea ceremony happens to be training. An example for the effect of mediation on mundane life is that the army should divert its course of march if a flower happens to be in the path enroot. It may be the symbolism of how a monk conducts himself to go and meet the Bodhi Dharma, the chief monk at the sanctum sanitarium and receive spiritual message. Tea decoction was considered to help meditation in those days.

The present day Japanese tea garden is sectioned into three areas *viz.*, sotoroji (outer section), machi (middle section) and uchiroji (inner section).

Outer section

The guests are supposed to wait after removing shoes. Paths will be provided with stepping stones to lead to middle section. Stone benches of irregular size are provided and the area is not planted with many kinds of plants except grasses.

Middle section

Stone troughs with water are kept for the guests to clean themselves before making entry into the inner section. Here also the stepping stones and naturally looking objects are located in an unkempt manner.

Inner garden

It is extremely simple and natural stones, lanterns, rocks water basins which look as antiques are placed. The trees, shrubs, annual and grasses are put in an informal manner. A rustic well compete with lever, rope, bucket, pulley etc. is an essential feature of inner garden. Hedge walls are provided to look natural. Stones *viz.*, kettle stone, front stone, sword hanging stones, candle stick stone and low basin stone are kept in an informal manner.

The selection of trees is such that when the outer garden is exposed to the light the inner must be darkened by shady evergreen trees.

In India, tea type Japanese garden exist at Kamala retreat of Mr. Singhniq, Kanpur; Roshanara Garden, New Delhi and Mrs. Indira Gandhi personal residence garden.

C) FLAT GARDENS

Flat gardens lack ups and down and devoid of hills, streams and ponds. They are created for confined places and are secondary in importance. Mostly Moore type gardens are developed to create scenic beauty, other adornments like stones, well, water basin, tree, etc. are used. Water current of an ocean effect is produced by covering the land surface with pure sand. The rocks or pebbles are so arranged that they give an effect of diversion or rush or water.

The key features of Japanese type

1. They are nature recreated in miniature.
2. They aid a person to meditate peacefully.
3. The colourful leaves or flowers which distract the eyes are avoided.
4. The green foliaged plants are made use of
5. Totally informal in design.
6. The natural elements like, mountains, islands, rivers, lakes, streams, bridges are made use of as components.

PERSIAN GARDEN

Water was central feature of garden design with religious symbolism; water occupied the space and interpenetrated from the open court into the enclosures.

The Islamic view of heaven or Paradise is a beautiful garden and the day of judgment will take place in gardens of pleasure complete with cooling springs and fountains.

The traditional Persian garden was composed of four essentials as below:

- i. Water for irrigation, display and sound
- ii. Shade trees for shelter
- iii. Flowers for scent and colour
- iv. Music to delight the ears



A typical garden is a quadrant pattern with water channels dividing the garden into four sections and this design is called as **Char Bagh Design**. There was usually a pool or small hill with a pavilion at the intersection of the channels.

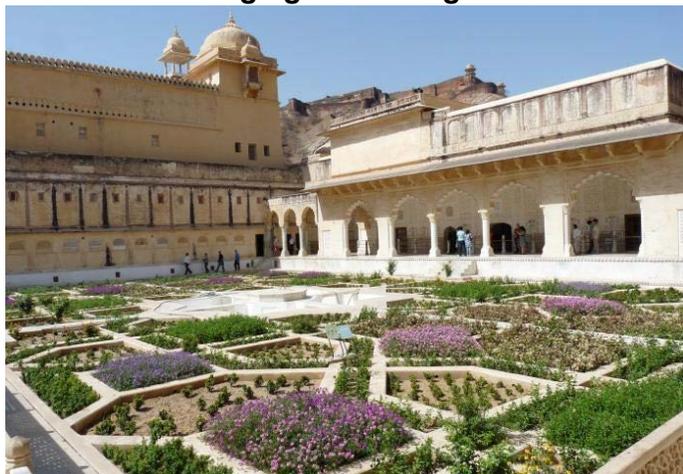
Desert of West Asia influenced the Persian type and functions of garden. The garden is a place to escape from the harsh aridity of desert. Shade trees and fruit trees were grown in four square plots as in Persian carpet. Scented flower were accepted in Persian gardens.

MOGHUL GARDENS

The great Moghul Emperor Babur had high aesthetic sense and was fond of gardens. Garden of Panipet and Arambagh garden at Agra are still maintained. Moghul gardens are synonymous of formal style of gardening which is an extended **dian** of primitive Persian garden is Char Bagh design. The same style of gardening was preserved by Moghul descendents.

Aram bagh garden at Agra

Humayun: Shady trees in all roads
 Akbar : Garden of Fatehpur Sikri
 (Agra) Tomb garden
 Jahangir: Shalimar Garden of
 Kashmir, Itmad-ud-Daula
 (Agra) Garden and
 Dikusha Garden at
 Lahore.
 Shahjahan: Shalimar of Lahore,
 Chashma Shahi (Srinagar) Taj Gardens
 Aurangazeb: Aurangabad Garden, Picturesque Pinjore Garden



Being architecturally superb, aesthetically designed, and harmonically planted, they create breathtaking sight. Broadly Moghul gardens can be categorised into two: i) Pleasure gardens of Kings and Queens ii) Tomb garden. The former gardens were made with the sole purpose of pleasure of King and Queen and family members whereas the latter gardens were attached to tombs of King or Queen for giving peace to soul.

General features

- ★ Gardens are formal in style; symmetrically planned with rectangular or square plots.
- ★ All Moghul gardens were extended Char bagh design of paradise garden of Persia.
- ★ The garden area is divided into four plots by water channels. These four channels represent four rivers of life. The running water provides coolness and freshness to the garden. Reflection of sky and trees provide unique beauty to the eye.
- ★ The four plots are planted with trees, shrubs, etc.
- ★ The axis is straight and central and sometimes represented by tree lines.
- ★ The water pool created in the centre with over flowing water serves as central specimen.
- ★ Fountains, cascades are linked to central pool to create scenic beauty.
- ★ In latter phase terminal building (Taj Mahal) has been added to enhance vista.

Key Features

i) Terraces

Terraces are components to maintain the proportion of land for extended view irrespective of topography of the area 7, 8 or 12 terraces symbolize 7 planets, 8 paradise and 12 zodiacal signs. The entrance is located at the lowest terrace.

As the Moghul emperors came from a hilly country, the idea of building a garden in terraces came to them naturally.

ii) Running water

Water is the life and soul of Moghul garden. Love for running water made the Moghuls to select sites centering round hill sides and rivulets for their garden.

- ★ The idea of constructing canals and tanks to keep the water brimming to the level of paths on either side was borrowed from Persians.
- ★ Water channels were paved with tiles of brilliant blue color to reflect the sky and give impression of depth.
- ★ Various patterns were used for paving the marble stones and style so that running water is thrown up and broken into ripples such white shawls of water is characteristic feature of Moghul garden. At dusk, tiny lamps placed in niches behind the water falls were lighted and the diffusion of light through the water creates a very pleasant sight.

iii) Site and design

A perennial river, the slope of a hill and river banks were the places selected for this purpose.

A typical Moghul garden is square or rectangle in shape. It is not merely a garden but serves the purpose of fort, residence and a place for recreation.

iv) High protecting wall

- ★ Moghul gardens are protected by a high strong wall.
- ★ The top of the wall is adorned with serrated battlements. The presence of high wall was protection against enemy and hot winds of summer.

v) Entrance

Entrance is generally tall and gorgeous. Doors are huge and strong wooden structure studded with heavy iron nails and spikes. Heavy gates are provided to protect the kings and gardens from enemy attack.

vi) Baradari

It is a canopied building with twelve open doors *ie.*, three in each direction. From baradari, one can sit and enjoy the fresh breeze and watch dark clouds and birds in the sky. The masonry pillars of baradari were painted with favourite design of bouquets of flowers in vases and the floor was furnished with thick carpets and cushions.

vii) Scented flowers

The flowers in Moghul gardens are mostly scented in nature and highly colourful. The colourful effects were created by massing mixed coloured annuals mixed colours have been preferred rather than mono, complementary or contrast colours.

Symbolism in Moghul gardens

- i. Water: Source of life
- ii. Cross at intersection of water channel meeting humanity with God.
- iii. Eight divisions: Eight divisions of Koran
- iv. Alternate planting of cypress and flowering trees: Immortality and renewal of life.
- v. *Bauhinia alba*: Youth and life.

ITALIAN GARDEN/ROMAN GARDENS

The second and first centuries of B.C saw a marked advance in the art of garden making among Romans. By the time the empire was established, Rome was girdled by magnificent villas and splendid gardens on the vast estate were to be found throughout Italy.

The key features are

- ★ There were terraces adorned with marble colonnades.

- ★ There were rose gardens, fountains, pools, alleys of ilex enriched with sculpture, edges, grove of walnuts and acacias.
- ★ Lavish buildings that graced those fabulous pleasure grounds.
- ★ Conquest of Greece had brought riches of the world to the gates of Rome and wealthy Romans were quick to adopt and adapt whatever ministered to their love of luxury and grandeur.



Eg:

- i) King Solomon's orchard, herb garden, vine yards and pleasure grounds.
- ii) King Ahaguerus's costly garden pavilions with divans of gold and silver.
- iii) Their gorgeous hanging of white, green and blue fastened with cords of fine linen.
- iv) Silver rings and marble pillars, their pavements in the gardens of Imperial Rome.

Rome set the pace in garden making for the whole civilized world. All gardens in Europe were fundamentally alike during Roman Empire.

MEDIAEVAL GARDEN

- ★ With the dissolution of Roman Empire, the art of garden making reached the low ebb.
- ★ Monks preserved the old garden tradition (Roman villas) in a humble scale with cheap emphasis on utilization.
- ★ The largest part of their garden area was devoted to orchard of plums, pears, apples peaches, almonds, walnuts and hazel nuts.
- ★ The revival of interest in gardening received more or less steady impetus from interaction and trade relations with Latin kingdoms and through commerce with other parts of East.
- ★ As a result, gardens gradually sprang up around castles.

- ★ A garden structure and design came into existence.
- ★ Along the inside of enclosing walls was usually built turfed seats, faced with wattle, stone and brick.
- ★ There were fountains, often of elaborate design.
- ★ There were pools and fish ponds.
- ★ There were beds surrounded by lathwork with ornamental posts.
- ★ There were arbours and vine covered galleries.
- ★ Sometimes, flowers in small enclosures were planted in the lawn - the kind of flowery meadow.

RENAISSANCE GARDENS OF ITALY

- ★ When the renaissance came, the fresh shoot from the roots of Roman civilization got nourishment.
- ★ Secular gardens had followed the fashion monastic garden.
- ★ Gardens provided the element of delight in nature and of being in the open and acquired a distinct status of quasi-utilitarian function.
- ★ It was a bit of nature tamed and made companionable; a bit of outdoors domesticated and made fit and accessible for daily or hourly retreat and occupancy.
- ★ There were walks and alleys straight as an arrow, environed with spreading vines with copious clusters *i.e.*, there were arbours and pergolas.
- ★ There were lemon and orange trees besides herbs, plants and 1000 diversities of flowers.
- ★ Fountain of white marble with gush of water.
- ★ There were formal designs, geometrically arranged flowerbeds and central fountain.
- ★ The different garden levels by means of terraces and steps were successfully maintained. Latter this led to development of hanging gardens at 'Villa Medici'
- ★ Highly ornamental vases, plastic forms, flower pots marble seats, secret gardens, fanciful topiary works, labyrinths, belvederes, little mounts to command views and islets on miniature lakes were incorporated.

FRENCH GARDENS

Long before the **villa modama** was dreamed of, Charles VIII and Louis XII had made their memorable expedition to Italy and carried back with him, the seeds of renaissance.

- ★ Gardens burst forth from the castles and assumed on hitherto unwonted area.
- ★ The rectangles, squares within broad borders were created to give a pattern.
- ★ Geometric designs and embroidery patterns were created.
- ★ Completely organized and balanced composition of garden was achieved.

- ★ The sense of design had measurably increased, the plan had expanded, the decoration was more sumptuous and varied.
- ★ The colours of flowers were now recognized as an important factor in composition.

Europe garden Scenario sum up

- ★ The origin of pleasure garden is Persia (Iran and Central Asia)
- ★ Greeks copied the act of gardening from Persians.
- ★ Romans borrowed it from Greeks.
- ★ With the fall of Roman Empire, the art of gardening decayed in Europe.
- ★ With renaissance, it blossomed into France but not to England.

BRITISH GARDEN

The English garden admirers were impressed by the contemporary developments in Italy and France but they refused to be dazzled. The elaborate parterre (pattern) that enjoyed in Italian and French gardens found no favour in England. In its place, there developed a peculiar and very characteristic knot gardens or British gardens.

English gardens are most beautiful garden among all European gardens. The reasons are:

- i. The UK enjoys the typical grassland climate with well distributed rainfall. This is favourable for the growth of herbaceous perennials.
- ii. Since they were ruling many countries, valuable plant collection was possible from diverse areas.
- iii. Gardening is a high cost technology and British were rich enough to afford luxury.
- iv. Britishers are very fond of flowers.

Stages of development

14th century

Monks introduced garden craft in England. They were planted with fruits, vegetables with a sole purpose of getting food for monasteries and herbs for medicinal purpose.

16th century

Gardens consisted of symmetrical walks of clipped evergreens, statutory and masonry metal stages, statues of Greek gods were scaled on architectural fantasies.

- ★ Introduction of various exotic plants through new trading companies.
- ★ Flower garden got a special stimulus.
- ★ Formal in design with topiary and carpet garden.

They key features of British garden in India are: i) Lawn ii) Rockery and iii) herbaceous border.

i) Lawn

To day grass lawn is a principal feature of English garden. A lawn can be any shape and it may be plain or undulating. It can be laid by seed, turfing or plastering.

ii) Rockery

It is the second important feature of an English garden. The colourful rockery with true rock plants which is not found in plains of India.

- * A regular design is not required for making rockery.
- * There are four types of rockeries.
 - a) Cold weather rockery of annuals like *Alyssum*, *Calendula*, *Candytuft*, *Dianthus*, *Ageratum*, *Gailardia*, *Verbena*, *Zinnia*.
 - b) Rockery of succulents for dry areas.
 - c) Rockery of fern in humid areas.
 - d) Rockery in the fernery

iii) Herbaceous border

Flower beds or borders are characteristic feature a British garden. The height of the plant, time, duration and overall colour scheme are taken into consideration.

* It is usually designed in three rows with tall and dwarf ones on the sides and the medium ones in the middle.



* Modern trend prefer a wavy design. To get this effect, the tall ones are alternated with medium in the 1st row and the medium ones are alternated with dwarf ones in the second row.



* The flower borders can themselves be bordered by a row of very dwarf plants like *Alyssum*.

Colour scheme

The natural and most pleasing colour scheme is the one that we observe in the rainbow. The order is Violet, Indigo, Blue, Green, Yellow, Orange and Red. If this is followed in flower beds, it would please many, but personal liking and individual taste differ with temperament. In nature, the primary colours are Red, Yellow and Blue. All other colours are combination of these colours.

Flower beds of mixed colours can be introduced when required colour is not available. 'Dot plants' are put in harmoniously planted places to break the monotony. They should be conspicuously coloured plants such as red, black and blue.

Hue : Pure colour with no addition of black or white

Tint : Lightening of basic hue by addition of white

Shade : Deepening of basic colour by addition of black

Tone : A chromatic change of pure hue by addition of black and white *ie.*, Grey.

Value : Describes the colour intensity of hue.

Colour scheme

i) Monotone

The use of one hue only but utilizing the full gamut of all its tints, shades and tones create a complementary harmony.

ii) Complementary

The use of two colours directly opposite to each other on the colour wheel plus their respective tints, shades and tones create a complementary harmony.

iii) Analogues

Neighboring colours are in harmony with each other because they have a common denominator.

Eg: Blue and Violet: Both contain blue

Red and Orange: Both contain red.

Preferably two neighboring colours are utilized and at times three.

iv) Triadic

It is the use of three colours in the triangle Yellow, Red and Blue, or Violet, Orange and Green.

Latest developments in British type

In the last century, the most conspicuous new development was the emphasis laid on lawns. The lawn became larger and more perfect, however, the old heritage of sundry elements of garden composition was not given up.

Up to the time of Sir William Kent, the gardens had definite form and enclosure of some sort.

But William Kent, thought garden as a part of whole landscape view.

- ★ Formal lines were broken into gently curvaceous lines as prevalent in nature.
- ★ Formal water bodies were converted into lakes of irregular shape.
- ★ Straight paths were replaced with winding paths.

- ★ Instead of clipped hedges, internal groups of hedges were planted.
- ★ He introduced the concepts of garden viz., Balance, Proportion, Unity, Movement, Surprise, Skyline, Rhythm and Harmony.
- ★ The basins of trees were planted with bulbous plants.
- ★ The lawn was introduced into a meadow form.

Eg: Royal Botanical Gardens

Psychic Garden at Chelsea

Cottage Gardens

1. Example of an informal garden
 - a. Taj Mahan
 - b. Budha Jayanti Park
 - c. Brindavan Gardens
 - d. Dilkusha Garden
2. An example of surface flowering plant used in water gardens
 - a. *Vallisnaria spirallis*
 - b. *Lemna gibba*
 - c. *Eichhornea crassipes*
 - d. *Victoria regia*
3. Which of the following is a carnivorous plant
 - a. Blood leaf iresive
 - b. Plush plant
 - c. Jade plant
 - d. Sun dew
4. Garden which is meant for royal ladies
 - a. Rajavanam
 - b. Nandavanam
 - c. Asokavanam
 - d. Brindavanam
5. Baradari is a key feature in which type of garden
 - a. Moghul
 - b. French
 - c. Japanese
 - d. British

USE OF TREES, SHRUBS, CLIMBERS, PALMS, HOUSEPLANTS AND SEASONAL FLOWERS IN THE GARDENS

Landscaping is an aesthetic branch of Horticulture, which deals with planting of ornamental plants in such a way that it creates a picturesque effect. Landscape gardening can also be defined as the beautification of a tract of land having a house or other object of interest on it. It is done with a view to create a natural scene by the planting of lawn, trees and shrubs. Further, landscape gardening is both an art and science of the establishment of a ground in such a way that it gives an effect of a natural landscape. It can also be defined as “improving of total living environment for the people”.

TREES

Trees can be classified into two groups namely, shade (or foliage) and ornamental trees and flowering trees. The line of demarcation between the two groups may sometimes get blurred. In the first group, only those trees are included which are planted for their showy ornamental foliage or for shade and which are either non flowering (e.g., Cone bearing gymnosperms) or bear inconspicuous flowers. In the second group are included trees bearing showy and ornamental flowers.

Trees can be used in gardens as specimen, avenue plantation, wind break and screening of less pleasing sites, and offer privacy. They provide shade and shelter and also reduce heat during hot summer.

Shade and ornamental trees tress

Botanical name	Family	Common name	Particulars
<i>Albizzia lebbek</i>	Leguminosae	Vahai, Siris tree, Lebbek tree, Womans tongue tree	Deciduous, fast growing and spreading tree with thin feathery foliage. Resistant to drought.
<i>Alstonia scholaris</i>	Apocynaceae	Devils tree	Elegant tree with whorled branches. Produces drumstick like fruits during summer
<i>Anthocephalus cadamba</i>	Rubiaceae	Kadamba	Tall tree with spreading crown and drooping branches. Flowers are ball like.
<i>Azadirachta indica</i>	Meliaceae	Vembu	Medium sized ever green tree with foliage light green, serrated leave. Recommended as a avenue tree for high ways.

<i>Callophyllum inophyllum</i>	Guttiferaceae	Alexandrian laurel, Dilo oil tree	Greek ‘Kalos’ meaning beautiful and ‘phyllon’ means leaf and ‘inophyllum’ means with strongly nerved leaves. The tree is more attractive for its large and shining leaves.
<i>Casuarina equisetifolia</i>	Casuarinaceae	Beef wood, she oak tree.	Suitable for growing in dry and hot tracts and is quick growing.
<i>Dalbergia sissoo</i>	Leguminosae	Sissoo tree.	Plant can stand drought as well as submerged conditions for a fairly long duration.
<i>Eucalyptus spp.</i>	Myrtaceae	Blue gum tree	It draws enormous amount of water from the soil. Grown as wind break at a spacing of 5 -8 m.
<i>Ficus bengalensis</i>	Moraceae.	Banyan	Huge tree with aerial roots originating from the branches strike into the soil and gives a columnar support to the immense head of foliage.
<i>Ficus benjamina</i>	Moraceae	Java fig tree, Golden fig.	Evergreen tree with drooping branches. The globose fruits when ripe are very ornamental.
<i>Ficus elastica</i>	Moraceae	Indian Rubber Tree	Quick growing often reaching 15 to 60 m height, smooth shining leaves. Young leaves remain enclosed in a pinkish stipule giving the plant an ornamental look.
<i>Filicium decipiens</i>	Sapindaceae	Fern leaved tree.	Ornamental tree with attractive foliage.
<i>Grevillea robusta</i>	Proteaceae	Silver oak	Evergreen tree with finely divided fern like leaves, the under surface of which is silvery downy.

Fruit trees for avenues

Botanical name and family	Family	Common name	Characters
<i>Averrhoa carambola</i>	Oxalidaceae	Carambola tree	Medium sized tree and very ornamental
<i>Eugenia jambolana</i>	Myrtaceae	Jambolan	Tall and spreading tree and propagated through seeds
<i>Mangifera indica</i>	Anacardiaceae	Aam	
<i>Phyllanthus emblica</i>	Euphorbiaceae	Amla	Ornamental tree suitable road side planting
<i>Tamarindus indica</i>	Leguminosae	Tamarind	Large tree suitable for road side planting.

Flowering trees

Botanical name and family	Family & Common name	Flower colour and flowering time	Characters
<i>Amherstia nobilis</i>	Leguminosae (Queen of flowering trees)	Vermilion coloured raceme with yellow flowers (February – May)	Medium sized spreading tree and young leaves remain folded with purplish coppery hue
<i>Bauhinia purpurea</i>	Leguminosae (Purple bauhinia or geranium tree)	Rosy purple or lilac or deep pink (November)	Medium sized evergreen tree with clawed or pointed flowers which are large and showy
<i>Callistemon lanceolatus</i>	Myrtaceae (Bottle brush tree)	Brilliant Crimson Scarlet (April May and Aug – Sep)	A small tree with narrow lanceolate leaves and weeping branches, propagated from seeds or layers
<i>Cassia fistula</i>	Leguminosae (Sarakonnai or Golden shower)	Bright yellow flower (February – May)	Medium size beautiful tree with long pendulous racemes, propagated by seed and suckers
<i>Erythrina indica</i>	Leguminosae (Kalyan Murungai or Indian coral tree)	Scarlet red flowers (March-May)	Propagated by seed and cuttings
<i>Delonix regia</i>	Leguminosae Gul Mohar	Orange scarlet flowers (April-May)	Raised from seed
<i>Jacaranda mimosifolia</i>	Bignoniaceae	Blue colour (March – May)	Deciduous often grows to 10 m. height, pretty foliage, feathery
<i>Lagerstroemia flosreginae</i> (Syn. <i>L. speciosa</i>)	Lythraceae Pride of India	Mauve coloured flowers (April –May)	A large deciduous tree, easily propagated from seeds
<i>Michelia champaca</i>	Leguminosae Shembagam	Light yellow whitish and red flowers (April - May and Sept - October)	Seedling takes three years to bloom
<i>Melia azedarach</i>	Meliaceae Persian Lilac	Lilac flower (March – May)	Deciduous 15 to 20 feet height, bipinnate leaves small heliotropic scented lilac flowers in large panicle
<i>Mellingtonia hortensis</i>	Bignoniaceae Indian cork tree or tree jasmine	Fragrant pure with jasmine like flowers (June – Nov)	A tall stately rapid growing tree, propagated from seed or by sucker
<i>Parkia biglandulosa</i>	Leguminosae Badminton ball tree	White flower (April – May)	Pretty foliage, pinnate leaves, small white flowers with long peduncle, propagation from seed
<i>Peltophorum</i>	Leguminaceae	Pale yellow colour	Quick growing tree, fine

<i>ferrugineum</i>	Copper shield	(April – May)	graceful feather foliage, pinnate leaves, raised from seed
<i>Plumeria alba</i>	Apocynaceae Pagoda tree or temple tree	White colour Throughout the year	Handsome trees with architectural shapes and fragrant flowers. Evergreen species gives waxy white flowers throughout the year
<i>Plumeria rubra</i>	Apocynaceae Pagoda tree or temple tree	Red colour Throughout the year	Handsome trees with architectural shapes and fragrant flowers. Evergreen species gives waxy red flowers throughout the year
<i>Spathodea campanulata</i>	Bignoniaceae Indian Tulip	Orange, Scarlet flowers (June – July)	Leaves are glossy and bright green raised from seed
<i>Tabebuia rosea</i>	Bignoniaceae	Pale mauve coloured flowers	Good avenue tree
<i>Tabebuia avalandi</i>	Bignoniaceae	Mauve flowers (November - January)	Umbrella shaped tree and a good specimen tree for gardens

Arboretum: Growing of different species of trees in one place is called ‘arboretum’. The trees form the main frame work of the garden.

SHRUBS

Shrubs are defined as woody or semi woody perennial plants, the branches of which arise from the base of the plant and grow up to a height ranging from 50 cm to 4 m.

Shrubs are very important in the garden as flowering shrubs produce beautiful flowers at eye level. They display their varied beauty by way of richly coloured flowers, handsome foliage and their shape. They form the frame work of garden as they are semi permanent in character.

Shrubbery border

In the garden, to secure privacy and provide partition, shrubbery can be preferred. E.g., *Duranta*, *Lawsonia* etc.

Uses:

- They are important garden plants not only because of the large number of cultivated species and varieties but also due to the wide range of variation in the shape and size of the plants.
- They fit very well to home gardens in cities and towns.
- Shrubs act as a foundation plant in the buildings.
- Flowering can be seen throughout the year from one or other plant.

- e) They can be used as a hedge, fencing and also for topiary. E.g., *Hibiscus*, *Divi Divi*, *Thevatia*, *Casuarina*, etc.
- f) They can also be grown as potted plants.

Botanical Name	Family	Colour of the flowers
<i>Acalypha hispida</i>	Euphorbiaceae	Long drooping spikes of crimson red flowers and the foliage is copper coloured and variegated.
<i>Adenium obesum</i>	Apocynaceae	Succulent stem and flowers is funnel shaped. Slow growing plant ideal for pots.
<i>Allamanda grandiflora</i>	Apocynaceae	Yellow funnel shaped flowers
<i>Artabotrys odoratissimus</i>	Annonaceae	Scented flowers, green and turn to yellow on ripening
<i>Aralia</i>	Araliaceae	Quite hardy plants and can be grown in plains.
<i>Barleria cristata</i>	Acanthaceae	Flowers are pink, violet, yellow in colours
<i>Beloperone guttata</i>	Acanthaceae	Terracotta red orderly arranged showy bracts
<i>Bauhinia tomentosa</i>	Caesalpinaceae	Sulphur yellow in colour
<i>Caesalpinia pulcherrima</i>	Leguminosae	Bushy shrub with few scattered prickles. Shrub gives orange scarlet flowers.
<i>Camellia japonica</i>	Theaceae	Double flowers with white, rose or pink colour
<i>Cestrum nocturnum</i>	Solanaceae	Scented flowers at night
<i>Cestrum diurnum</i>	Solanaceae	Evergreen plants, bears white flowers during day time
<i>Clerodendron inerme</i>	Verbenaceae	White flowers
<i>Cassia alata</i>	Leguminoase	Yellow flowers during winter
<i>Crossandra</i>	Acanthaceae	Hardy suitable for shrubbery with yellow or pale lilac or brick red or orange flowers
<i>Cuphea jorullensis</i>	Lythraceae	Much branched shrub with yellow tipped scarlet minute flowers
<i>Dombeya spectabilis</i>	Sterculiaceae	Cream/deep pink flowers
<i>Duranta plumieri</i>	Verbenaceae	Blue flowers
<i>Eranthemum bicolour</i>	Acanthaceae	Plants with colourful foliage and grows well in shady and semi shady areas
<i>Hamelia patens</i>	Rubiaceae	Orange red flowers

<i>Hibiscus rosasinensis</i>	Malvaceae	Mostly red in colour, yellow, pink and orange colours also available
<i>Hibiscus mutabilis</i>		Flowers fade from pink to crimson
<i>Holmskioldia sanguinea</i>	Verbenaceae	Peculiar orange red flowers
<i>Hydrangea</i>	Saxifragaceae	Flowers borne in round heads of white, pink or blue.
<i>Ixora</i>	Rubiaceae	Bears large terminal trusses of flowers in white, yellow, pink, orange, scarlet and orange scarlet colour.
<i>Lantana camera</i>	Verbanaceae	Common weed but can be grown as shrubbery along paths and roads
<i>Lawsonia inermis</i>	Lythraceae	Bears white scented flowers followed by profused bearing of berries
<i>Nerium oleander</i>	Apocyanaceae	Single or double in rosy pink colour
<i>Nerium</i>	Apocynaceae	Bushy shrub with cane like stems. Bears sweet scented flowers and are white, pink deep red and cream in colour.
<i>Pentas cornea</i>	Rubiaceae	Red, pink or violet colour
<i>Poinsettia pulcherrima</i>	Euphorbiaceae	Red or orange colour
<i>Tecoma stans</i>	Bignoniaceae	Yellow colour flowers
<i>Thevetia nereifolia</i>	Apocyanaceae	Yellow colour flowers
<i>Tabernamontana coronaria</i>	Apocyanaceae	White colour flowers
<i>Tephrosia candida</i>	Leguminosae	White or reddish pea shaped flowers
<i>Thunbergia erecta</i>	Acanthaceae	Dark blue flowers

CLIMBERS

Climbers are an important group of ornamental plants. The beauty of any garden can greatly be enhanced by carefully selecting and planting them in suitable places. Plants which have special structure to climb on supports are defined as climbers.

Botanical Name & Family	Common name	Features
<i>Adenocalymma</i>	Garlic vine	Heavy evergreen climber with shiny leathery foliage and

<i>alliaceum</i> (Bignoniaceae)		large trumpet shaped pink flowers blooming during March to June
<i>Allamanda cathartica</i> <i>var grandiflora</i> (Apocynaceae)		Flowers are large, yellow and scented and bloom almost round the year
<i>Antigonon leptopus</i> (Polygonaceae)	Coral vine	Tuberous rooted quick growing climber, bearing rose coloured flowers in great abundance. Flowers throughout the year.
<i>Artabotrys odoratissimus</i> (Annonaceae)		Large woody climber or half scandent shrub. Flowers are solitary, greenish yellow in colour when ripe and gives a strong scent resembling that of
<i>Beaumontia grandiflora</i> (Apocynaceae)	Nepal Trumpet climber	Quick growing ornamental climber with woody stem and large shiny foliage. Gives out white trumpet shaped lily like flowers with faint scent.
<i>Clerodendron splendens</i> (Verbanaceae)		Dwarf growing climber with dark green leaves and bears dazzling crimson coloured flowers.
<i>Clitoria ternatea</i> (Leguminosae)		Summer growing perennial climber with a woody base, can climb tall grasses and crops. Leaves are elliptic to narrowly lanceolate and Flowers solitary, attractive, deep blue, occasionally pure white,
<i>Ipomea cairica</i> (Convolvulaceae)	Railway creeper	Quick growing climber with palmate light green colour. Produces purple coloured flowers with large corolla tube.
<i>Jacquemontia pentantha</i> (Convolvulaceae)		Light and neat climber grows on trellis and arbours with bell shaped violet blue coloured flowers throughout the year.
<i>Petrea volubilis</i> (Verbanaceae)	Purple wreath	Woody shrubby climber with wreath like spikes of star shaped light mauve flowers during summer
<i>Porana paniculata</i> (Convolvulaceae)	Bridal bouquet	Strong shrubby climber having large dark green heart shaped leaves and white fragrant small flowers in abundance

<i>Quisqualis indica</i> (Combretaceae)	Rangoon creeper	Widely grown and hardy climber. Curved spines enable it to climb and flowers are white at the time of opening but gradually turn into pink and reddish and hence white and pinkish flowers are seen together
<i>Thunbergia grandiflora</i> (Acanthaceae)	Heavenly blue , clock vine	Extensively growing heavy climber with dense foliage and lovely bell shaped blue coloured flowers with yellow shades inside it.
<i>Vallis heynei</i> (Apocynaceae)		Evergreen climber with pretty foliage and bears white fragrant flowers.
<i>Vernonia elaeagnaefolia</i> (Compositae)		Quick growing evergreen limber and useful for screening. The branches are pendulous hang close to their support thus forming a neat screen. The flowers are white in colour but insignificant
<i>Bougainvillea spp.</i> (Nyctaginaceae)		Versatile plant and can be used like bush, standard bush, climber, hedge, pot plant, bonsai, ground cover for sloppy land.

PALMS

The large family of palms (Palmae) is pre-eminent in the plant world for their grandeur, which is especially remarkable in regions where palms grow naturally to their full luxuriance. Linnaeus appropriately styled them "Princes of the vegetable kingdom." There are some 1,150 species of palms known and more doubt less still remain to be discovered. They may be divided into two main classes: (1) feather or pinnate leaved and (2) fan or flabelliform leaved. About two thirds of the species come under the former class. Most palms have upright, straight, unbranched stems, many reaching a great height. Some are bushy, throwing out numerous stems from the base. E.g., *Chrysalidocarpus*, *Ptychospema*, species of *Licuala*, etc. while others as *Chamaedorea*, are dwarf, flowering and fruiting at a height of but a few feet. A few are naturally branched or forked, as the Doum Palm (*Hyphaene*). Some have bent stems, as in coconut; others are enormous climbers, e.g. *Calamus*. Palms are either wind or insect pollinated or both. Some are dioecious e.g. Date palm, Palmyra, Lodoicea and Phytelephas and others monoecious, as the Coconut and Oil palm.

Pinnate leaved palms

<i>Acanthophoenix crinita</i>	Thorny stems
<i>Acanthoriza aculeata</i>	30-40 ft. Spiny aerial roots on stem
<i>Acrocomia sclerocarpa</i>	Macaw Palm. Stout erect stem, 40-50 ft. Very spiny; spines 3-4 in long.
<i>Archontophoenix alexandrae</i>	Handsome sp., flowers in large white panicles
<i>A. cunninghami</i>	40-50 ft.
<i>Areca catechu</i>	Arecanut; Betel palm
<i>A. concinna</i>	Ceylon. Small slender stem
<i>Arenga saccharifera</i>	Gomuti- or Sugar-palm. Leaves up to 25 ft. or more in length; pinnate, 2-3 ft. by 3 in. broad. Very large, handsome species
<i>Astrocaryum rostratum</i>	Petioles very spiny
<i>Attalea cohune</i>	Cohune Palm. Honduras. 50-60 ft. Bears very large spadix
<i>Bactris (Guilielma) utilis</i>	Peach nut; Pejibaye; Pewa; Pupunha. Slender stems; whole palm spiny, 30-40 ft. Fruit in clusters, reddish-yellow, eaten boiled with salt or roasted
<i>Bentinckia condapanna</i>	Slender sp. about 30 ft. high
<i>Calyptrocalyx spicatus</i>	30-40 ft. Bright red berries on long spikes

Feather leaved palms

<i>Caryota cumingii</i>	Handsome genus with bi-pinnate leaves
<i>C. urens</i>	Toddy Palm. Handsome, bi-pinnate leaves; 50-60 ft. Flowering spadices 7-9 ft. long, in huge bunches
<i>Chamaedorea elegans</i>	Dwarf, single stem; flowers when 2-3 ft. high
<i>Chrysalidocarpus lutescens</i>	Cane Palm. Many stems; handsome, fine, feathery leaves excellent for pot culture
<i>Cocos flexuosa</i>	30-40 ft. Handsome feathery leaves
<i>C. nucifera.</i> <i>C. plumosa and</i> <i>C. schizophylla</i>	Coconut Palm Handsome palms, 40-50 ft.
<i>C. weddelliana</i>	Small elegant sp. with fine pinnate
<i>Cyrtostachys renda</i>	Sealing wax palm; Pinang-rajah. Bright red leaf-sheaths,

	numerous stems
<i>Desmoncus major</i>	Climbing palm, very spiny; small, round, red fruit
<i>Diplothemium caudescens</i>	Very handsome, small palm. 10-12 ft
<i>Elaeis guineensis</i>	Oil Palm
<i>Euterpe edulis</i>	Tender stem tops edible, used as a vegetable in Brazil, etc
<i>Guilielma speciosa</i>	Peach palm; Pejibaye
<i>Hydriastele wendlandiana</i>	Slender palm; small round, scarlet fruit
<i>Kentia (Howea) australis</i> ; <i>K. belmoreana</i> ; and <i>K. forsteriana</i>	Single stem, handsome pinnate leaves; favourite palms for pot culture in Europe, etc.
<i>Manicaria saccifera</i>	Bussu Palm
<i>Metroxylon Rumphii</i>	Prickly sago palm
<i>Myrialepis Scortechinii</i>	Strong growing climber, spiny leaves and stem
<i>Nephrosperma vanhoutteana</i>	Erect, slender stem
<i>Nipa fruticans</i>	Nipa; Water palm. See sugar palms
<i>Oncosperma fasciculate</i> , <i>O. filamentosa</i>	Nibung palm. Many stems; handsome, drooping pinnate
<i>Oreodoxa oleracea</i>	Palmiste. Cabbage Palm. 80-100 ft., very stately, cylindrical stem; effective in avenues. Top part edible
<i>O. regia</i>	Royal palm; Bottle palm. Stem usually barrel-shaped. Tender top portion edible, commonly used as a vegetable
<i>Phoenix dactylifera</i>	Date palm
<i>Wallichia disticha</i>	Fan-shaped feathery Palm
<i>Rhopaloblaste hexandra</i>	80-100 ft., single, slender stem; narrow pinnate, ornamental in small state

Fan Leaved Palms

<i>Borassus flabellifer</i>	Palmyra palm
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<i>Copernicia cerifera</i>	Carnauba wax palm
<i>Corypha umbraculifera</i>	Talipot palm
<i>Hyphaene thebaica</i>	Doum palm. One of the few branching palms. 30-40 ft. Fruit edible
<i>Latania Commersoni</i>	40-50 ft. L. purplish, glaucous
<i>Licuala elegans</i>	Small sp. with many stems; petioles prickly
<i>L. gracilis</i>	Bushy, 5-7 ft
<i>L. (Pritchardia) grandis</i>	Single stem. 6-8 ft. Leaves almost circular, pleated fan like; very elegant.
<i>Livistona altissima</i>	60-80 ft.; petioles prickly; berries scarlet
<i>Stevensonia grandifolia</i>	40-50 ft., single stem; leaves. spiny, reddish tint when young

Sub tropical palms

<i>Brahea dulcis</i>	Fan leaved, dwarf sp
<i>Chamaerops fortunei</i> (<i>Trachycarpus excelsus</i>).	Fan leaved
<i>C.humilis</i>	Fan leaved, dwarf sp., only European palm
<i>Nannorrhops ritcheana</i>	Small bushy palm. Leaves used for fans, baskets, etc.
<i>Rhapis flabelliformis</i>	Small slender palm, numerous stems; used for walking sticks
<i>Rhopalostylis (Areca) sapida</i>	Nikau palm. Small, pinnate leaved
<i>Trachycarpus excels</i>	Fan leaved, dwarf sp.
<i>Washingtonia filifera</i>	Handsome fan leaved; copiously furnished with long, creamy white, filiform threads. elegant, fan leaf margins

HOUSE PLANTS/ INDOOR PLANTS

- Plants can be a beautiful and unique way to add a decorative touch to any room in a home or office. For a beautiful centerpiece, use plants with colorful foliage or blooming plants.
- Common indoor houseplants may provide a valuable weapon in the fight against rising levels of indoor air pollution, by absorbing carbon dioxide and releasing oxygen so they do actually clean the air.

Botanical Name & Family	Common name	Features
<i>Aglaonema sp</i> (Araceae)		Plants have an erect habit with long, slender pointed leaves with depressed lateral veins and corrugated appearance. <i>A. costatum</i> has white spotted leaves.
<i>Anthurium sp</i> (Araceae)		This genus comprises more than 200 species which are valued for ornamental leaves and colourful spathes which are rigid and waxy. Plants are rhizomatous and can be propagated through division.
<i>Aralia</i> (Araliaceae)		Leafy bushy shrub with leafs coarsely toothed.
<i>Asparagus plumosus</i> (Liliacea)	Asparagus fern	Beautiful foliage plant with numerous horizontal spreading branches and bristle like leaves.
<i>Begonia</i> (Begoniaceae)	Elephants ear or beef steak geraniums	Large handsome ornamental foliage plant. Grows well in a humid and shaded conservatory. Flowers are beautiful resembling roses but the texture is finer. The margin of the petals may be plain, fringed or fimbriated.
<i>Caladium</i> (Araceae)		Popular indoor plant valued for its highly ornamental foliage. The leaves are broadly arrow shaped and membranous in texture. The colour of the leaves vary from white to purple, bronze, pink and deep crimson and blotched, splashed and spotted with conspicuous colours.
<i>Codiaeum</i> (Euphorbiaceae)	Crotons	Popular ornamental shrub with colourful and attractively shaped leaves. The plants are hardy in nature.
<i>Coleus</i> (Labiatae)		Perennial herbaceous plant grown for its colourful foliage. Grown commonly as pot plant.
<i>Colocasia</i> (Araceae)		Tuberous rooted herb similar to alocasias.
<i>Dracaena</i> (Liliaceae)		Evergreen shrubs or trees known for their richly

		coloured foliage including variegated forms.
<i>Pleomele reflexa variegata</i> (Liliaceae)	Song of India	Strikingly beautiful plants and leaves are leathery, densely clustering, short, narrow, margined by two broad bands of yellow or cream.
<i>Ficus elastica</i> (Moraceae)	Indian Rubber plant	Plant is with showy large leathery oblong shaped leaf deep green in colour and the young leaves are enclosed in a rosy sheath.
<i>Heliconia</i> (Musaceae)		Dwarf plantain like plants. Plants are grown for their colourful foliage and in some species have beautiful markings.
<i>Peperomia</i> (Piperaceae)		Small succulent herbaceous plant with ornamental foliage often prettily marked.
<i>Philodendron</i> (Araceae)		Shrubby creeping plants or stem less herbs valued for their graceful foliage that are leathery.
<i>Pilea microphylla</i> (Urticaceae)	Artillery plant	A multitude of lime green leaves on short, arching stems gives this plant a fine textured fern like appearance. Common name is derived from the forcefully ejected pollen.
<i>Polyscias fruticosa</i> (Araliaceae)		Erect shrub, leaves leathery, irregularly pinnate and the margin of the leaves often edged white and the rachis and the stalk are spotted.
<i>Scindapsus aureas</i> (Araceae)	Pothos or money plant	Fleshy root climbing vine with thick long aerial roots. The leaves at the young are broadly ovate, waxy, green having yellow variegation. The mature leaves become 60 cm long and the blades become lobed or slashed.
<i>Syngonium</i> (Araceae)		Quick growing ornamental foliage climber suitable for pots and trellies. Leaves are generally sagitate and are variegated.
<i>Tradescantia</i> (Commelianceae)		Low growing herbs with trailing or creeping habit with variegated foliage.

SEASONAL FLOWERS OR ANNUALS

Seasonal flowers or Annuals or are the group of plants which complete their life cycle in one season or one year. They are easily grown plants. They vary widely in form, habit, colour

and size of flowers. They beautify the surroundings and exhibit a good show of blooms at low cost and labour.

Botanical name	Common Name	Colour range	Remarks
<i>Agaveartum houstonianum</i>	Floss flower	Blue, pink, white	Grown for bedding purposes
<i>Althaea rosea</i>	Holly hock	White, crimson, pink, yellow, red	Can be used for screening purpose, background of border
<i>Antirrhinum majus</i>	Snap dragon	White, yellow, pink, rose, mauve	Bedding and pot growing good cut flower
<i>Bellis perennis</i>	English daisy	White, blue, light pink	For pot cultivation
<i>Calendula officinalis</i>	Pot marigold	Yellow, orange	Bedding, pot growing , good cut flower
<i>Callistephus chinensis</i>	Aster	White, pink, blue	Bedding and pot growing, good cut flower
<i>Chrysanthemum coronarium</i>	Annual chrysanthemum	White, yellow	Bedding purpose, good loose flower
<i>Cosmos bipinnatus</i>	Cosmos	White, pink, yellow, mauve, magenta	Can be grown throughout the year
<i>Dahlia variabilis</i>	Dahlia	Yellow, red, white, mauve, crimson	Bedding and pot growing
<i>Dianthus caryophyllus</i>	Carnation	White, pink, crimson, mauve, yellow, violet, red	Bedding, pot growing good cut flower with long lasting vase life and scented flower
<i>Helichrysum bracteatum</i>	Straw flower	Yellow	Bedding purpose and good cut flower
<i>Petunia hybrida</i>		Red, blue, white, pink, violet	Good for pot and bedding
<i>Phlox drummondii</i>		White, red, blue, violet, pink	Dwarf plants are very showy when growing flower border, baskets and pots
<i>Salvia splendens</i>	Sage	Scarlet, pink, orange, white, yellow	Easily grown in shady places and rockery
<i>Tagetes erecta</i>	African marigold	Yellow, orange	Easily grown, good for bedding grown for loose flower
<i>Tagetes patula</i>	French marigold	Red, Orange, yellow	For bedding and pot growing
<i>Verbena hybrida</i>		Purple, pink, blue, red, white	Good for bedding, pots, hanging baskets, window

			boxes and rockery
<i>Viola tricolor</i>	Pansy	Yellow, red, violet and bicolour	blue, purple, and Sunny site is preferred, good for bedding and pot

1. Example of a tree with scented flowers

- a. *Mimusops elengi*
- b. *Grevillia robusta*
- c. *Albizia lebbelle*
- d. *Casuarina equisetifolia*

2. *Jacaranda mimosifolia* produces _____ coloured flowers

- a. blue
- b. white
- c. yellow
- d. red

3. *Nerium* belongs to the family

- a. Rubiaceae
- b. Apocyanaceae
- c. Verbanaceae
- d. Caesalpineae

4. Scientific name of rangoon creeper

- a. *Thunbergia grandiflora*
- b. *Quisqualis indica*
- c. *Petrea volubilis*
- d. *Ipomoea cairica*

5. *Sandaspus aurus* in _____

- a. Croton
- b. Elephant ear
- c. Money plant
- d. English Daisy

PRODUCTION TECHNOLOGY OF ROSE

Scientific Name: *Rosa hybrida*

Local Name: Gulab

Hindi Name: Gulab

Family: Rosaceae

Origin and History

Rose is also mentioned in the Bible and is believed to be known before the Bible era. According to archaeological findings, the Palestinians cultivated roses before the birth of Christ. Rose is surely very much steeped in history. It is the national flower of England, and some American States adopted rose as their emblem. It is assumed that some of the important rose species were hybridized in nature and the present day improved forms have been evolved/small over centuries. In fact, Crimson China Rose is considered as the father of modern roses. In the early nineteenth century itself, one or two hybrids closely allied to *R. chinensis* were introduced to Europe from China. These were actually hybrids between *R. odorata* and *R. gigantea*. La France was the hybrid Teas rose, by M. Guillot of France and was developed out of open pollination.



However, out of over 120 species of roses distributed in the old as well as the new world, only eight species have played a major role in the development of the modern garden roses.

Area and Distribution

Roses are being cultivated from ancient times in France, Cyprus, Greece, India, Iran, Italy, Morocco, USA and Bulgaria for production of perfume. In India, several species are found growing wild mostly in the Himalayan ranges. Their cultivation is concentrated at Aligarh, Kannauj, Ghazipur, Ballia and Jaunpur in Uttar Pradesh, at Haldighati in Rajasthan, Chandigarh and in Tamil Nadu in a total area of about 8,000 ha. The major rose producing areas are Karnataka, Maharashtra, Punjab, Uttar Pradesh, Delhi and Chandigarh, while in Gujarat, Haryana, Himachal Pradesh, Madhya Pradesh, Rajasthan, Tamil Nadu and West Bengal they are grown to a limited extent.

Uses / Nutrient Values

The rose, because of its place amongst the flower crops and is one of the oldest of fragrant flowers to be cultivated by man. Its different types having beautiful flowers of exquisite

shape, sizes, bewitching colours and most delightful fragrance has made it an important flower for its varied uses. Most important uses of flower are given below.

Cut flower

Roses are of foremost commercial importance and cut roses have the highest demand throughout the world and year round. The cut flowers are used for vase and table decoration.



Garden Display

Roses are also the most important perennial garden plants in almost all parts of the world. Roses are not only hardy, the variation in growth and many forms of flowers having numerous colours have made them the suitable garden plants for different uses. They can be used as bushes, standards, climbers, hedges and edges, hangers and in rock gardens.



Pot plants

Roses as pot plants in suitable containers are also commercially grown and kept both indoor as well as outdoors.



Perfume and allies products

Rose water

Rose water is also an important commercial product from rose petals. It is used as a perfume and in medicines and confectionary. It has the property of cooling the body and is often used in eye lotions and eye drops for its soothing qualities. It is also used in drinking water and sprinkled on the guests at weddings, feasts and other social functions.

Rose oil

Rose oil is an important commercial product obtained from rose petals. Apart from sweet fragrance, it has medicinal property and is often used in Ayurveda. Bulgarian rose otto is largely used in perfuming soaps and cosmetics.

Gulkand

Rose petals are also preserved for direct consumption, by making gulkand which is prepared by pounding equal proportions of petals and white sugar. It is considered both as tonic and laxative.

Pankhuri

Dried rose petals are known as pankhuri which is occasionally used for preparing sweetened cold drinks.

Gul-roghan

It is rose hair oil prepared from rose petals by effleurage with wet sesamum seeds.

Source of Vitamins

Rose hips are very good sources of ascorbic acid, every 100 g of rose hip syrup contains 150 mg of ascorbic acid compared with only 50mg present in fresh orange juice, 20 mg in tomatoes and 5 mg in apples.

Other uses

Rose are also use for making pot-pourri, conserves, rose vinegar, rose petal wine, jams, jellies etc.

Botanical Description

The stem is prickly. The leaves are alternate and pinnately compound. The oval leaflets are sharply toothed. The fleshy berry like fruit is known as hip. Roses have a determinant inflorescence that may assume corymbs, paniculate or solitary form.



Climate

Temperature

Temperature is an important factor regulating the growth of rose plant. Plants are planted at a place where flower yield was highest in plants kept at night temperature between 15 to 18°C and day temperature of 20 to 25°C. During winters, because of the low temperature the quality of flowers is good.

Light

A light duration lesser than 12 hrs leads to lower number of flowers and the flowers are of inferior quality too.

Humidity

Humidity plays an important role in the incidence of pests and diseases affecting the growth and flowering. In case of higher humidity in the atmosphere, water drops accumulate on

the rose leaves which if remain over there for a longer period leads to many fungal diseases. Certain diseases like mildews are associated with relative humidity.

Season in which the crop is grown

It can be grown throughout the year. The best planting time is between September and October in plains & in the hills it is during October-November or February-March.

Growing of roses under open conditions

Roses for local market and for preparing different products are grown under open conditions. The details are as follows:

Soil requirement and preparation

Preparation of soil is the key to success in roses. Although any soil is good for rose cultivation provided it has proper drainage. The ideal soil should be medium loam having sufficient organic matter, with a pH of 6.0 and 7.5. The soil should have a fine tilth up to a depth of 50 cm and should have a good drainage facility. The soil should be free from gravel, stones, brick pieces and other foreign material and exposed to sun for at least a week.

If the soil is deficit of organic matter then 10-12 per cent of additional organic matter may be added to it. Upon land preparation, beds/ plots of 1- 1.5m wide and 30-40m long should be prepared.

Planting Distance

The planting distance depends on the types of roses and location. For cut flower production, a spacing of 60 x 30 cm is recommended. Normally roses are planted at 60 x 60 cm spacing.

Varieties

There are different classes of roses according to the type of flowers they bear:

(A) Hybrid Tea

This is the most important class of roses. The flower buds of this class are longer and look beautiful. The flowers of this class are slow opening and hence can be kept in vases for a longer time. The flower spikes are also longer. Flowers of wide range of colours are available in this class but red, orange, yellow and some other dark colours are more preferred in the market.

Red: First Red, Avon, Happiness, Mr. Lincoln, Raktagandha, Black Lady, Montezuma, etc.

Yellow: Aalsmeer Gold, Gold Medal, Golden Star, Golden Time, Yellow Success, Pusa Sonia

Orange: Super Star, Summer Hoilday, President and Grand Gala

Bi-colour: Anvil Spark, Mudhosh, Double Delight, Supriya, Abhisarika, Kiss of Fire, Tata Centenary.

Scented: Avon, Granda, Papa Meilland, Blue Perfume, Eiffel Tower, Oklahoma

(B) Floribunda

There is profuse flowering in this class of roses but the flowers shed soon. That's why this class of roses is largely used for decoration and bedding purpose. The important varieties under this class are as follows:

White: Iceberg, Summer Snow, Margee Maril, Chitchor, Chandrama

Pink: Prema, Sadabahar, King Arthur, Bridal Pink

Yellow: Arthur Bell, Dr. Foun, Allgold, Sea Pearl, Golden Times

Mauve: Neelambari, Angel Face, Africa Star

Orange: Doris Norman, Suryakiran, Jorina, Jambra

Bi-colour: Charisma, Mask Red, Paint Box, Nav Sadabahar, Red Gold, Rare Addition

Scented: Angel Face, Delhi Princess

(C) Polyantha

The rose plants of this class are small and the flowers come in cluster. The main varieties of this class are Anjani, Rashmi, Nartaki, Priti, Swati, etc.

(D) Miniature

The roses of this class are dwarf in stature and the twigs and the leaves are also small. The flowers of this class are used in flower arrangement:

Red: Beauty Secret, Dark Beauty, Fast Fire

White: Green Ice, Z-Trail, Aany

Pink: Windy City, Sweet Fairy, Dizzler

Yellow: Baby Gold Star, Kale Gold, Delhi Star Late

Mauve: Silver Tip, Blue Bird

Orange: Angel Ripynance, Petayit Foly

Bi-colour: Star and Strip, Jainy Williams, Over the Rainbow

(E) Climber

The branches of these roses are soft and spread like climber. They flower at the end of the branches in small clusters. They are used for raising over the pergolas and the walls. The important varieties are as follows:

Red: Climbing Crimson Glory, Blaze, Cocktail, Black Boy

White: Delhi White Pearl, Shelderer White, Rambler, American Pear, Lemark

Pink: Climbing Show Girl, Lady Water Loo, Climbing of Silk, Soft Silk, Climbing Piece, Pink Meradan

Lemon: Miracle Neel, All Gold, Golden Shower, High Moon

There is profuse demand of red, pink and orange coloured cut roses. It is suggested that the following varieties are more profitable to grow.

Gladiator, Queen Elizabeth, Bull's Red, First Red, Happiness, Grand Gala, Confetti, etc.

Preparation of Field

Beds are prepared for the cultivation of roses. If the soil is light and proper drainage is there, the planting can be done even without making beds but if the soil is heavy and proper drainage is not there, raised beds (40 cm above the ground) should be prepared. Pits must be dug before the onset of rain so that the soil may settle down. Pits of 20-30 cm wide & 30 cm deep should be prepared and likewise the beds should be prepared. Care should be taken that the top soil should remain on the top.

Propagation

Commercial method of propagation is by cutting and budding.

a) Cutting

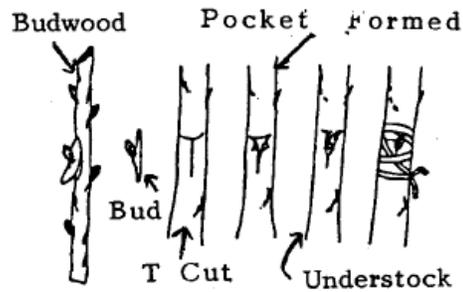
Scented roses are mainly propagated through cuttings. Hard wood Cuttings in case of polyanthas, climbers, ramblers and soft or semi hardwood cuttings for miniatures are used. Cuttings are collected from healthier plants with 15-20 cm length and 3-4 nodes. Cuttings are treated with IAA, BA 100ppm. Cuttings are planted in mist chamber for easy and quicker rooting.



B) Budding

Hybrid and Floribunda roses mainly propagated through budding. 'T' budding is the common method. Root stocks used are *R. multiflora* (Briar root stock), *R. indica* var. *odorata*, *R. bourboniana*, *R. laxa*, *R. canina* and *R. noisettiana*.

When a rose plant comes into flower small swellings are visible between the stem and stalk of the leaf. Select the eyes which are plump and not started to elongate and grow. Cut off the portions of the branch with the eyes selected is called as 'bud wood' with a budding knife remove a shield shaped piece of the bark and the eye. The Root stock should be kept ready by cutting the branches and side shoots which are not required. Make a sharp horizontal cut at a suitable height in the stock and then make a vertical ' T ' shaped cut in the stem of the stock. The 'eye 'should point towards the top and is tied with fibre.



Steps in T / Shield Budding

Preparation of buds from Scion



'T' shaped cut in the stem of the stock



Inserting and wrapping of the bud



Preparation of Beds and pits

The beds or pits for planting are prepared at least a month before the date of planting. The preparation of beds may be taken up during May or June so that the soil gets a thorough exposure to sun and air, and during the rainy season it gets a chance to settle down before planting. The beds are prepared to a depth of 60-75 cm and a trench of 45-60 cm across is dug to 30 cm depth. The trench is again dug and forked. While forking a basketful of well-rotten cow dung manure and a double handful of bone meal may be mixed in the soil.

If the soil of the bed is heavy clay with poor drainage, the beds are raised to a level of 5 - 10 cm above the ground. To improve the heavy clay soil, hydrated lime @ 1.5 kg/sq.m is forked 30 cm deep into the soil at the bottom of the bed. Gypsum @ ½ kg /sq.m can also be applied. If the soil is light or sandy, plenty of compost or FYM can be added to improve the water-holding capacity. Pits of size 45 cm 3 can be dug while planting in pits.

Season

Planting can be avoided during hot summer and heavy rains. In plains roses can be best planted during Sep-Oct after the cessation of the rains. In hills, planting can be done during Oct-Nov/ Feb-Mar. depending upon the temperature but the former season is more suited.

Spacing

For,

- ✓ Cut flower production – 60 x 30 cm
- ✓ Oil extraction – 2.5 x 0.5 m
- ✓ Vigorously growing cultivars. 60 x 75 cm / 75 x 75 cm
- ✓ Polyanthas – 45 cm
- ✓ Miniatures – 30 cm
- ✓ Climbing types – 3 m

Selecting plants

Plants may be pruned lightly by removing the suckers and the dead, unhealthy and diseased twigs. Plants selected for planting should have at least three strong canes.

Planting

Before planting, the top 30 cm soil from the pits should be removed. The plant along with the earth ball may be gently lowered into the pit, keeping the main stem in the centre of the pit. The bud union point where the scion joins the stock is kept just above the ground level. Generally, in temperate countries the bud union point is kept below the ground level. While planting it is necessary to spread out the roots evenly. The soil is returned to the pit and firmed towards the center. The plant must be watered copiously immediately after planting.

After care

The newly planted roses require frequent watering in the beginning. After that they may be watered once in five days during summer, and once in ten days during winter. If the soil is sandy, more frequent watering may be necessary. On the other hand if the soil is heavy and retentive of moisture the watering interval may have to be increased. Care should be taken to avoid 'wet feet', i.e. to avoid stagnation of water too long in the beds or near the base of the plants as it is harmful to the roots. Suckers originating from the root stock must be removed frequently to prevent the loss of vigour of the plants.

Manuring

After pruning basins formed around the plant sand manures are applied 10-15 cm depth.

- 6:6:12 g NPK/plant - Edward and Red rose
- 8:8:16 g NPK/plant - HT/Polyanthas/FB

Application in 3 stages

1. 15 DAP
 2. After first flush of bloom
 3. After second flush of bloom
- Dose/plant - FYM 10 kg, Urea 65 g, Super phosphate 25 g, MOP 50 g
 - Foliar feeding - micro-nutrients - 20 g $MnSO_4$ + 15 g $MgSO_4$ + 10 g $FeSO_4$ + 5 g Boron @ 2g/l of water results in bright coloured flowers.
 - Organic manures- oil cakes and bone meal are excellent sources of N and P respectively and may be applied after pruning.

Plant Growth Regulators

- **GA3** @ 250 ppm sprayed during the flushing if found very effective to,
 - Increase the length of the stem/shoot

- Increases the no. of shoots/plant
- Induces early flowering
- Prolongs the flowering period
- Enhance the flower yield
- **CCC @ 3%** results in more no. of buds and also,
 - Increase the flowering and size
 - Increase the yield.

Field view



Irrigation

Flood irrigation is given at 10 days interval depends upon the soil and climate. Avoid irrigation immediately before and after pruning.

Weeding

Mulching 2 to 4 inches of organic material like wood chips if found to reduce annual weeds and make hand weeding easier. Manual weeding is effective. Hoeing and roguing is also effective. Effective control of broad leaved weeds by spraying with 2,4-D, at the rate of 2 kg/600 l of water/hectare 25–30 days before flowering followed by cultivation of soil to a depth of 6-10 cm.

Pruning

Pruning is the removal of unwanted and unproductive portions of the plant and makes the plant more vigorous and productive.

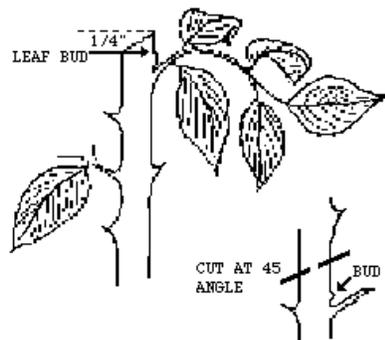
Objective

- Remove the unproductive shoots
- Improve the quality of blooms

- Bush in desired shape and size
- Open up the bush to penetrate sun light
- Rejuvenate the old plants
- Facilitate cultural operations

How to prune

- Remove dead, diseased or damaged wood.
- Remove branches that grow towards the centre of the plant
- Remove the weakest crossed branch and sucker growth (growth coming from below the bud union)
- Shape the plant
- Make a cut at 45 degree angle $\frac{1}{4}$ inch above an outward facing bud.



Too high

Too low cut

Correct cut



Time of pruning

Exactly 45 days prior to the date of requirement of flowers during October-December. Pruning is necessary when the yield and quality declines.

Method

1st Year: Cut back the shoots to four developed buds remain. Allow the lateral shoots.

2nd Year: Retain all strong shoots and remove weak and diseased shoots. Cut back the strong shoots to 4-5 buds.

3rd Year: Cut back vigorous shoot to half of its growth.

Rejuvenation

After 5-6 years the plants are to be rejuvenated. Cut back all the main branches at 15-20 cm from the base. Apply Bordeaux paste over cut ends to prevent diseases.

Harvesting

Flowering starts from 1st year onwards. Economic yield 2nd to 10th year. Flowers are harvested when the flower buds are in half open stage. For cut flowers, they are harvested at tight bud stage with long stalks.

Handling

As soon as the flowers are harvested, the stems are harvested the stems are lowered in to clean buckets containing water with preservative. The flowers are then cooled down to 2-4 °C for 5-6 hours. The flowers are graded according to the length of the flower stalk. It varies from 40-110cm depending on the variety and packed 20 per bunch.

Yield

- Loose flowers : 7.5 t/ha
- Cut flowers : 1st year : 100-120 flowers/m²
2nd year: 200-240 flowers/m²
3rd year: 300-360 flowers/m²

Pest management

Aphids (*Macrosiphum rosae*)

The incidence is more in the months of January-February on leaves and flower buds. These are small, black in colour with green tinge. The young and adult both suck the sap from the young twigs, buds and flowers. They suck the cell sap, discolour the leaves and affect flower buds which fall and lose their beauty. This can be effectively controlled by spraying 0.1% Malathion or Metasystox (0.1-0.2%) or Rogor (0.1-0.2%).

Red scale (*Lindigapsis rosae*)

It is very serious pest of roses which attack mostly in August and September. The branches are covered with reddish-brown encrustations under which the insect sucks the juice of the plants. These pests can be controlled by spraying Malathion (0.1%) or Parathion (0.25%) in April and again in October.

Chaffer beetles (*Onycetonia varsicolor*)

The adults of these beetles appear in August-September and cut away the leaves. This can be controlled by Monocrotophos (1ml/l) or Dimethoate (1.5 ml/l).

Disease Management

Dieback (*Diplodia rosarum*)

This is a very serious disease of roses and appears after pruning. The drying up and blackening of pruned shoots start from top to downwards. The stems become black and die. At the point where dry and healthy twigs meet, there appears brown lining and also black spots appear at these places. The conditions favourable for the prevalence of the disease include: application of large fertilizers and manure, excessive irrigation and poor drainage facility, incidence of stem borer, continuous incidence of mites, less light penetration. For its effective control, the infected portion should be dehisced and burnt and the cut ends should be painted with Chaubattia paste (4 part Copper Carbonate + 4 part Red lead + 5 parts linseed oil) or Bordeaux paste, application of optimum dose of fertilizer and by facilitating proper drainage or spray of 3g/ litre of Copper oxychloride (50%).

Black spot (*Diplocarpon rosae*)

This disease appears in during the humid months. Conspicuous circular black spot (less than 1 cm) with fringed margins appear on either side of leaf; leaves become chlorotic, dry up and prematurely drop. It can be easily controlled by spraying Carbendazim (1g/litre of water) or Captan (0.2%) fungicide at fortnightly intervals.

Powdery mildew (*Sphaerotheca pannosa var. rosae*)

It is a serious disease that occurs when days are warm & nights are cool. Young growing shoots and leaves are covered with white powdery growth. Infected leaves turn purplish and drop. Flower buds may fail to open. It can be checked by removing all the infected leaves at the time of pruning so that the source of infection is damaged or dusting with 80% Sulphur or spraying 0.1% Kerathane fungicide at fortnightly interval.

Post Harvesting

After harvesting the flowers they are dried on floor under shade for 2-3 days. Upon drying, the seeds are separated by hammering the flowers and the flower straw is separated out by winnowing of the hammered flowers. The seeds are thoroughly cleaned and graded before packing in poly bags or cloths bags, and are stored in cool places. The moisture contents of the seeds must be examined before the packing.

Extraction of Oil and Quality Control

All parts of *Tagetes patula* contain essential oil, which can readily be extracted by steam distillation. The oil has a pronounced odour and acts as a repellent to flies. It has been reported that 1-limonene, ocimene, 1-linalyl acetate and 1-linalool have been extracted from *Tagetes erecta*. While evaluating the different species for essential oil contents, *T. signata* contained higher essential oil (4.25 of dry matter) of very good quality which can be used in perfume industry.

Marketing, Distribution and Transportation

Crop has a good demand in decoration, garlands, loose flower and religious function etc. So can be marketed to major/ big cities where these can be supplied to hotels, institutions, etc. For garlands distribution distributed to the market flower should be packed in bamboo basket which should be covered under moist muslin cloth.

Pinching

Apical portion of shoot if removed early, a large number of axillary shoots arise resulting in well shaped bushy plants bearing more number of uniform flowers. The removal of shoot apices 40 days after transplanting enhances the flower yield.

Important tips and best practices for crop cultivation

- Always use disease free planting material
- Timely weed management should be done.
- Flower should be harvested at proper time and stage. These are distributed to the market in bamboo basket which should be covered under moist muslin cloth.

Alternative Uses

Loose flower, cut flower, perfumery industry, bedding purpose, medicinal and cosmetic industry, colour making, garland, decoration, etc.

1. First hybrid variety of rose is developed by
 - a. M. Guillot
 - b. B.P. Pal
 - c. William Kent
 - d. M.S. Randhawa
2. Hybrid tea roses are communicably propagated through
 - a. cuttings
 - b. layerings
 - c. T-budding
 - d. Patch budding
3. Time of pruning in rose during
 - a. Jan-March
 - b. Oct-December
 - c. July-August
 - d. Sept-October

4. Fruits of rose is called as

- a. berry
- b. capsule
- c. hips
- d. pod

5. Causal organism of die back in rose is

- a. *Diplodia*
- b. *Diplocarpus*
- c. *Colletotrichum*
- d. *Cercospora*

PRODUCTION TECHNOLOGY OF JASMINE

Scientific name: *Jasminum* spp.

Local name : **Jasmine**

Hindi name : **Juhi, Chameli, Mogra, Champa Bela etc.**

Family: **Oleaceae**

Origin and History

Jasmines are native of tropical and subtropical regions and introduced in the mid sixteenth century. Among the large number of species existing, only three species have attained importance in commercial cultivation. *Jasminum sambac* is considered as a native of the East Indies. Jasmine blossoms have been in use in India, China and countries of mystic orient for ceremonial purpose, as religious offerings and for perfuming the hair oils, etc. since time immemorial. The name Jasmine is of Arabic origin and is believed to have been derived from Yasmin. It is reported that the height of its popularity reached its peak two to five hundred years ago at canton and metropolis of southern China.

1. *Jasminum auriculatum* - Mullai



2. *Jasminum grandiflorum*- Jathimalli (or) Pitchi (or) Spanish jasmine



3. *Jasminum sambac* - Gundumalli / Malligai / Arabian jasmine / Tuscan jasmine



4. *Jasminum pubescens* - Kakada



Uses/Nutrient Value

Jasmine has been cultivated for various purposes since very early times. Flowers and buds are used for making garlands, bouquets, veni for religious offerings. They are also used for the production of perfumed hair oils and attar. The world famous jasmine oil is extracted from the flowers of Spanish jasmine (*J. grandiflorum*). The oil is also used in soap and cosmetic industry. The flowers of Arabian jasmine (*J. Sambac*) are reported to be used in China for flavoring tea. They also contain yellow pigments and hence used as substitute for saffron. Flowers and other parts also used in medicines.

Area and Distribution

Though jasmines are distributed in tropical and subtropical countries of the world, a large number of scented species are around the regions comprising India, China and Malaysia. Among these, about 40 species are reported to occur in India. Gamble (1957) were recorded 20 species in the former Madras Presidency State and some of these species are found in

Mumbai, Bihar, Orissa, Chotanagpur, upper Gangetic plains and sub Himalayan tracts. The distribution of some important jasmine is given below: -

<i>J. auriculatum</i>	India	<i>J. grandiflorum</i>	Subtropical Himalayan Region
<i>J. favreri</i>	Myanmar	<i>J. humile</i>	Tropical Asia
<i>J. flexile</i>	India	<i>J. multiflorum</i>	India, China, Myanmar, Malaysia, U.S.A
<i>J. officinale</i>	Iran, India, China		

Botanical Description

The genus *Jasminum* belongs to the family Oleaceae and order Oleales. They are climbing, trailing and erect shrubby flowering plants and these are both over green and delicious species. Leaves are opposite or alternate, simple, trifoliate or pinnate, leaflets entire. Flowers are white, yellow or rarely reddish, sometimes solitary, more often in cymose clusters of three to many, usually fragrant; corolla tubular with four to nine lobes, stamens two, ovary 2 loculed with 1-4 erect ovaries. Fruit is a berry and black in colour.

Cultural requirements

Climate Requirement

The ideal conditions for their successful cultivation are warm summer and mild winter. *Jasminum spp.* is usually grown in the open field for commercial flower production. The Cool house species should be kept in a temperature of 45-55° F (7-13° C). *J. grandiflorum* and *J. sambac* are sensitive to frost.

Soil Requirement

Jasmine prefers well drained rich sandy loam to clay soil. *Jasminum* species are usually grown in the open for commercial flower production.

Varieties

J. auriculatum

Parimullai: Selection from a local type. Medium round bud. Resistant to gall mite. Yield



8 t/ha with flowering duration about 9 months/year.

- CO.1: Selection from a Long Round type. Flowers have long corolla tube; easy for harvesting and marketing. Yield 8.8 t/ha.



- CO.2: Induced mutant from a Long point type. Longer corolla tube; flower buds bolder; field tolerant to phyllody; Yield 11.1 t/ha.



- Others: Long Point, Long Round, Medium Point, Short Point and Short Round.

J. grandiflorum

- CO.1: Clonal selection from germplasm. Suitable for both loose flower production and oil extraction. Pink streaks are found on external surface of petal. Average yield 10 t/ha. The concrete recovery is 0.29 per cent.



- CO.2: Induced mutant from CO1 Pitchi. Bolder pink buds with long corolla tube yield 11.68 t/ha.



J. sambac

Ramanathapuram gundumalli: Round flowers with good fragrance; yields 7 to 8 t/ha.

Khoya: Flowers familiar to *J.sambac*, but bolder buds with less fragrance.

.Others: Ramabanam, Madanbanam, Single Mogra, Double Mogra, Iruvatchi, Kasthurimalli, Oosimalli, Soojimalli.



Single Mogra

Double Mogra

Preparation of field

Land with proper drainage, irrigation facilities and sunny location are essential. Pits of 45 cm³ are dug at least one month before planting and exposed to sunlight. A few days before planting, pits are filled with 2 parts of FYM and one part each of fresh earth and coarse sand.

Propagation

Jasmine can be propagated by cuttings, layering, sucker, grafting, budding and tissue culture.

<i>J. auriculatum</i>	Semi hard wood cuttings
<i>J. grandiflorum</i>	Terminal cuttings
<i>J. sambac</i>	Terminal and semi hardwood cuttings.



Semi hardwood of *J. sambac*

- Growth regulators. Quick dipping (of the basal cut end) in IAA (or) IBA @ 1000 ppm for terminal cuttings and 2500 ppm for semi hard wood cuttings is done.
- Best rooting medium: - sand: vermiculite: moss at 1:1:1 ratio.

Plant Spacing, density and season

Species	Spacing	Density (Plants/ha)	Season
<i>J. auriculatum</i>	1.5 x 1.5 m	4400	June to November
<i>J. grandiflorum</i>	2.0 x 1.5 m	3350	- do -
<i>J. sambac</i>	1.25 x 1.25 m	6400	- do -

Time of Planting

The best time for planting in most parts of India is during the monsoon but one can plant jasmine almost round the year in climates as of Bangalore. Once planted, the jasmine remains in the field for 10-15 years.

Planting

- Land with proper drainage, irrigation facilities and sunny location are essential.
- Pits of 45 cm³ are dug at least one month before planting and exposed to sunlight.
- A few days before planting, pits are filled with 2 parts of FYM and one part each of fresh earth and coarse sand. Pits are to be watered to settle the mixture.
- Well rooted, healthy and strong plants are planted one in each pit.

Nutrition

- Jasmine responds to intensive manuring.
- Too much of manuring encourages vegetative growth and hampers quality and quantity of blooms.

Nutritional requirement

Species	Quantity(g/plant)			Method
	N	P ₂ O ₅	K ₂ O	
<i>J. auriculatum</i>	60	120	120	6 split doses at bimonthly intervals
<i>J. grandiflorum</i>	100	150	100	2 split doses : (1) June - July (2) December - after pruning
<i>J. sambac</i>	60	120	120	2 split doses : (1) June-July (2) November - after pruning

Foliar Nutrition

- Spraying of zinc 0.25% and magnesium 0.5% before flowering increases flower yield.
- For Fe deficiency, FeSO₄ at 5g/lit. is sprayed at monthly intervals until the chlorotic symptoms disappear.

Irrigation

- Flooding once in a week or once in ten days depending on the soil and climatic conditions.

Pruning

Need for Pruning

- In jasmine, flowering habit is terminal and axillary. So increasing the number of shoots would increase the yield, for which pruning is essential. Pruning influences growth, flower bud initiation, differentiation and ultimately the flower production.

Pruning period

Species	Time of pruning
<i>J. auriculatum</i>	Last week of January
<i>J. grandiflorum</i>	Last week of December
<i>J. sambac</i>	Last week of November

Pruning height: 45-50 cm from the ground level.

Weeding

- Commonly done manually but is expensive.
- Chemical weed control is effective and economical.
- Spraying Oryzalin 1 or 2 applications is effective.
- Mulching also reduce weed population.

Harvesting

- Jasmine gives economic yield only from the third year and up to 12-15 years and then the yield starts declining.
- The stage of harvest depends on the purpose of flowers to be harvested. For fresh flowers, fully developed unopened flower buds are picked in the early morning, while for extraction of concrete only fully opened fresh picked flowers are required.
- Picking of flowers after 11 a.m. will considerably reduce the yield and quality of the concrete.



- Damage to flowers during harvest and transit will affect shelf life of fresh flowers and concrete recovery.

Yield

Species	Flowers yield (kg/ha)	Concrete recovery (%)
<i>J. auriculatum</i>	4733 to 9152	0.28 to 0.36
<i>J. sambac</i>	739 to 8129	0.14 to 0.19
<i>J. grandiflorum</i>	4329 to 10144	0.25 to 0.32

Grading

- There are no standard grades available for jasmine.
- The flowers may be graded according to the corolla tube length, bud size, shape and freshness.

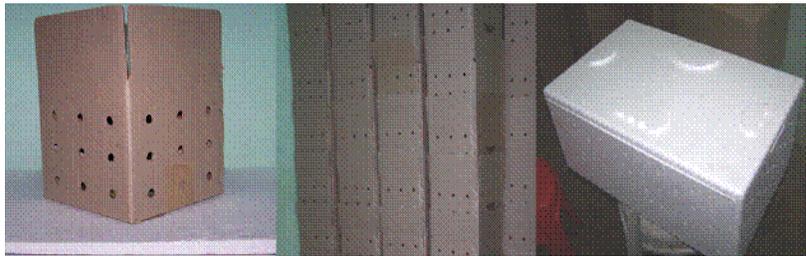
Packing

- Harvested flower should be given cold treatment before packing.
- Packing should be functional, economical and attractive besides being acceptable in markets. Corrugated cardboard boxes are good for distant market.
- Wholesalers pack flowers in bamboo baskets.
- They are packed so as to maintain some moisture and air circulation in the baskets.
- Water is sprinkled on the newspapers covering the inside of the basket.
- The top is covered with paper again and closed with a bamboo basket cover or gunny sack which is stitched at the edges.

Packing Jasmine for local market



Special Packing for Export



Longevity of flowers

Stage of harvest and pre and post harvest handling markedly influence the quality of picked flowers. In *J. sambac* var. Khoya treatment with boric acid (0.5%), sucrose (1%), aluminium sulphate (0.1%) and silver nitrate (0.01%) flowers remained fresh up to 72 hrs.

Plant protection

Pests

Bud worm (*Hendecasis duplifasciallis*): The bud worm which is a greenish larva with a black head bores into immature buds and feeds on floral structures. Spray of Monocrotophos 2 ml/l should be applied for the control of bud worm.

Red Spider Mite (*Steneotarsonemus pallidus*): The incidence of red spider mite is high during warm and dry weather, especially during summer. The mites are seen feeding on under surface of the leaves which become yellow and drop off. Thimet 2g/l should be given. Five applications of Aldrin at ten days interval were found effective.

Blossom midge

Spray Monocrotophos 36 WSC 2 ml/lit or Endosulfan 35 EC 2 ml/lit

Diseases

Leaf Blight

Caused by two fungi viz., *Cercospora jasminicola* and *Alternaria jasmini*. Symptoms are reddish brown spots on upper surface of leaves. Spray of Benlate (0.4%), Bavistin (0.1%) and Bordeaux mixture (1%) are equally effective.

Wilt

Caused by *Fusarium solani*, symptoms are yellowing of lower leaves which gradually spread upwards and finally resulting in death of the plant. Drenching of soil around the plants with Bordeaux mixture (1%) is the control measure.

Yellowing of leaves

It is caused by 3 factors viz., iron deficiency, nematode infection and root rot disease.

Iron deficiency

It can be rectified by spraying ferrous sulphate 5 g/lit at monthly intervals until the chlorotic symptoms disappear.

Nematode

Initially test the soil for nematode infection. Apply 10 g of Temik granules near root zone and then irrigate the field.

Root rot

Drench the soil around the plant with Copper oxychloride at 2.5 g/lit.

Season of flowering and harvest

Flowering commences in March - April. Fully developed unopened flower buds should be picked in the morning hours.

Extraction of jasmine concrete

Jasmine concrete obtained from Jathi Malli (Pitchi) – *Jasminum grandiflorum* is a wax like substance containing the natural flower perfume together with some plant waxes, albumin and colouring matter. The natural perfume is available in very small quantity (0.25%) in jasmine flowers in the form of volatile oil. The usual and simple method of steam distillation for the extraction of the volatile oil could not be adopted in this case as jasmines do not yield the perfume oil on steam distillation. Hence, the solvent extraction method is practiced in which the principle is that the odoriferous substances of the flower are allowed to be absorbed by a highly volatile solvent and then the solvent is evaporated leaving the odoriferous principles.

STEP I – Solvent treatment

Flowers are soaked in Food Grade Hexane (Having Boiling point of 70°C).



Mixing Hexane 2 litres / kg of flowers for 30 minutes.



Rotate the container slowly for 20 minutes in the rotary type of extractor.



Perfume substance along with wax and pigments dissolved in Hexane

STEP II – Evaporation

Perfume laden solvent is led into the evaporator



Evaporation at a constant temperature of 75°C.



Vapour of the solvent condensed into liquid for recycling



Liquid (Perfume, wax & pigments) is distilled in a vacuum distillation unit for complete removal of solvent in the still



Floral concrete settled in the still in the form of molten wax



Cooled and Stored in glass (or) aluminium containers

Marketing, Distribution and Transportation

Transporting of jasmine flower is done through trucks, ships (Refrigerated) etc. Before long distance transportation it is better to keep flowers in bamboo basket which should be

covered under moist muslin cloth. Proper care should be taken so that flowers are not handled badly or damaged during transportation.

Intercultural operations

Pruning

In Jasmine flowering habit is terminal and axillary so increase in the number of shoots is main criterion for increasing yield. In *J. auriculatum* pruning from 24 January is best time. In *J. sambac* pruning in either November or February to 30 cm gives highest flower yield. In *J. grandiflorum* mid December time is found suitable for pruning.

Important tips and best practices for crop cultivation:

- Always use disease free planting material.
- Timely weed management should be done.
- Flower should be harvested at proper time and stage. These are distributed to the market in bamboo basket which should be covered under moist muslin cloth.

Alternate Use

Veni, gajra, garland, loose flower, flower arrangement



1. Spanish Jasmine is botanically called as

- a. *Jasminum grandiflorum*
- b. *J. auriculatum*
- c. *J. sambae*
- d. *J. pubescens*

2. Inflorescence of jasmine is

- a. Raceme
 - b. Panicle
 - c. Cymose
 - d. Spike
3. *J. sambac* is commercially propagated through
- a. Semi-hardwood cutting
 - b. Terminal cutting
 - c. Air layering
 - d. Hardwood cutting
4. Post harvest life of jasmine can be increased by spraying
- a. Boric acid
 - b. Sucrose
 - c. both a & b
 - d. None of the above
5. Solvent used for the extraction of jasmine concrete in
- a. Methane
 - b. **Hexane**
 - c. Ethrel
 - d. Toluene

CHRYSANTHEMUM

Scientific name: *Dendranthema grandiflora*

Local name: Chrysanthemum

Hindi name: Guldaudi

Family: Asteracea

Origin and History

It is native to the northern hemisphere chiefly Europe and Asia. Historically, Confucius the great Chinese philosopher has, in his writing, mentioned chrysanthemum as early as in 500 BC making it one of the most ancient cultivated flower of the world. In England, the popularity of chrysanthemum as exhibition flower is at its peak. It has second ranks as commercial crop. In the United States, it is the number one dollar earner flower and the most reliable. It is difficult to say with certainty when its culture began in India. Shant Gyanehsvar has mentioned it in his famous Marathi exposition of Gita "Gyaneshwari" written in AD 1290. The Hindi name guldaudi (meaning flower of Daud) suggests that it must have been grown during the Moghul period in this country.



Uses

Chrysanthemum is versatile; it can be planted in the bed, cultured in the pot, used for garland making and also as cut-flower for flower arrangement. In India, large flowered varieties are grown for exhibition purpose while small flowered varieties are grown for cut flower, making garland, wreaths, veni and religious offerings.

Area and Distribution

The chrysanthemum is one of the most important flower crops commercially grown in different parts of the world. The Netherlands, Italy, Colombia, Spain, Germany and USA are the important countries where it is mainly grown under greenhouse conditions. In India, it is commercially grown in Tamil Nadu, Karnataka, and Maharastra. In different states of India, it is grown with different names, Guldaudi in Hindi belt, Chandramalika, in the eastern state, Samanti in the southern states and Shevanti in the western states. It is grown in on area of about 4,000 ha.

Botanical description

It belongs to family Asteraceae. The species of chrysanthemum have fibrous root system (shallow rooted plant), herbaceous perennial plant growing to 50-150 cm tall, with deeply lobed leaves and large flower heads, white, yellow or pink.

Climate Requirement

Chrysanthemum requires long days for good vegetative growth and short days for flowering. The most important environmental factors influencing the growth and flowering of these plants are light and temperature. The rate of vegetative growth and flowering are also affected by temperature. The optimum temperature of 15.6 °C is required. The relative humidity of 70 to 90% is suitable for the plants.

Soil Requirement

The ideal soil for chrysanthemum growing is a well drained, sandy loam of good texture and aeration. Good amount of organic matter and pH of 6.5 is essential. It is a shallow fibrous rooted plant and is very sensible to water logged conditions.

Varieties

Brief description of the some of the important varieties developed at different research institutions are given below:

Kirti: It is hybrid between Angle x G.P.I. It flowers early (88 days). It bears white coloured Korean type of flowers which fades to pink tinge. It is floriferous and produces 119 flowers per plant. It yields 168 g of flowers/plant. Shelf life of flowers is 7.5 days. It is suitable for bedding and potting purpose besides the flower can be used for floral decoration.

Arka Swarna: A cross between Nanko x CO-1. This hybrid bears pompon yellow flowers. It is found superior in respect to plant height, number of flowers per plant, flower size, flower weight, flower yield per plant and flowering duration. This is suitable for cut flower and loose flower purposes.

Birbal Sahni: This variety flowers in October to November. It requires about 121 days for flowering. Plants are about 65 cm tall and grow upright. Flowers are pompon type, snow white in colour and small sized. Its average yield is 32 quintals/ha.

Shanti: It is a small flowered, white decorative type chrysanthemum. It is good cut flower and garland variety. Its plant grows 51.2 cm height 99 flower heads/plant; floret length 1.6 cm, floret colour is white.

Y2K: It is a small flowered, white anemone type mini chrysanthemum. It requires neither 'pinching nor 'staking. Its plants are 34.6 cm tall, 370 flower heads/plant. Flowers are white in colour.

Arka Ganga: This is a cross between Flirt and Red Gold. It takes 127 days for flowering. It produces 143 flowers per plant. Flowers are white colour having pink tinge. The vase life is 11 days. It is suitable for loose flowers and cut flowers.

Sadbhavana: It is small flowered, double Korean type mini chrysanthemum. Plant heights 29.1 cm, 303 flower heads/plant, and floret colour is red purple group.

Appu: Flowers purple in colour & suitable for mini culture. Flower length is 1.5 cm it weighs 0.4 g.

Bindiya: Flowers dark crimson, Double Korean type suitable for mini culture. Flower lengths are 1.1 cm and flower weight is 0.3 g.

Coimbatore varieties: Selection from a local variety of Coimbatore. It has longer flowering duration as compared to the parent. CO 1 (yellow coloured flowers), CO 2 (purple coloured flowers) and MDU 1 (yellow coloured flowers) are commonly cultivated.



Pankaj: It bears pink attractive flowers, which are decorative type. Diameter of flower is 4.8 cm which weigh 2.68 g. It is high yielding and produces 140 flowers with a yield of 363 g per plant. Its attractive flowers on stiff stalk make them suitable for cut flower purpose. Loose flowers can be used for floral decoration.

Preparation of field

The field is ploughed two to three times before preparation of beds for planting. Trials conducted under All India Coordinated Research Project on Floriculture recommended a basal application of FYM @ 5 kg/m².

Time of planting

Terminal cuttings of stock plants are taken in June and they are transplanted after rooting in 15 cm pots at the end of July. These plants are ready for pinching during end of August or beginning of September.

Spacing

30 x 30 cm (plant to plant and row to row)

Propagation

Chrysanthemum is propagated vegetatively through suckers, cuttings or by micro-propagation.

Suckers

After flowering, the stem is cut back just above the ground. This induces the formation of side suckers which are separated from the mother plant and are planted in sand bed. Well rooted suckers can be directly transplanted in the field.

To plant one hectare of land, 1, 11,000 suckers obtained from 15 cents of the previous crop are required. Dip the roots of the suckers in 1 g Emisan in 1 lit of water to protect against wilt. The suckers are planted during June - July at 30 x 30 cm spacing on one side of the ridges. Pinching is done once in 4 weeks after planting to induce more branching.

Terminal Cuttings

These cuttings are taken from a healthy stock plant. Length of cuttings is about 5-7 cm. The cuttings are dipped in 2500 ppm indole butyric acid (IBA) or in seradex/ keradex (rooting hormone). These cuttings are put in sand beds in shade conditions.

Nutrient Management

As the crop responds well to manuring, add 8-10 tonnes of well rotten FYM per acre. Apply 50 kg of Nitrogen, 160 kg P₂O₅ and 80 kg K₂O as a basal dose. Spray GA3 at 50 ppm at 30, 45 and 60 days after planting to increase the flower yield.

Irrigation Management

The frequency of irrigation depends on the stage of growth, soil and weather conditions. Proper drainage system should be maintained for chrysanthemum grown both in beds and in pots. The height and vigour of the chrysanthemum plant can be influenced by regulating quantity and frequency of irrigation. In our country, the method of irrigating the fields is by channel system and for pots manual bucket system

Weed Management

Weeds should be avoided in the greenhouse as well as fields. They deplete moisture and nourishment from plants. Shortly after cuttings are established, carefully scratch the ground to uproot the weeds when they are small. 2-3 hand weeding are required for proper growth of the plant. First weeding should be done one month after planting. Herbicide can also be applied to control weeds from the field.

Harvesting

Depending upon the varieties plant start yielding flower after 3-4 months of transplanting. For cut flower purpose, stem is cut about 10 cm above the soil to avoid cutting into wooden tissue. The lower 1/3 of stem are placed in water to extend the vase life of cut flowers. The best way to protect the flowers is to sleeve the bunch with a transparent plastic sleeve. The correct stages of harvest depend up on the cultivar, marketing and purpose etc.

Yield

Flowering seasons vary from region to region. The natural blooming seasons for most of the regions lasts from July to February. One can harvest the flowers around 15 times. The yield ranges from 9 to 10 tonnes of loose flowers per acre.

Post Harvest Activities

Loose flowers are packed in bamboo baskets or gunny bags for marketing. The capacity of bamboo baskets ranges from 1 to 7 kg while gunny bags can accommodate 30 kg of loose flowers.

CUT CHRYSANTHEMUM (*Dendranthema grandiflora* Tzeuleu)



Varieties

Ajay, Sonali, Swarna, Ravi Kiran, Akash, Yellow Start, Chandrakand, Red Gold, Indira and Rakhee are some of the popular varieties.

Growing media

The growing media consists of soil, compost and coco peat in the ratio of 1:1:2. The beds are formed with 1 m width, 0.3m height and at convenient length. The soil pH must be 6.5 with 1 to 1.5 EC (Electrical Conductivity).

Propagation and planting

Rooted cuttings are planted at 20 cm between rows and 15 cm between plants within the row, accommodating 30 plants/m².

Irrigation

About 8 – 9 lit of water/sq.mt is required/day.

Fertilizer management

NPK @ 20:20:10 g/m² is applied through fertigation at weekly intervals

Growth regulators

Alar 50 – 150 gm/100 lit water and B 9 at 8 – 25 ml/lit of water is used twice at the growing stage.

Pinching

Removal of the growing tip is done at 3rd and 5th week after planting to encourage axillary shoots.

Disbudding

Removal of excess flower buds is done 7 weeks after planting to improve the flower size.

Blindness

It occurs when the night temperature is too low and the days are short at the time when flower buds are forming. A rosetted type of growth is indicative of this difficulty. Center petals that fail to develop can be due to excessive heat; or in dark weather some varieties apparently lack enough food to open the flower. Chlorosis, or yellowing of the upper foliage, is generally associated with over watering, excessive fertilizer in the soil, or insects or diseases attacking the root system. Continued growth of shoots and failure to form flower buds when short days are started the mean night temperature was too low. Sunscald is prevalent on standards in flower in very warm weather. The petals turn brown and dry up.

Light requirement



Lighting for chrysanthemum

Growth phase	Weeks from planting	Photoperiod
Vegetative phase	Up to 4-5 weeks from planting till the plant attains 50 to 60 cm height	Long day: 13 hrs light and 11 hrs dark
Flowering	5 -6 weeks after planting till harvest	Short day: 10 hrs light and 14 hrs dark

Harvest

Harvest index

Flowers are cut soon after the disappearance of green colour in the centre of the flowers and the center petals are fully expanded. Pompons are cut when they are fully developed. Spray types should be cut when the central flower is open and the surrounding flowers are well developed and the varieties which shed pollen badly will have to be cut before they become **unsightly**. Cutting the stem while the flowers are slightly on the “green” side is preferred because it offers a better quality product for the customer. Harvested flowers are to be kept immediately in a bucket containing water and preservatives to avoid desiccation.



Yield

The yield ranges about 270 sprays / m²

Post harvest technology

Grading of flowers depends on colour, diameter of flower and on stem length.

- Pulsing : Sucrose 4 % for 24 hrs
(Vase life: 18 days : Control: 8.5 days)
- Holding solution : BA 10 ppm + Bavistin 0.1 % + Sucrose 2 %
(Vase life: 17 days; Control: 8.5 days)
- Wrapping material : Polysleeves with holes (50 gauge thickness)
(Shelf life: 9.25 days; Control: 6.5 days)

After harvest, the stem have to be cut at equal length (90 cm is the standard), bunched in five, putting a rubber band at the base and sliding them into a plastic sleeve and putting bunches in plastic buckets filled with water. The mature chrysanthemum can be stored dry for 6-8 weeks at a temperature of 0.5 ° C. Early morning on the day of shipment (or night before), bunches can be packed in boxes.

Common features for both cut and loose chrysanthemum

Marketing and Transportation

Transporting of flowers is done through train, trucks, ships (refrigerated) etc. Before a long day transport, it is better to keep flowers in water for at least 4 hours in a cold store. Among the cut flowers chrysanthemum are amongst the top three best selling flower in all most all major flower consuming countries.

Few striking features which have made this flower commercial in the international market are:

1. The standard type flowers fetch higher price though their share is less.
2. Spray types have smaller flower size and has major share in the world market.
3. Maximum imports from European nation are from June to October.

International market of chrysanthemum is in Japan, the Netherlands, Germany, United Kingdom, United States, France, Italy, Denmark and Belgium.

Best Practices of Crop Cultivation

Pinching

After planting the growth is mostly upwards with very little branching. To arrest such tall growth, a single procedure called 'pinching' is used. Only soft vegetative shoot tips 1.5 to 3.0 cm long are removed. Pinching is one of the most important operations in chrysanthemum culture. Pinching is most essential for small flowered chrysanthemum. Pinching increases the number of flowering stems in each plant.

Disbudding & De-shooting

These operations are mostly performed for long flowering & decorative type chrysanthemum. Disbudding of spray varieties is very easy because in this case only the large apical bud is removed and the auxiliary buds are allowed to develop, while in standard varieties remove all axillary buds & apical bud is allowed to develop.

Staking of plants

Staking is necessary to keep plants erect and to maintain proper shape of plants and bloom. Stakes are prepared mostly from bamboo sticks. Staking of plants is required for vertical support of the plants. Only one stake is used when a grower needs single bloom per plant.

Desuckering

For proper and vigorous growth of the plant; suckers are removed from time to time. Without de-suckering, the main plant will loose vigour and become weak.

Important Tips and best practices for crop cultivation

- Always use disease free planting material
- Crop rotation should be practiced
- Proper pinching and disbudding should be followed for standard/spray chrysanthemum production
- Maintain proper temperature for quality flower production.
- Use bamboo stick for the support of tender stem of the plant.

Pest Management

Common pest their Control measures:

Aphids (*Myzus persicae*)

This are small greenish to black dot like insects which are seen in large number sucking the sap from the tender parts like stem tips, flower buds and young leaves. The affected flower buds fail to open and dry up before opening. Damage begins in December and is in peak during Feb-March.

Control measures

Spraying at fortnightly interval with 0.5% Monocrotophos or 0.1% Malathion or 0.02% Phosphomidon.

Mites (*Tetranychus urticae*)

Very minute dot-like insects of red colour seen on the under surface of leaves, particularly in hot dry season. The affected flower buds fail to open and dry up even before opening.

Control measures

Spray of 0.05% Dicofol or 0.05% Vertimac or Pentac at fortnightly interval.

Thrips (*Thrips tabaci*)

Thrips cause damage to summer blooming varieties. Infected flowers become discoloured & dry.

Control measures

Spraying Dimethoate at 0.05 per cent 2 or 3 times at 15 days interval.

Leaf miners (*Phythomyza syngenesiae*):

Incidence is maximum during March-June. The infestation is more severe in polyhouse. The young maggot stage attacks the leaves by making tunnels in between the upper and lower surface of the leaf. In severe cases, the leaves completely dry up and fall off.

Control measures

1. Removal & destruction of affected leaves help in containing the spread.
2. Spraying of 0.05% Monocrotophos or 0.05% Triazophos.

Leaf folder

All the larval stage attack the plant with the help of silky threads, the larve folds the leaves starts feeding on leaves from inside.

Control measures

Spray 0.02% Cypermethrin or 0.02% Decamethrin or 0.05% Quinolophos at fortnightly interval.

Disease Management

Common Diseases & their Control Measures

Root rot

(*Pythium* spp or *Phytophthora* spp) In this disease the infected plant suddenly wilt the plant parts like roots, stems, leaves.

Control measures

1. Provide good drainage conditions to prevent water logging.
2. Soil drench with Thiram or Captan or mixture of both at the rate of 2.5 g/m² area prevents the infection.
3. Mancozeb, Metalaxyl and Fosetyl also used for control.

Leaf spot: (*Septoria chrysanthemella*)

Grayish brown spots appear on leaves which turn yellow surroundings. When flowering starts, the infection occurs on flower buds, which rot completely. The disease spreads from down to upwards.

Control measures

1. Spraying with Mancozeb at fortnightly interval helps in controlling the disease.
2. Burning and destroying of infected leaves.
3. Spray of Copper Oxchloride (0.2%)

Wilt: (*Verticillium dahliae*.)

The leaves turn yellow to grey and the branch or whole plant wilts gradually. It may occur due to a number of diseases, disorders or even just lack of water.

Control measures

1. Solarization of soil by using black polythene mulch during summer months.
2. Soil treatment with Dithane M-45 (0.2%)
3. Dipping of rooted cuttings in Benomyl suspension before planting.
4. Use of resistant varieties.

Rust: (*Puccinia spp*)

It is serious disease especially in the early spring. Brown spores appear in the underside of the leaves. Severely infected plants become very weak and fail to bloom properly.

Control measures

1. Sanitation and clean cultivation prevent the disease.
2. Early removal of infected leaves.



3. Dusting plants either with sulphur and other fungicides such as Zineb, Captan etc. can be used.

Powdery mildew: (*Oidium chrysanthem*)

There is powdery coating on the leaves appear. It may lead to defoliation.

Control measures: Use of Sulphur fungicides or Carbendazim

Viral disease

Chrysanthemum stunt

Overall reduction in plant size, foliage become pale in colour, flower may open prematurely. Disease occur diving pinching. This disease occurs during pinching.

Control measures

Use of cuttings from virus free plants.

Chrysanthemum mosaic disease

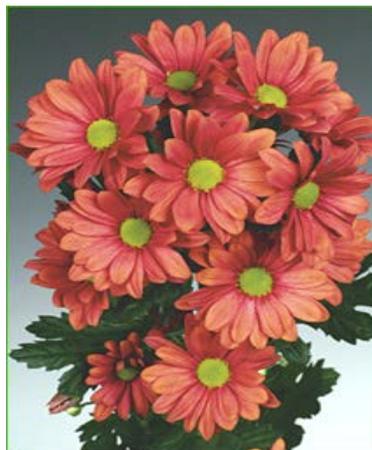
1. Cuttings should be obtained from virus – free indexed stocks.
2. Removal and destruction of infected plants.
3. Destruction of the weed host.
4. Spraying Monocrotophos 0.05 per cent controls the vector and reduces the disease.



Alternative Use and Value Addition

Besides being used for cut/loose flower purpose, it is also used for garlands, bouquet, greeting cards, dry flower etc.

As cut flowers



As loose flower



In landscaping



1. Common name of chrysanthemum is _____
- a. Guldaudi b. Glory of east
c. Autumn Queen d. All the above
2. Chrysanthemum is a _____ plant
- a. short day b. long clay
c. day neutral d. photo insensitive
3. _____ increases the number of flowering stems in chrysanthemum
- a. pruning b. pinching
c. netting d. deshooling
4. Japanese style of chrysanthemum culture
- a. Ikebana b. Kimono
c. Sen Rin tsukisi d. Naker
5. Plant growth regulator used to enhance the rooting of cuttings in chrysanthemum
- a. NAA b. 2,4-D
c. GA₃ d. IBA

PRODUCTION TECHNOLOGY OF CROSSANDRA

Scientific name: *Crossandra spp.*

Family: Acanthaceae

Crossandra is an important commercial flower, mainly grown in India, tropical Africa and Madagascar. The flowers are commonly used for hair adornment. Though not fragrant, flowers are very popular because of its attractive bright colour, light weight and good keeping quality. These are used for making



garland, either alone or in combination with jasmine flowers. Using Crossandra flowers in combination with jasmine is becoming increasingly popular in India, particularly in southern parts, because the jasmine flowers provide colour contrast and the desired fragrance.

Species and Cultivars

Crossandra belongs to the family Acanthaceae. There are 20-25 species but only few like *Crossandra infundibuliformis*, *Crossandra undulaefolia*, *C. guineensis*, *C. mucronata* and *C. subacaulis* are cultivated. The species grown for commercial flower production is *Crossandra undulaefolia*. These are small, evergreen shrubs freely producing flowers in dense sessile spikes. Orange, Delhi, Lutea Yellow and Sebaculis Red are four different cultivars of the species.

- Orange Crossandra is tetraploid ($2n=40$), sets seeds profusely, breeds true and produces bright orange coloured flowers.



- The cultivar Delhi is triploid ($2n=30$) and produces more attractive flowers of bright deep orange colour.



- Lutea Yellow is tetraploid ($2n=40$) and the flowers are orange yellow colour.



- Sebaculis Red is tetraploid ($2n=40$) and hardy cultivar, which possesses high degree of tolerance to nematodes.



Breeding

The breeding work done at the Tamil Nadu Agricultural University (TNAU) resulted in a hybrid between two local types collected from Palni and Marudha malai hills. This hybrid produces larger flowers and has high degree of field tolerance to nematode -fungus complex. The flowers are very attractive with yellowish orange petals. Another hybrid, evolved by crossing the orange-flowered cultivar and the sebaculis Red, produces very attractive dark pink flowers.

Climate and Soil

Crossandra is a tropical plant and cannot tolerate low temperature and frost. It grows well in places where the temperature is around 30°C and requires a well-drained soil rich in organic matter. Alkaline or saline soils are not suitable because plants develop chlorosis.

Propagation

The plants can be raised through the seeds as well as by cuttings or seedlings. The required seed rate is 5 kg/ha for optimum plant population. For Delhi Crossandra, rooted cuttings have to be used for planting. Cutting should be transplanted when sufficient roots are developed. In case of seedlings, they are raised in the month of April – May and Aug – Sep. The seedlings are raised in poly bags.

Planting

Seedlings or rooted cuttings, treated with fungicide and nematicide like Emisan (1 g/lit of water), should be planted on the side of ridges at a spacing of 30 cm between plants and 60 cm between the ridges. Planting should be done in moist soil. Providing partial shade is beneficial to maintain the health of plants and obtain higher yield of flowers.

In case of seedlings they are transplanted at 4- 6 leaves stage i.e 8-10 days old seedlings

Manuring and fertilization

High fertility in the soil is essential for good yield. In addition to the basal application of farmyard manure, periodical top dressing with fertilizers and organic manure is essential. The first application of fertilizers should be done in 50-60 days after planting. The doses of chemical fertilizers recommended are urea @ 50 kg/ha, superphosphate @ 100 kg/ha, and muriate of potash @ 60 kg/ha. Fertilizer should be applied twice at an interval of 6 months, except in the rainy season. Application of either farmyard manure or compost has to be done at the rate of 25 tonnes per hectare. The application of fertilizers is to be necessarily followed by irrigation. Weeding, application of fertilizer and earthing up are combined together and done simultaneously for easy operation.

Irrigation

Adequate irrigation helps in rapid growth of the plant and also to obtain regular flower yield. At the time of planting, the soil should have optimum moisture for initial growth. During dry period irrigation should be given at shorter intervals and also during the flowering stages which results in more flower and also encourage better plant development.

After cultivation

Spray Diuron (pre-emergence) @ 2.5 kg a.i/ha for controlling the weeds.

Flowering



Crossandra comes to flowering 2-3 months after planting and continues to bear flowers throughout the year with a drop in production during the rainy season. The flowers open in sequence from the base of the spike. Two flowers which are diagonally opposite in the spike, open at the same time. It takes about two days for complete opening of the flower.

Plant protection

Pests

Nematode

Avoid planting Crossandra in nematode infested fields. To control nematodes, apply Phorate or Carbofuran 3 G at 1 kg a.i./ha a week after planting and any one of the above chemicals at 3 and 9 g respectively per square metre length after six months of the first application.

Aphids

To control aphids, spray Dimethoate 30 EC @ 2 ml/lit.

Diseases

Wilt

Drench the soil around the plants with Methoxyethyl mercury chloride (Emisan) at 2 g/lit or Carbendazim 0.5 ml/lit.

Crop duration

It extends up to 3 years including ratoon crop in the third year.



Picking/Harvesting

Picking of flowers has to be done on alternate days. Depending on the length of spike, it takes nearly 15-25 days to complete flowering on a spike. After the flowering is over, the spent spikes are removed. The fully opened flowers remain fresh on the plant for about three days but when picked they fade away in 36-48 hours.

Yield

An average yield of 2000 kg of flowers per ha/year can be obtained. In Delhi Crossandra, 2800 kg of flowers per ha per year can be obtained.

Marketing

For marketing loose flowers the flowers are packed in wet cloth or gunny bags and sometimes in basket.

1. Polidy levels in crossandra
2. What is the method of propagation in crossandra?
3. Mention the commercially grown species
4. Mention the nematode tolerant type
5. Explain the crop duration of crossandra

MARIGOLD

Scientific Name: *Tagetes* spp.

Hindi Name: Gainda

Season in which crop is grown

Marigold can be grown three times in a year – rainy, winter and summer seasons. The season of sowing and transplanting of seedlings for obtaining flower at different seasons of the year are given below:



Flowering season	Sowing Time	Transplanting time
Late rains	Mid June	Mid July
Winter	Mid September	Mid October
Summer	January-February	February-March

Origin and History

Marigold is native of Central and South America, especially Mexico. From Mexico it spread to different parts of the world during early part of the 16th century. The name *Tagetes* was given after Tages, a demigod, known for his beauty. African marigold was first introduced into Spain early in the 16th century and became popular in Southern Europe. Another well known type of marigold i.e. French marigold (*T. patula*) followed a similar route from Mexico to that of African type.

Uses/Nutrient Value

Marigold is grown as an ornamental crop for loose flowers as well as a source of pigment for poultry feed. Flowers are sold in the market as loose or after making into garlands. Other than loose flower, it can also be used as cut flower. Marigold is used especially for beautification and also in landscape plans due to its variable height and colour of flowers. It is highly suitable as a bedding plant purpose in herbaceous border and shrubbery. French marigold is ideal for rockeries, edging, hanging baskets and window boxes.

Leaf paste is used externally against boils and carbuncles. Leaf extract is a good remedy for ear ache. Flowers extract is considered as blood purifier, a cure for bleeding piles

and is also a good remedy for eye disease and ulcers. The essential oil present in different species of *Tagetes* can find use in the perfume industry.

Area & Distribution

Cultivation tends to be located close to big cities like Mumbai, Pune, Bangalore, Mysore, Chennai, Calcutta and Delhi. The estimated area on which flowers are grown in India is about 1,10,000 hectares. Major growing states are Karnataka, Tamil Nadu, West Bengal, Andhra Pradesh and Maharashtra. Traditional flowers, including marigolds, occupy nearly two thirds of this area. In northern India in Himachal Pradesh, small scale farmers are growing marigold and other flower crops for garlands and decoration.

Botanical Description

***Tagetes erecta* (African marigold)**

The African marigold plant is hardy, annual; about 90 cm tall erect and branched. Leaves are pinnately divided and leaflets are lanceolate and serrated. Flowers are single to fully double with large globular heads. The florets are either 2-lipped or quilled. Flower colour varies from lemon yellow to yellow, golden yellow or orange.



***Tagetes Patula* (French marigold)**

The French marigold is a hardy annual, about 30 cm tall, forming a bushy plant. Foliage is dark green with reddish stem. Leaves are pinnately divided and leaflets are linear lanceolate and serrated. Flowers are small, either single or double borne on proportionately long peduncles. The flower colour varies from yellow to mahogany red.



Climatic Requirement

Marigold requires mild climate for luxuriant growth and flowering. Mild climate during growing period (14.5°-28.6°C) greatly improves flowering while higher temperature (26.2°-36.4°C) adversely affects flower production.

Soil Requirement

Marigold is adaptable to different types of soil conditions and thus can grown successfully in a wide variety of soils. However, a deep, fertile, friable soil having good water holding capacity, well drained and near to neutral in reaction (pH 7.0 – 7.5) is most desirable. An ideal soil for marigold cultivation is fertile and sandy loam.

Varieties

Tagetes erecta (African marigold)

Giant Double African Orange, Giant Double African Yellow, Crackerjack, Climax, Doubloon, Golden Age, Chrysanthemum Charm, Crown of Gold, Spun Gold.

Tagetes patula (French marigold)

Red Brocade, Rusty Red, Butter Scotch, Valencia, Succana.

Tagetes tenuifolia

Golden Gem, Lulu, Pumila, Ursula. However, in the market mostly orange coloured varieties are preferred.



Field Preparation and Sowing

Preparation of Field

Nursery beds are thoroughly prepared by digging and incorporating well rotten FYM. Before sowing the seeds, Malathion dust should be dusted on outer side of nursery beds to avoid ants.

Planting Material and Propagation

Marigold is mainly propagated by seeds, besides; it can also propagated by cuttings. Crop raised from seeds is tall, vigorous and heavy bloomer.

For raising seedling for one hectare, about 1.0 kg seed is required. For raising seedlings seeds can be sown in pots, seed boxes or on flat or raised nursery beds.



Seeds should be sown thinly and be covered with light soil or sand or sieved leaf mould and watering should be done by fine nose. For cutting method, 6-10 cm long cuttings are made from the apical portion of the shoot and treated with root promoting hormones like IAA and IBA. Cuttings planted in sand or vermiculite root easily and rooted cutting are transferred in bed or pots for flowering.

Time of Transplanting

Mid July, mid October and February-March are suitable time for transplanting. At the time of transplanting they should of 7 to 10 cm height and bear 3-4 true leaves. Transplanting should be done in well prepared land in the evening hours.

Spacing

Tagetes erecta require 40 x 30 cm spacing while *T. patula* require 20 x 20 cm or 20 x 10 cm spacing for high yield.



Nutrient Management

FYM is given @ 50 tones/ha at the time of field preparation. In African and French marigold application of 400 kg N, 200 kg P and 60 kg K per hectare should be done. Nitrogen should be given two or three time during growth period.

Water and Irrigation Management

The frequency and quantity of water mainly depends upon factors like soil and season. In lighter soil, more frequent irrigation is required than heavy soil. Weekly irrigation is necessary from September-March in sandy loam soil. During summer months from April to June, frequent irrigation at an interval of 4-5 days is required.

Weed Management

In marigold production, control of weeds is an important operation. In India, 3-4 manual weeding are required for entire period. Chemical weed control is also recommended.

Pest Management

Red spider mite (*Tetranychus* sp.)

These mites sometime appear on the plant near flowering time. Plants give dusty appearance. It can be controlled by spraying Metasystox 25 E C, or Rogor or Nuvacron 40 E C or Kethone @ 1 ml/l of water.

Hairy caterpillar (*Diacrisia oblique*)

This caterpillar eats away foliage. This caterpillar can be controlled by Nuvan or Thiodan at 1 ml/l of water.

Disease Management

Fungal diseases

Damping off

It is caused by *Rhizoctonia solani* and appears as brown necrotic spots girdling the radicle, later on extends to plumule and pre-emergence mortality. When infected seedlings are pulled, the root system appears fully or partially decayed. Seeds should be treated with Captan @ 3 g or Carbendazim @ 2.5 g per kilogram of seeds before sowing.

Collar rot

It is caused by a number of pathogens and common ones are *Phytophthora* sp. *Rhizoctonia solani*, *Pythium* sp. Collar rot is caused either in nursery or in grown-up plants. It can be prevented by soil sterilization or by using healthy seedlings.

Flower bud rot

It is caused by *Alternaria dianthi*. The disease mainly appears on young flower buds and results in dry rotting of buds. Symptoms are less prominent on mature buds but these buds fail to open. To control this disease regular spraying of the crop with Dithane M- 45 @ 0.2% should be followed.

Powdery mildew

Oidium sp. causes powdery mildew in marigold. Whitish, tiny, superficial spots appear on leaves, later on the whole aerial parts of the plant is covered with whitish powder. The disease can be controlled by spraying with Karathane (40 E C) @ 0.5% or dusting with sulphur powder at fortnightly intervals.

Plucking-Harvesting

Harvesting

Marigold flowers are plucked when they have attained full size. Plucking of flowers should be done in cool hours of the day. The field should be irrigated before plucking so that flowers keep well for a longer period after harvest. Plucked flowers are collected in polythene bags or bamboo baskets for carrying to markets.



Yield

The yield of flowers in African and French marigold not only varies with cultivar but also cultural practices including planting, spacing and fertilization showed a marked variation in flower number from 6 to 8 millions and from 1.5 to 2.5 millions per hectare, in French and African marigold, respectively, the corresponding ranges of variation in the weight of flowers were 8 to 12 tonnes/ha in French marigold and 11 to 18 tonnes/ha in African marigold.

Post Harvesting

Postharvest processing, grading, packing and storage

After harvesting the flowers they are dried on floor under shade for 2-3 days. Upon drying, the seeds are separated by hammering the flowers and the flower straw is separated out by winnowing of the hammered flowers. The seeds are thoroughly cleaned and graded before packing in poly bags or cloths bags, and are stored in cool places. The moisture contents of the seeds must be examined before the packing.

Extraction of Oil and Quality Control

All parts of *Tagetes patula* contain essential oil, which can readily be extracted by steam distillation. The oil has a pronounced odour and acts as a repellent to flies. It has been reported that Limonene, ocimene, linalyl acetate and linalool have been extracted from *Tagetes erecta*. While evaluating the different species for essential oil contents, *T. signata* contained higher essential oil (4.25 of dry matter) of very good quality which can be used in perfume industry.

Marketing, Distribution and Transportation

Crop has a good demand in decoration, garlands, loose flower and religious function etc. So can be marketed to major/ big cities where these can be supplied to hotels, institutions, etc. For garlands distribution distributed to the market flower should be packed in bamboo basket which should be covered under moist muslin cloth.

Pinching

Apical portion of shoot if removed early, a large number of axillary shoots arise resulting in well shaped bushy plants bearing more number of uniform flowers. The removal of shoot apices 40 days after transplanting enhances the flower yield.

Important tips and best practices for crop cultivation

- Always use disease free planting material
- Timely weed management should be done.
- Flower should be harvested at proper time and stage.

These are distributed to the market in bamboo basket which should be covered under moist muslin cloth.

Alternative Uses of Produce or Value Addition

Loose flower, cut flower, perfumery industry, bedding purpose, medicinal and cosmetic industry, colour making, garland, decoration etc.





1. Mention the season of cultivation
2. Differentiate African and French marigold

3. What are the propagation methods
4. Biochemical constituents of essential oil
5. What is pinching

TUBEROSE

Scientific Name : *Polianthes tuberosa* L.

Family : Amaryllidaceae

Common Name : Tuberose

Hindi Name : Rajanigandha

Origin and History

Tuberose is a native of Mexico from where it spread to the different parts of the world during 16th Century. It is believed that tuberose was brought to India via Europe in 16th century.

Uses/Medicinal

They are used for making artistic garlands, floral ornaments, bouquets and buttonholes. The long flower spikes are excellent as cut flowers for table decoration. The flowers emit a delightful fragrance and are the source of tuberose oil which is used in high value perfumes and cosmetic products. Furthermore, fragrant flowers are added along with stimulants or sedatives to the favourite beverage prepared from chocolate and served either cold or hot as desired. The bulbs are reported to contain an alkaloid lycorine, which causes vomiting. The bulbs are rubbed with turmeric and butter and applied as a paste over red pimples of infants. Dried tuberose bulbs in the powdered form are used as a remedy for gonorrhoea. In Java, the flowers are eaten along with the juices of the vegetables.



Area and Distribution

Tuberose is cultivated in large scale in France, South Africa, North Carolina, USA and in many tropical and subtropical areas including India. In India, the commercial cultivation of tuberose is done mainly in Mysore, Devanhalli taluk (Karnataka), East Godavari, Guntur, Chittoor, Krishna, Distt. (Andhra Pradesh), Coimbatore and Madurai (Tamil Nadu), Pune, Thane, Sangli (Maharashtra), Bagnen, Kolaghat, Midnapore, Panskura, Ranaghat, Krishnanagar (West Bengal). At present the total area under tuberose cultivation in the country is estimated to be about 3,000 hectare.

Botanical Description

Tuberose is half-hardy, perennial, bulbous plant. Bulbs are made of scales and leaf bases and stem remains concealed within scales. Roots are mainly adventitious and shallow.

Flowers have a funnel shaped perianth and are fragrant, waxy white, about 25 mm long. Stamens are six in number, ovary 3 locular, ovules numerous and fruits are capsule.

Climatic Requirement

In India, commercial cultivation of tuberose is confined to warm humid areas with average temperature ranging from 16° to 30°C. Tuberose is also grown in hilly areas up to 1200 to 1500 meter height. Moist or humid and temperature are the two main factors responsible for the increasing or decreasing the production. Temperature over 40°C leads to decrease the length of spike and quality of flowers. Likewise, fall in temperature or incidence of frost damages the plant and the flowers. It prefers sunny situation and should not be grown on shady or semi-shady situation which drastically reduces the flower yield.

Tuberose although not strictly photosensitive, long-day exposure promotes vegetative growth as well as early emergence of the first flower spike and also increases the length of flower spike. A day length of 16 hours promoted growth and flowering.

Soil Requirement

Tuberose should be grown in well-drained place, as it cannot tolerate water logging even for a short period. Tuberose is grown in wide range of soils from light sandy to clay soils including those affected by salinity and alkalinity conditions. Fertile loamy and sandy having pH range from 6.5 to 7.5 with good aeration and drainage are ideal for tuberose cultivation.

Varieties: There are four types of tuberose

Single: With one whorl of corolla and are highly scented which are chiefly used for concrete extraction. Concrete content has been observed to be 0.08 to 0.11 per cent. Loose flowers are used for making floral ornaments. Single, Kalyani Single, Shringar, Prajwal, Rajat Rekha, Hyderabad Single, Culcutta Single are main varieties.



Semi-double: Bearing two to three whorls of petals, used for concrete extraction as well as cut flower.



Double: This group comprises of varieties with more than three whorls. They are mainly used for cut flower and bouquet purpose. The main varieties are Double, Kalyani Double, Swarn Rekha, Hyderabad Double, Calcutta Double, Vaibhav & Suvasini.



Variegated: In these varieties, leaves with white/yellow streaks are visible. National Botanical Research Institute, Lucknow has developed two variegated varieties Rajat Rekha & Swarn Rekha by gamma irradiation.

Rajat Rekha

- Single flowered type with silvery white streak along the middle of the leaf blade.
- It is a mutant evolved by irradiating bulbs of single flowered cultivar.

- Concrete content has been found to be 0.089 per cent.

Swarna Rekha

- Double flowered type with golden yellow steaks along the margins of leaf.
- It is a gamma ray induced mutant, in which mutation occurred in chlorophyll synthesis resulting in change in leaf colour.
- Concrete content has been found to be 0.062 per cent.

Shringar

- This variety has been developed form a cross between 'Single x Double'.
- It bears single type of flowers on sturdy spikes.
- The flower bud is slightly pinkish tinged.
- Florets are bigger and appealing than 'Calcutta Single'.
- Resistant to *Meloidogyne incognita* nematode.
- Loose flowers are ideal for making garland, while spikes can be used as cut flower.
- Yield of loose flowers is about 15,00 kh/ha per year, which is 40% higher than 'Calcutta or Mexican Single' and the concrete content of the Hybrid is at par with Mexican Single.
- Shringar is preferred by farmers and perfumery industries.

Suvasini

- A multi whorled variety developed form the cross between 'Single' x 'Double'.
- Pure white flwers are bold and big, borne on a long spike.
- Spikes are best suited as cut flower.
- Suvasini recorded 25% more yield than cv. Double.
- IIHR, Bangalore has also evolved two more new varieties of tuberose namely Prajwal and Vaibhav recently.

Prajwal

- This hybrid which bears single type flowers on tall stiff spikes is from the cross 'Shringar' x 'Mexican Single'.
- The flower buds are slightly pinkish in colour while the flowers are white.
- The individual flowers are large in size, compared to 'Local Single'.
- It yields twenty per cent more loose flowers than 'Shringar'.
- Recommended both for loose flower and cut flower purpose.

Vaibhav

- The hybrid which bears semi-double flowers on medium spikes is from the cross 'Mexican Single' x IIHR – 2.

- The flower buds are greenish in colour in contrast to pinkish buds in 'Suvasini' and 'Local Double'.
- Flowers are white.
- Spike yield is 50 per cent higher compared to 'Suvasini'.
- Hence, recommended for cut flower purpose.

Field Preparation and Sowing

Preparation of field

The field should be ploughed deep to a good tilth by 2-3 ploughings (45 cm) and properly manures. The field is left for 15 days that destroys the weeds and insect-pest. Well rotten cow dung or farmyard manure, at the rate of 50 tonnes per hectare should be incorporated in the soil. After field preparation, the plots of appropriate size should be prepared.

Spacing

Bulbs are planted at a spacing of 30x20 cm or 20x20 cm at a depth of 4-6 cm. 40,000-50,000 bulbs are required for one acre planting of tuberose.

Propagation

Tuberose is propagated by bulbs. In general, bulbs having diameter between 1.5 and 2.5 cm are suitable for planting. About 1.25-1.5 lakh bulbs (800-900 kg) are required for planting one hectare.



Seed treatment

These bulbs are first thoroughly cleaned and treated with Bavistin (0.2%) for 30 minutes. Dipping the bulbs in 4% solution of thiourea can break the resting period. Pre-plant storage of bulbs at 10°C for a period of 30 days to improve the plant growth, increased spike and flower yield.

Pre-planting treatment of bulbs with GA₃, etherel or thiourea promoted early appearance of flower and produced highest number of longer spikes with maximum number of florets.

Season: Planting done in the month of March-April in plains and April-May in hills.

Nutrient Management

In general, a basal dose consisting of FYM @ 10 kg/sq m, single super phosphate and murate of potash each @ 80 g/sq m, 10-15 days prior to the planting of bulbs is recommended. Nitrogen @ 15 g/sq m should be applied in three split doses. First one-third dose is given at the time of planting of bulbs, second at 60 days after planting and the third when flowering starts.

Water and Irrigation Management

It is very essential to irrigate before planting to provide optimum moisture for sprouting and further irrigation should be avoided until the bulbs are sprouted. During summer, irrigation should be given at weekly interval or even earlier in case soil dries out and during winter at 10 days interval.

Weed Management

Manual weeding is effective and should be done at monthly interval.



For chemical weed control, Atrazine @1.0-1.5 kg /ha in 1000 litres of water is sprayed immediately after planting of bulbs.

Pest Management

The important insects are thrips, aphids and weevil. Thrips and aphids are controlled by the spray of Rogor or Metasystox @ 1.75 to 2.0 ml/litre. The weevils can be controlled by the spray of Thiodon @ 2.0 mg/litre.

Bud borer (*Helicoverpa armigera*)

This can be controlled by the spray of endosulfan (0.2%), monocrotophos (0.2%) or Thiodan (0.5-0.8%).

Nematodes

Tuberose is damaged by nematodes and resulting in extensive yield losses. Nematodes like the root-knot nematode (*Meloidogyne incognita* and *M. javanica*) and reniform nematode (*Rotylenchulus reniformis*) and also greasy stem caused by *Aphelenchoides besseyi* have been reported to be responsible for the complete wiping out of the tuberose flower industry. Application of Furadon @ 2 g/plant or carbofuran @ 2-5 kg/ha, neem @ 1 tonne/ha controls nematode infestation.

Disease Management

Stem rot

The disease symptom is preceded by the appearance of prominent coarse mycelial masses on leaf surface at or near the soil level. The infection is caused by *Sclerotium rolfsii*. The disease can be controlled by soil application of brassicol or Zineb (20%) at the rate of 30 kg per hectare. Also, the incidence can be minimized by reducing soil moisture or planting at wider spacing.

Flower Bud rot

It is caused by *Erwinia* sp. Results in dry rotting of the buds with brown sunken necrotic discoloration of peduncles. The diseased plants should be uprooted and destroyed. The disease can be controlled by the spray of Streptomycin (0.01%)

Leaf blight or Botrytis blight

Fungal disease caused by *Botrytis elliptica*. The disease can be controlled by spraying the plant with ammoniacal copper (2%) or Greeno (0.5%). The treatment should be repeated at 15 days interval.

Alternaria leaf spot

Fungal disease caused by *Alternaria polyanth*. The disease can be controlled by the spray of Mancozeb (0.2%) or Iprodione (0.2%) at 10 days interval.

Harvesting

Flowering of tuberose starts 80 to 100 days after planting and flowering time is July onwards. Tuberose flowers all the year round.



Spikes are harvested at bud-burst stage preferably in the morning before sunrise or late in the evening by clipping with a sharp knife or secateurs that gives a clean cut. About 4-6 cm basal portion has to be left to allow the growth of bulb. The lower portion of the cut spikes immediately after harvest, are to be immersed in water for prolonging life of spikes. For loose flower purpose individual flowers are plucked early in the morning.

Lifting, Curing, and Storage of Bulbs

Bulbs reach maturity at the cessation of flowering when the leaves become yellow and dry during winter (February-March) in North India. At this stage, irrigation is withheld and the soil is allowed to dry. The leaves are cut off at the ground level and the bulbs are dug out. After digging, the bulbs are lifted out and the adhering earth shaken off neatly and thoroughly. The offsets are then separated out by hand, which are used as seed-stock for the next season.



The bulbs are graded based on the size into mature (> 1.5 cm diameter) and immature (< 1.5 cm diameter). Cleaned and graded bulbs are placed on sheives to dry or cure. To hasten curing, artificial heat of 27° to 35° C may be applied. The bulbs must be stirred or have their position changed every few days to prevent fungal attack and rotting. The bulbs are also treated with 0.2 per cent Bavistin or mancozeb powder to prevent them from rotting. An ambient air temperature of at least 18°C for four to six weeks or exactly six weeks at 30°C stimulates the yield of commercial sized bulbs. Longer storage at 30°C advances flower spike yield but the quality of spike deteriorates and the bulb number decreases.

Yield

The yield of loose flowers/spike depends on variety, planting distance and climate condition prevailing in the area. One hectare of tuberose plantation yield 4-5 lakhs of spikes per year from single varieties, 10.5 tonnes/ha of loose flowers may be harvested. In addition, 20 tones/ha of bulbs may be harvested after 2-3 years.

Post Harvest Activities

Grading

- The flower spikes are graded according to the stalk length, length of rachis, number of flowers per spike and weight of spikes.
- Straight and strong stem of uniform length and uniform stage of development are preferred.
- Flowers should be free from bruises and diseases and pests.
- Florets are graded according to their size for loose flowers.

Packing and Transport

For room decoration, long spikes are preferred and are sold in bundles. Each bundle contain 100 spikes. To avoid damage of the flowers and buds, the whole bundle should be wrapped in soft, white tissue paper or polythene. These bundles are packed in rectangular bamboo baskets lined with Hessian cloth.

For long distance transport, they are packed in square boxes or airy baskets but packing in cardboard boxes is more suitable which can be easily transported by rail, bus or by truck.

Loose flowers are packed in bamboo baskets holding about 10-15 kg flowers and the baskets are covered with muslin cloth and are transported to the nearby wholesale market where they are sold by weight.

Holding solutions

A holding solution consisting of sucrose 2% + $Al_2(SO_4)_3$ 300 ppm was found best for increasing the post harvest life and quality of cut spikes of tuberose.



Extraction of Oil and Quality Control

The flower oil is extracted by effleurage and solvent extraction with petroleum ether. Freshly picked flowers, before they open are effleuraged. About 150 kg of flowers yield 1 kg of absolute of enfleurage which contains 11-15% of steam volatile oil. Extraction of tuberose flowers with petroleum ether yield 0.08 – 0.14 per cent of concrete. The concrete contains 3 – 5 per cent of a steam volatile oil. Out of the approximate total yield of 30,000 kg of loose flowers from one hectare, in three years, 27.5 kg of 'concrete' could be obtained. This concrete in turn will yield about 5.50 kg of absolute. One hectare of tuberose plantation may yield upto 12 kg of concrete.

Marketing and Export Potential

Graded spikes are usually stored less than 24 hours before they are packed and shipped to the markets. Most tuberose flowers are shipped in refrigerated trucks. Spikes must be held in an upright position.

Miscellaneous Information

Ratooning

In November-December, when the temperature drops, the leaves of the plants turn yellow and die and the plants undergo dormancy. Digging of bulbs should be done at this stage. With the increase in temperature the crop regains growth from the previously planted bulbs which is termed as ratooning. The ratoon crop results in more number of spikes but reduces number of florets, length of spikes and weight of flowers. Therefore, ratoon crop should be used only for loose flower or oil extraction purpose.

For ratooning in tuberose, the yellowing plants should be twisted from the ground level which leads to early maturing of bulbs. For the proper growth and development of plants, fertilizer dose as given in the main crop should be applied in two equal split doses in January-February and April. All other cultural practices should be done as in case of main crop. There is early flowering in ratoon crop as compared to main crop.

Important Tips and Best Practices for Crop Cultivation

- Treat the bulbs with 0.2% Bavistin before planting.
- The recommended doses of fertilizers must be applied.
- The bulbs of 1.5 -2.5 cm diameter should be planted in for better growth and harvesting.
- No hoeing/weeding should be done till the sprouting takes place.
- Crop is sensitive to water stagnation so ensure proper drainage or otherwise planting be done on bund.

1. What is the alkaloid present in the bulbs
2. Swarn Rekha is bred by which institute
3. Mention the parentage involved in suvasini
4. Propagation method in tuberose
5. What is the solvent used for extraction of oil



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