Importance of Vegetable and Spices in human nutrition and national economy

Vegetables

A simple definition of vegetable may be given as "**An edible, usually a succulent plant or a portion** of it eaten with staples as **main course or as supplementary food** in **cooked or raw form".**

Those products of **herbaceous plants (mostly annual)** which provide fresh material **for culinary purposes and generally cooked before consumption** or used as raw/salad are called vegetables.These are the products of **herbaceous plants** which are **annuals, biennial and perennials (mostly annual)** whose plant parts such as **fruits, leaves roots, stems, petiole, flower** etc. are **used for culinary or consumed as raw.**

Olericulture: The science of vegetable cultivation is termed as **olericulture**.

It **is** derived from two **Greek holar/holas + cultra:** Vegetable crops represent a diverse group of plants and it is difficult to comprehend the term with a single acceptable definition. They vary in life span (annual, biennial, perennial), propagation (seeds, vegetative), growth habit (herbaceous, vine, shrub, tree), growing season (summer, winter) and their uses of different parts and at different stages.

Importance and scope of Vegetables in India

India: second largest producer of vegetables in world

Area under vegetable : 10.34 million ha (2018-19)

Total production: 187.47 million tonnes (2018-19)

The fruits and vegetables play an important role in the balanced diet of human beings by providing not only the **energy-rich food** (good source of productive foods carbohydrates) but also promise supply of vital **protective nutrients like minerals and vitamins.**Consumption in sufficient quantities provides **taste**, **palatability and increases appetite and provides fair amount of fibers.** Currently reckoned as important adjunct for maintenance of good health and beneficiin **protecting against some degenerative diseases. Neutralizes the acids** produced during digestion of proteinacious and fatty foods. Provide valuable **roughage which promotes digestion and helps in preventing constipation.**

Intake of 300g of vegetables every day to make our diet balanced along with other diets is recommended. This includes **125 g leafy vegetables, 75 g other vegetables and 100 g root and tuber vegetables .**The average intake of vegetables of the country is about **230 g/head/day.** With the projected population of 1330 million in 2020 and 1650 millions in 2050, we have to produce at least 190 and 240 million tonnes respectively.With increasing focus on processing and exports, the production targets are likely to **increase further and creating more opportunities for vegetable growers.** Out of **total vegetable production** in the country, **major share goes** to potato (28.9%), tomato (11.3%), onion (10.3%), brinjal (8.1%), tapioca (5.5%), cabbage (5.4%), cauliflower (4.6%), okra (3.9%) and peas (2.4%).

Importance of vegetables as healthy food

I. Productive foods (energy-rich food) are carbohydrates, protein, roughages

Nutrient	**Deficiency causes**	**Nutrient rich vegetables**
Carbohydrates (400-500 g)	Serve as a chief source of energy in the food. It is found in vegetables mainly in the form of starch and cellulose.	Sweet potato, Potato, cassava, carrot, taro, pea, onion, elephant foot yam etc.
Protein (60-70 g)	• Retarded growth in children. • Discolouration of skin and hair. (Vegetables contain less protein compared to the product of animal origin. However, protein quality (composition of amino acids) is quite good although sulfo-amino acids (methionine, cystine) are most of the time limited in vegetable protein.)	Pea, cowpea, broad bean, lime bean, fenugreek leaves, celery, drumstick
Fats	Vegetables contain very low fats (ranges between 0.1 and 0.2%	Chilli, sweat pepper, brinjal, snake gourd,

*Values in parenthesis is the daily requirement of an adult

II. Protective foods:

a) Vitamins:

Nutrient	**Deficiency causes**	**Nutrient rich vegetables**
Vitamin A (5000 IU)	• Night blindness, Xerophthalmia, Frequent respiratory infection.	Carrot, Amarathus, Palak, Spinach, Fenugreen leaves, broccoli, kale, tomato
Thiamin (B1) 1.2 mg	beri-beri disease Loss of appetite. Dilation of heart.	Palak(0.26mg), Pea(0.25 mg), tomato, chilli, musk melon, garlic, leek
Riboflavin (B2) 1.7mg	Ulcers in the oral cavity. Loss of hair & dry scaly skin. Cracked lips.	Palak (0.56 mg), chilli (0.39 mg), sweat pepper, broccoli, lettuce, celery, Asparagus.
Niacin (19 mg)	Pellagra Nervous break down. Stomach and intestinal disorder. Sore tongue.	Palak (3.3mg), Aamaranth (1mg), bitter gourd, chilli, radish, lettuce, carrot, pea.
Pyridoxin (B6)	Ulceration of oral cavity, anaemia, skin diseases (acrodynia).	Widely distributed in vegetables.
Vit C (70 mg)	Scurvy (oedema, anaemia, bleeding gums and mucus membrane). Reduced resistance to diseases.	>100 mg: Sweat pepper, chilli, cabbage, broccoli, kale, drumstick, parsley. 70-100 mg: cauliflower, bitter gourd, amaranths
Vit K (0.15 mg)	Delayed and faulty coagulation of blood in cut wounds. Hindrance in normal secretion of bile.	Green leafy vegetables

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Some other vitamins which are not generally associated with vegetables are pantothenic acid, biotin (Vit H), vitamin B12 (Cobalamin), Cholin (sinkalin), inositol and vitamin D. These are present in the product of animal origin and may be synthesized by intestinal bacteria (eg pantothenic acid, biotin).

III Minerals:

- Play a major role in the functioning of physiological activities and reproduction.
- Components of various vital body constituents. For example:

Ca: bones & teeth, blood clotting, osteo-malacia in women after repeated pregnancies.

Fe: important component of haemoglobin, Anaemia – pale smooth tongue, pale lips, eyes & skin: spoon shaped nails, frequent exhaustion.

P: Component of DNA (deoxyribonucleic acid) – basis of life.

Ca	Fe	P
200-400 mg /100 g in hyacinth beans, palak, fenugreek	Green leafy vegetables are rich in sources.	Vegetables are quite rich in P.
Highest in curry leaves.	Highest in Amaranthus	Highest in garlic.
100-200 mg in chow chow, parsley, onion.	>100 mg in palak, spinach, fenugreek, other vegetables are: lettuce, water melon.	>100 mg in pea, limabean, taro, mushrooms. 70-100 mg in chilli, cauliflower, broccoli, bitter gourd, cowpea, winged bean, hyacinth bean, globe artichoke.

III. Roughages/Fibre: Help in digestion & prevent constipation. Leafy vegetables and root vegetables have more cellulose/fibre content.

Vegetable cultivation as a source of income and self-employment

I. Yields high/Area/Time:

Tomato-400-500 q/ha, Garden pea: 100q/ha Wheat 25-30 q/ha and Pulses 10-15 q/ha.

II Important source of farm income:

Vegetables: Net return may be 1.0-1.25 lakhs/ha which is 4-5 times more than cereals

- ✓ Cereals: Rs. 25000/ha
- ✓ Off-season: Tomato Rs 1 lakh/ha and peas Rs 80,000/ha.

III. Vegetable production assures more farm employment

Labour intensive operations and related secondary activities like transportation and marketing**, more job opportunities/more work to the farmer/his family.**

Tomato requires 2180 Tomato requires 2180 (processing) to 8020 (fresh market) labour hours per ha compared to only 761 for rice (a study in Taiwan).

Thus, vegetables have a great potential for using idle or seasonally underemployed farm workers to increase the family and total cash earnings.

IV High Cropping Intensity: on account of short duration of a number of crops e.g. radish, turnip, pea, okra, potao. e.g. Potao-onion-frenchbean-okra (400%) and Radish-pea- frenchbean-okra (400%)

V. Industrial Development:

- **Processing:** Wastage avoided and availability of product for a longer period.
- **Seed Industry:** come up on a big scale.

VI. Foreign Exchange Earner: Vegetables are exported in fresh, dried and preserved form or as processed products. The value of export from total horticultural products were Rs. 6964.6 crores out of which fresh onion alone contributed about 25 % (1741.55 crores) and share of others fresh vegetables were 12.8 % during 2010-2011

VII. Vegetable seed: 142 crores. Processed vegetables: Tomato, pea(140 crores).

Problems associated with vegetable production

- Non-availability of quality seeds.
- Paucity of authentic literature for growers, traders and consumers.
- Marketing problem.
- Pest problems.
- Cultural practices.
- Irrigation facilities.
- Consumption pattern: Below poverty line no money to purchase even cereals.

Spices

Spices: Spices are those plants, the products of which are made use of as food adjuncts to add ***aroma and flavour*** (**ex.** Pepper, Cardamom, Clove, Nutmeg etc.). **Condiments** are also spices, the products of which are used as food adjuncts to add ***taste*** only. Both spices and condiments contain essential oils, which provide the flavour and taste. They are of little nutritive value. They are used as whole, ground, paste or liquid form, mainly for flavouring and seasoning food. Most spices increase the shelf-life of food, especially the dry varieties. Some are added to improve texture and some to improve a palatable colour or odour.

Uses of spices:

- The principal use of spices is to season the insipid foods to impart flavour, aroma and taste.
- They are also used as preservatives and fumigants.
- Spices are also used in perfumery, soaps, cosmetics, tooth paste, confectionery, incenses, dyes, etc.

Properties of spices:

- Spices are well known as appetizers.
- They add a tang (taste) and flavour to otherwise insipid foods.
- Some of them also possess anti-oxidant properties.
- Some of them have preservative qualities (clove and mustard)
- Some have strong anti-microbial and antibiotic activities.
- Several of them possess medicinal properties.

Classification of spices: According to International Organization for Standardization (ISO), there are about 109 spices grown all over the world, which are classified in different ways.

I. Botanical classification (family wise)

Piperaceae - Pepper.
Zingiberaceae – Ginger, Cardamom, Turmeric
Apiaceae – Coriander, Fennel, Cumin.
Myrtaceae – Clove, Nutmeg
Fabaceae – Fenugreek
Lauraceae – Cinnamom

II. Plant part useful as spice:

Root spice - Angelica, Horse radish.
Rhizome spice – Turmeric, Ginger.
Bulbous spices – Onion, Garlic.
Bark spice – Cinnamon, Cassia
Leafy spices – Mints, Coriander, Methi
Aril spices – Mace.
Seedy spices – Coriander, Celery, Methi
Fruit spices –

- ✓ ***Berries*** – Pepper, Allspice.
- ✓ ***Capsules*** – Cardamom, Chillies

III. Depending upon the longevity of spice plants

Annual spice – Coriander, Mints, Methi
Biennial spices – Onion, Garlic
Perennial spices – Clove, Nutmeg, Pepper etc.
IV. Depending upon the type of the plant:
Tree spices – Clove, Nutmeg, Cinnamon, Cassia
Bush spices – Cardamom
Herbaceous spices – Coriander, Fenugreek, fennel, Cumin.
Climber spices – Pepper, Vanilla.
V. Economic importance: Depending upon the magnitude of trade, earnings and use.
Major spice: Black Pepper, Cardamom, Turmeric, Ginger, Clove, Nutmeg.
Minor spice: Coriander, Fenugreek, Cumin, Fennel.

Importance of spice industry in India

India is often referred as ―*Home of spices".* This is because many of the 109 spices grown in the world are *native to India.* Further, since antiquity, India pioneered in growing spices and exported. India has enjoyed virtual monopoly in the international spice trade since ancient times. Out of the 109 spices, several of them can be grown in India, whereas in other countries a few spices are only grown. This is because; India has a great extent of diversity in the climate and soils, which enables to grow a variety of spices. Spices are always export oriented crops not only in India, but also in other spice producing countries.

Both spices and condiments contain essential oils, which provide the flavour and taste. They are of little nutritive value. They are used as whole, ground, paste or liquid form, mainly for flavouring and seasoning food. Most spices increase the shelf-life of food, especially the dry varieties. Some are added to improve texture and some to improve a palatable colour or odour. Spices and spice products are indispensible part of our culinary preparations especially used for flavouring and seasoning of food. Most of the spices have potential medicinal values. Besides, they are also indirectly used as flavouring or colouring agents or as preservatives in many pharmaceutical preparations. Spices have been used in cosmetic and perfumery industries. Spice oil are used in the manufacture of soap, tooth pastes, talcum powder, aftershave lotions, vanishing creams, mouth freshners and room freshners etc.

Classification of vegetables

There are different methods of classification of vegetables *e.g.*

- Botanical classification.
- Classification based on climatic zones
- Classification based on the growing seasons.
- Classification based on economic parts used as vegetables.
- Classification based on method of cultivation

Botanical classification:

Most of the vegetables belong to the class Dicotyledonae. These classes are further divided into family, genus, species, sub-species, and finally botanical variety. The cultural operations of the vegetables belonging to the same family are not always similar *e.g.* potato and tomato belong to the same family but their cultural requirements are very different.

Table: Botanical classification of some of the important vegetables

Common name	Family	Genus	Species
A. Monocotyledonae			
Onion (Piyaj)	Alliaceae	*Allium*	*cepa*
B. Dicotyledonae			
Tomato (Tamatar)	Solanaceae	*Solanum*	*lycopersicum*
Brinjal (Baingan)		*Solanum*	*melongena*
Bell Pepper (Shimla Mirch)		*Capsicum*	*annuum*
Okra (Bhindi)	Malvaceae	*Abelmoschus*	*esculentus*
French bean (Frasbean)	Leguminosae	*Phaseolus*	*vulgaris*
Cucumber (Khira)	Cucurbitaceae	*Cucumis*	*sativus*
Bottle gourd (Ghiyya)		*Lagenaria*	*siceraria*
Bitter gourd (Karela)		*Momordica*	*charantia*
Musk melon (Kharbuja)		*Cucumis*	*melo*
Water melon (Tarbooj)		*Citrullus*	*lunatus*

Garden pea (Matar)	Fabaceae	*Pisum*	*sativum*
Cauliflower (Phool gobhi)	Brassicaceae	*Brassica*	*oleracea var. botrytis*
Cabbage (Band gobhi)		*Brassica*	*oleracea var. capitata*
Carrot (Gajar)	Umbelliferae	*Dacus*	*carota*
Radish (Mooli)	Brassicaceae	*Raphanus*	*sativus*

Classification based on climatic zones:

- **Tropical vegetables:** Tomato, brinjal cucumber, okra, French bean, cowpea, most of cucurbits, amaranthus, cluster bean.
- **Sub-tropical vegetables:** Okra, cucumber, brinjal, chilli, tomato, gourds (all), ginger, turmeric, cowpea.
- **Temperate vegetable crops:** Cauliflower, cabbage, broccoli, radish, carrot, turnip, spinach, onion, garlic, pea, fenugreek, potato, asparagus and rhubarb**.**

Classification based on hardiness: Also known as thermo Classification. Under this classification vegetables are grouped according to their ability to withstand frost. This class helps to know the season of cultivation of vegetables and is classified in three classes:

Hardy vegetables (withstand frost without any injury)	Broccoli, cabbage, pea, Brussels sprout, garlic, onion, leek, radish, spinach, turnip, parsley etc.
Semi-hardy vegetables (Generally they are not injured by light frost)	Carrot, cauliflower, potato, celery, lettuce, beet, palak etc.
Tender vegetables (can not withstand frost and are even killed by light frost)	Tomato, chilli, brinjal, cucumber, okra and all cucurbits, pea, French bean, sweat potato, cassava, yam drumstick, elephant foot, yam.

Classification based on growing season:

- **Summer or warm season vegetable crops:** These vegetables need optimum monthly average temperature of 20-27°C for better growth and development. However, they can tolerate minimum temperature of 15°C. *e.g.* tomato, brinjal cucumber, okra, French bean, cowpea, most of cucurbits, amaranthus, cluster bean.
- **Winter or cool season vegetable crops:** Optimum monthly average temperature for better growth and development of these vegetables is 12-17°C though can tolerate minimum temperature of 5°C. *e.g.* cauliflower, cabbage, broccoli, radish, carrot, turnip, spinach, onion, garlic, pea, fenugreek, potato etc. Asparagus and Rhubarb can tolerate even temperature of 1°C.

Classification based on tolerance to soil reaction: In this classification vegetables are classified in 3 groups according to their tolerance to soil acidity.

Slightly tolerant (pH 6.0-6.0)	**Moderately tolerant (6.8-5.5)**	**Very highly tolerant (6.8-5.0)**
Broccoli, cabbage, cauliflower, bhindi, spinach, leek, Chinese cabbage, lettuce, asparagus, muskmelon, onion.	Beans, carrot, cucumber, brinjal, garlic, pea, tomato, radish, turnip, Brussels‟s sprouts, knolkhol, pumpkin.	Potato, sweet potato, watermelon, chicory, rhubarb.

Classification based on salt tolerance: Vegetables are grouped in three categories:

Sensitive	**Moderately resistant**	**Resistant/tolerant**
Pea, beans, radish, potato, brinjal, sweet	Onion, carrot, cabbage, cauliflower, broccoli, tomato,	Asparagus, beet, lettuce, bitter gourd, ash gourd.

potato.	melons, chilli.	

Classification based on photo period requirement: Vegetables are grouped according to the period for which the light is available. The response of plants to light for induction of flowering is called **photo-periodism** and based on it vegetables are classified in three groups:

Long day vegetables and shorter night (8 -10 hours of dark)	**Short day vegetables (10-14 hours dark)**	**Day neutral vegetables (Photo insensitive) (not influenced by day length)**
Onion, cabbage, cauliflower, potato, radish, lettuce, knolkhol, turnip, carrot.	Sweet potato, lablab bean, winger bean, cluster bean.	Tomato, brinjal, chilli, okra, frenchbean, cucumber, cowpea.

Classification based on rooting depth: The knowledge of rooting depth is essential for scheduling the time and quantity of irrigation water. According to this class vegetables are classified into five categories:

Very shallow rooted (15-30 cm)	**Shallow rooted (30-60 cm)**	**Moderately deep rooted (60-90 cm)**	**Deep rooted (90-120 cm)**	**Very deep rooted (120-180 cm)**
Onion, lettuce	Cabbage, cauliflower, garlic, celery, palak, potato, spinach, cowpea, radish, broccoli, Brussels‟s sprout	Brinjal, cucumber, muskmelon, frenchbean, carrot, beet	Chilli, turnip, summer squash, pea, rutabaga	Asparagus, artichoke, limabean, pumpkin, sweet potato, tomato, watermelon

- Shallow rooted require frequent and light irrigation.
- Deep rooted require less but heavy irrigation.

Classification based on economic parts used as vegetables:

Leaves	**Flower**	**Fruits**	**Modified stem**	**Under ground (plant parts)**
Cabbage, palak, fenugreek, amaranthus, lettuce, celery, parsley	Broccoli, Globe artichoke	Tomato, brinjal, chilli, beans, okra, and all cucurbits	Knolkhol, cauliflower, asparagus	Carrot, turnip, beet, radish, potato, sweet potato, taro, ginger, garlic, onion, elephant foot yam, cassava

Classification based on methods of cultivation: This is the most convenient method of classification. In this classification, vegetable crops having same cultural requirements are placed together. As a consequence, it is possible to give the general cultural practices for the group without the necessity of repetition while describing the individual crop. Some groups like cucurbits, cole crops, solanaceous and bulb crops not only have similar cultural requirements for the group but the crops belonging to each group also have the same family.

Most of the crops belonging to bulb and salad group have similar temperature requirements. Therefore, this method of classification even though not in all but in the majority of cases fulfills the basic requirements of classification of vegetables.

Group 1: Potato
Group 2: Solanaceous fruits *e.g.* Tomato, brinjal, capsicum, chilli *etc.*
Group 3: Cole crops *e.g.* cabbage, cauliflower, broccoli, knolkhol, kale.
Group 4: Cucurbits *e.g.* cucumber, bottle gourd, bitter gourd, ridge gourd, snake gourd, water melon, pumpkin, summer squash, winter squash.
Group 5: Root crops *e.g.* Radish, carrot, turnip, beat.
Group 6: Bulb crops *e.g.* Onion, garlic, and leek.
Group 7: Salad crops *e.g.* Lettuce, celery, parsley.
Group 8: Greens and pot herbs *e.g.* Spinach, coriander, fenugreek, palak, beat, leak, amaranthus.
Group 9: Peas and beans *e.g.* Pea, Frenchbean, asparagus bean, lima beans, cluster bean, cowpea *etc.*
Group 10: Tuber crops other than potato *e.g.* Taro, yarn, elephant foot yam.
Group 11: Sweet potato.
Group 12: Okra.
Group 13: Pointed gourd.
Group 14: Temperate perennials e.g. Globe artichoke, Rhubarb.
Group 15: Tropical perennials vegetables e.g. Curry leaves, drum stick.
Group 16: Chow-chow (Chayote).

Types of Vegetable Gardening

Importance of vegetable gardening

- Vegetable farming is an important source of income.
- Cultivation of vegetables occupies an important place in agricultural development and economy of the country.
- It is important in balanced diet.
- It is the cheapest source of natural protective food.
- Vegetable farming gives higher yield per unit area within the shortest possible time which ultimately increases the income.
- Several vegetables are exported to foreign countries which provide an opportunity for earning exchange.

Types of Vegetable gardening

- Kitchen/ Home gardening
- Market/Peri-Urban gardening
- Truck gardening
- Vegetable Forcing
- Vegetable gardening for processing
- Floating gardening
- Organic Vegetable garening
- Container gardening

Kitchen gardening/Home garden: It is the growing of vegetable crops in residential houses to meet the requirements of the family all the year around. Every individual is concerned with home or kitchen garden. Irrespective of the fact that the individual is a villager, a city dweller, live in town. Kitchen garden should be a future of his home.

Importance of Kitchen Gardening

- Efficient and effective use of land for growing essential vegetables for use of family.
- Saves some money as vegetables are quite costly in the market (fresh vegetables).
- Play important part in vegetable production.
- Constitute a very healthy hobby and the spare time of the family is well utilized.
- Kitchen gardening should be aimed at giving a continuous supply of vegetables

Design and Layout of Kitchen Garden: Design of kitchen garden depends upon the character of the particular piece of land, its extent, situation etc.

The following principles should be followed in designing the layout of kitchen garden

Location and site
Proper layout
Cropping pattern
Size 25 x 10 m for family of 5 persons.
Shape should be rectangular and South east aspect is the most preferred for having more sun light.

- For kitchen garden land should be selected in the backyard of the house (easier to work & make use of kitchen waste water.
- Layout of the garden should be such that it looks attractive and allow access to all the parts.

- The land should be laid out in small plots with narrow and path borders.
- In homes where no space is available one can grow vegetables in pots or boxes. Preference should be given to such vegetables which produce more number of fruits from an individual plant e.g. cucurbits, tomato, brinjal, chilli etc.
- Climbing type vegetables like cucurbits, pea beans etc. can be trained on the fences.
- Several sowings of one particular crop at short intervals should be done to ensure a steady supply of vegetables.
- Quick growing fruits trees like papaya, banana, lime etc. should be located on one side of the garden, preferably on Northern side so that there shading effect on the vegetables is on minimum side.
- Ridges which separate the beds should be utilized for growing root crops like radish, turnip, beet, carrot.
- Early maturing crops should be planted together in continuous row so that the areas may be available for putting next crop.
- The inter-space of some crops which are slow growing and take long duration to mature like cabbage, cauliflower, brinjal should be used for growing some quick growing crops like radish, turnip, palak, lettuce.

Market Gardening /Peri-urban vegetable farming: This is a type of garden which produces vegetables for local market.

- This type of garden was confined to the near vicinity of the cities when a quick transport was not developed.
- Most of the market gardens even today are located within 15-20 km of a city.
- The cropping pattern of these gardens will depend on the demand of the local market.
- The most important consideration is to develop a clearly focused marketing plan before any vegetable crops are planted.
- The land being costly, intensive methods of cultivation are followed.
- A market gardener will like to grow early varieties to catch the market early.
- He should be good salesman as he may have to sell his own produce.
- He must be a versatile person as he will have to grow a number of vegetables throughout the year.
- The high cost of land and labour is compensated by the availability of municipal compost, sludge and water near some cities and high return on the produce.

The preference of Indian consumers is mainly to have fresh and lush green vegetables and least for processed products. This provides a business opportunity to the growers living nearby the big cities or towns, generally referred as peri-urban areas to meet the requirement of consumers and earn higher profit. This production system focussing nearby big cities is also called as market gardening. Thus, peri-urban vegetable cultivation provides the possibility to cultivate a small piece of land on commercial line to generate income to meet the basic needs of a family.

Large quantity of solid waste is generated in cities during handling and marketing of fresh vegetable produce and otherwise also which in general creates health and environmental hazards. This can be recycled to produce manure for use in organic vegetable production.

Many farmers try to maximize their income by selling directly to consumers, thus bypassing wholesalers and other middlemen. Common marketing strategies can be adopted such as farmers stall in weekly vegetable market, roadside stands and sale agreement to restaurants, modern retail stores. Sometimes, organically grown vegetable produce in general get higher prices in the market. So, farmers may go for raising vegetable crops organically.

Considering the high cost and small size of farm land in the vicinity of a city and high cost of labour, water and energy, it is necessary for the farmer to have high productivity per unit area. Diversified crops are grown in peri-urban vegetable farms which also include specialty vegetables like red and yellow coloured sweet pepper, cherry tomato, broccoli, Brussels sprouts, baby corn, sweet corn, gherkin, leek, bunching onion, celery, parsley, chive, pak-choi, asparagus, artichoke *etc*. The specialty vegetables are becoming popular to meet the demands of consumers, restaurants and hotels in big cities.

The other important considerations are choice of vegetables adapted to soil and climatic conditions, facilities of labour, water for irrigation and transport, proximity to market, and preferences of market and consumers. It is often profitable to have intercropping, succession of crops, relay cropping, mixed cropping and early maturing cultivars for continuous supply and for obtaining high price by bringing early produce in the market. Peri-

urban production is either fast diminishing or moving farther from the city because of expansion of urban areas.

Truck Gardening:

- This is a type of garden which produces special crops in relatively large quantities for distance markets.
- Truck gardens, in general, follow a more extensive and less intensive method of cultivation than market garden.
- The word truck has no relationship with a motor truck but it is derived from French word „troquer" means "to barter".
- The location of this type of garden is determined by the soil and climatic factors suitable for raising a particular crop.
- The commodities raised are usually sold through middle man.
- The truck gardener should be a specialized person.
- He should be proficient in large scale cultivation and production and handling of some special crops.
- He follows the mechanical method of cultivation hence cost of cultivation is less.
- The net income is also less as this includes the cost of transport and the charges of middle men.
- With the development of quick and easy transport system, the distinction between market and truck garden is continuously diminishing.

Vegetable Gardens for Processing:

- These gardens come up around vegetable processing factories.
- Mainly responsible for regular supply of vegetables to factories.
- Emerging more rapidly now in India with the establishment of processing industries by corporate sector.
- Earlier only a few factories existed which were dependent upon purchases from local markets.
- The end product from such local factories was not good from such a heterogeneous mixture.
- The prospects of future development are quite bright as people"s interest in the processing industry is growing.
- These gardens specialize in growing only a few vegetables in bulk.
- A heavier soil is chosen to obtain high and continuous yield rather than early yield.
- These gardens are required to grow particular varieties for canning, dehydration or freezing.

- The return may be low but the cost of marketing and the transport charges are negligible.

Vegetable Forcing:

- In the method known as forcing, vegetables are produced out of their normal season of outdoor production under forcing structures that admit light and induce favorable environmental conditions for plant growth. Greenhouses, cold frames, and hotbeds are common structures used.
- Hydroponics, sometimes called soilless culture, allows the grower to practice automatic watering and fertilizing, thus reducing the cost of labour.
- To successfully compete with other fresh market producers, greenhouse vegetable growers must either produce crops when the outdoor supply is limited or produce quality products commanding premium prices.
- Tomato, cucumber and capsicum are commonly grown vegetables under these structures. These are mostly used during winter in the temperate regions. These crops cannot be grown without protection for their availability throughout year.
- In India this type of garden has very little chance to develop because the country being so large and transport facilities becoming advanced, all vegetables can be grown normally throughout the year in one or the other part.
- River bed cultivation is a type of vegetable forcing i.e. growing of summer vegetables on river beds during winter months with the help of organic manures and wind breaks of dry grass.Sometimes, for early produce seedlings of tomato, brinjal, bell-pepper, chilli and cucurbits in poly-bags are forced to germinate in small protected structures.

Different kinds of vegetable forcing:

Protected Cultivation:

It refers to agriculture with human interventions that create favourable conditions around the cultivated plants offsetting the detrimental effects of prevailing biotic and abiotic factors. Plants in open field conditions experience short cropping season, unfavourable climatic conditions (too cold, too hot, too dry and cloudy ambient) impairing photosynthetic activities, vulnerable to predators, pests, weeds, depleted soil moisture and plant nutrients. In protected agriculture one or more of these factors are controlled or altered, to the advantage of plants, where usually factors such as temperature, $C0_2$ concentration, relative humidity, access to insect and pest *etc.,* are controlled to desirable limits. The factors controlled and range of control is decided by devises chosen and fitted on the structure. For economic reasons, protection or control is provided against the most significant stresses. Structures and environment control measurers employed separate this cultivated space and allowing cultivation in unfavourable ambient conditions in reasonably close to optimal conditions.

Advantages of protected cultivation:

- Crop production with high productivity under unfavourable agro-climatic conditions.
- Productivity levels could be significantly higher (sometimes two-three times of that in open field agriculture).
- Quality of produce is usually superior because of isolation and controls.
- Higher input use efficiencies are achieved in the production of plant and animal products. Income per unit area
- Production of crops under protected conditions has great potential in augmenting
- production and quality of vegetables, in main and also during off season and maximizing water and nutrient use efficiency under varied agro climatic conditions of the country.

This technology has very good potential especially in peri- urban agriculture, since it can be profitably used for growing high value vegetable crops like, tomato, cherry tomato, coloured peppers, parthenocarpic cucumber, healthy and virus free seedlings production in agri- entrepreneurial models.

Off season vegetable cultivation under walk-in-tunnels

- Walk in tunnels are the temporary structures erected by using G.I. pipes and transparent plastic.
- Walk in tunnels are used for complete off season cultivation of vegetables like bottle gourd, summer squash, cucumber *etc.* during winter season (Dec.- mid February) the basic objective and utility of walk in tunnels is to fetch high price of the complete off season produce to earn more profit per unit area.
- The ideal size of a walk in tunnel of 4.0 m width and 30m length (l20 m^2) and total cost of fabrication may be Rs.12000-14000

Vegetable Gardens for Seed Production: Good seed is the base of any successful farming industry. Seed production is a specialized field of vegetable growing.A thorough knowledge of the crop, its growth habit, mode of pollination, proper isolation distance are of prime importance for quality seed production.

Floating Vegetable Gardens: One more type of vegetable garden known as floating garden is seen on the Dal lake of Kashmir valley.Most of summer vegetables are supplied to Srinagar from these gardens. A floating base is made from the roots of typha grass which grow wild in some parts of lake. Once this floating base is ready, seedlings are transplanted on leaf compost made of vegetations growing wild in the lake. All the inter-cultural operations and occasional sprinkling of water are done from boats.

Organic Vegetable Gardening

Organic farming was defined as a system that excludes the use of synthetic fertilizers, pesticides, and growth regulators.

Approaches and production inputs of organic farming

Strict avoidance of synthetic fertilizers and synthetic pesticides
Crop rotations, crop residues, mulches
Animal manures and composts
Cover crops and green manures
Organic fertilizers and soil amendments
Biostimulants, humates, and seaweeds
Compost teas and herbal teas

Container gardening: In urban areas mainly in big cities, land is a big constraint for home/kitchen garden, many types of vegetables can be grown well in containers and space available in backyard, terrace, varandah, balcony can be utilized for this purpose where sunshine is easily available. Start with large enough pots. The 14 inch pots are plenty large for brinjal and cucumber and the 20-inch pots worked out well for tomatoes. Generally we should grow those vegetables which facilitate multiple harvests like tomato, leafy vegetables etc. instead of single harvest like cabbage or cauliflower etc

Tomato

- **Botanical name:** *Lycopersicon esculentum*
- **Family:** Solanaceae
- **Chromosome no. (2n)** : 24
- **Origin:** Peru, Ecuador – Bolivia
- **Common Name: Love Apple , Poor Man Orange**

Importance and Uses

- The tomato is one of the most important **"protective foods"** both because of its special nutritive value and also because of its widespread production.
- It is the world's largest vegetable crop after potato. Tomatoes are used for soup, salad, pickles, ketchup, puree, sauces and in many other ways. Tomato is a major source of vitamins and minerals. It is widely used as salad vegetable.
- Tomato contains many important minerals like Na, Ca, Mg, P, K, Fe, Zn, Boron.
- The steroidal glycoalkaloid present in tomato is called **tomatin** and the coloured pigment is called **lycopene (red colour)**. Lycopene content is high at 21^{O}C.

Climate

- Tomato is a warm season vegetable, is grown extensively in cool season also. It requires a long season optimum temperature is 15 to 27^{O}C.
- Temperature and light intensity effect the fruit set, pigmentation and nutritive value. Mild winter condition in northern plains is ideal for seed germination, plant growth, fruit set, fruit development and ripening.
- At low and high temperatures, there is low germination of seeds, poor plant growth, flower drop, poor fruit set, and ripening. At high temperatures, generally the quality of fruits is poor and there is high incidence of sun scald.
- Maximum fruit set occurs at a night temperature of 15 to 20^{O}C. High temperature (38^{O}C) accompanied by low humidity and dry winds adversely affect the fruit set. Excessive rains adversely affect its fruit set causing flower drop.
- Tomato has a yellow pigment ‘Carotene’ and red pigment (at ripened stage) called ‘Lycopene’ and at very high temperature formation of lycopene is inhibited.

Soil

- Tomato can be grown in a wide range of soils from sandy to heavy soils. However, sandy loam, rich in organic matter ideal for its cultivation.
- A well drained, fairly fertile loam with fair moisture holding capacity is ideal for growing a good crop of tomato.
- Tomato is highly susceptible to water logging. Well drained soils are highly necessary. The preferable pH range is 7 to 8.5.

Origin, taxonomy and botany: Cultivated tomato originated from Peru, Ecuador, Bolivia. Domesticated place of tomato lies in Mexico. The ancestor of cultivated tomato is cherry type (***Licopersicon esculenta var. cerasiformae*** **-** cherry tomato). Tomato belongs to the family Solanaceae.

Cultivated tomato is an annual herb, 0.7 to 2m tall, erect with thick solid stems or spreading, coarsely hairy with strong characteristic odour. Strong tap root with dense fibrous and adventitious roots are formed. Tomato can be classified depending on the growth habit.

Indeterminate: terminal buds ends with a leafy bud and continue it vegetative growth. (Inflorescence cluster occurs at every third internode and the main axis continues to grow indefinitely.) **Ex:** Pusa ruby.

Determinate fruits: terminal buds ends with floral bud and further its vegetative growth is checked and are called as Self topping or self pruning types. (Inflorescence occurs more frequently in almost every internode until terminal ones are formed and elongation ceases at this point) **Ex.** Pusa Early Dwarf

Semi-determinate: have semi dwarf growth and it is between determinate and indeterminate. Number of nodes between two consecutive inflorescences will be around one. **Ex:** S-12, Roma.

The leaves are compound pinnatifid with small leaflet. Flowers are borne in small forked raceme cyme. They vary in numbers from 5 to 12. Flowers are pendent, perfect, hypogynous. Stamens 6 in number and inserted on throat of corolla tube, filament bright yellow. Carpels 6, united and basal ovary typically 6 celled with a central fleshy placenta. Dehiscence of anther is longitudinal, 1-2 days after opening of corolla. If the pollen is shed as the style grows up through anther tube, self-fertilization occurs and when the stigma protrudes, chances of cross pollination through bees increase. The optimum temperature for pollination as around 21^{O}C.

Varieties & Hybrids: In certain varieties of tomato, the vegetative growth automatically stops, giving rise to bushy growth. They are called self pruning varieties.

- Certain varieties like Pusa rubi, Pusa early dwarf, Marutham, Arka vital, Pusa 120, sweet 72, S-12, Co-1 are suitable for cultivation in **plains**.
- Varieties like Sioux, Best of all, Pusa early dwarf are suitable for **hilly areas**.
- Varieties like Roma and Punjab chhuhara are suitable for **processing.**
- Varieties released by IIHR Bangalore are Arka Abha, Arka Abhijit, Arka Ahuthi, Arka Aloukik, Arka Meghali, Arka Sourab, Arka Srasika, Arka Vartnan, Arka Vikas, Arka Visal.
- **Pusa Sheetal:** cold resistant variety
- **Best of all:** Mid season variety
- **IVRI-2 :** variety developed from IVRI, Varanasi
- **Floradade:** It is a variety brought from Florida
- **PUSA-120:** resistant to nematode and released by IARI, New Delhi.
- **S-12:** Evolved by PAU**,** Ludhiana, fruit round to flattish with persistant pedicel suitable for summer crop all over the India.
- **Sioux:** American variety, resistant to growth cracks
- HS-101, HS-102, HS-110, Hisar Anmol, Hisar Arun, Hisar Lalima, Hisar Lalit etc. are developed by HAU Haryana.

S. No	Hybrid	Parentage	Characters
1	Pusa rubi	Sioux X Improved meeruti	Indeterminate
2	Pusa Early Dwarf	Improved meeruti X Red cloud	Determinate and slightly furrowed
3	Pusa Red Plum	*L. esculentum* X *L. Pimpinellifolium*	

Co-1, Co-2 – released from TNAU, Coimbatore. Co-3 it is a mutant of Co1. Gulmohar (MTH 6) – released from Maharastra hybrid Seed Company. Punjab chhuharra, Ox heart, Punjab kesari, Pusa early dwarf, Pusa rubi, Pusa red plum, Pusa sadabahar, Sweet – 72, Roma, Yasvanth-2 are other hybrids.

A high yielding tomato F_1 hybrid **"Arka Rakshak"** triple disease resistance, Tomato leaf curl virus (ToLCV), bacterial wilt (BW) and early blight (EB), developed by Indian Institute of Horticultural Research (IIHR), Bangalore. This is the first multiple disease resistant public bred tomato F_1 hybrid released for commercial cultivation in the country. Plants are semi-determinate.

Seed sowing: It is grown almost the year round. In north India, generally autumn and spring summer crops are taken. Therefore, seed sowing is done in November and transplanting during the month of January. In case of South India, 3 crops are taken which are sown during June-July, October-November and January- February.
Seed rate: Seeds are very light in weight. 400 to 500g of seed sufficient to raise nursery and transplant in one hectare.

Nursery bed preparation: Tomato is a transplanting crop. Seeds are sown in the area of 250 m^2. A raised bed prepared by well decomposed FYM is mixed @ 4kg FYM per m^2 of nursery bed. A fertilizer dose of 0.5 kg N, P, K per bed is also mixed in the soil.Seeds are treated with fungicides (Thiram or Bavistin @ 2g/kg) and 40% formalin solution at 500ml/m^2 area of nursery bed sterilisation. During summer and rainy season, there is very heavy incidence of damping off. To protect seeds and seedlings, the beds should be treated with 10% formaldehyde. After fumigation the beds are covered with polythene for 24 hours. Seeds are sown 4 to 5 days after removal of polythene sheets. In line sowing 7.5cm distance is kept between the rows. The beds are covered with straw or polythene till the seeds germinate. Seedlings are protected against wind, exposure to sun and excess rainfall. Fungicides are sprayed weekly to avoid of damping off. Nursery can also be grown in poly house. Hardening is done by withholding water 4-5 days before uprooting seedlings. Adding 4,000ppm sodium chloride or spraying of 2,000ppm CCC is effective for hardening of seedlings.

Transplanting of seedlings: Seedlings are transplanted at 25 to 30 days and 10-15cm height, on the evening of sunny day. Whole day transplanting is done in a cloudy day. In some of the areas tomato is directly sown. Seeds should be sown 1.25 to 2.5mm deep. Direct sowing is reduce the infestation of root knot nematode, bacterial wilt and damping off. The seedlings are transplanted at the side of ridge. Later, earthing up is done to keep the plant in the middle of the ridge. For indeterminate varieties and hybrids, row to row spacing of 60 to 120 cm and plant to plant distance from 45 to 75 cm is adopted. In case of determinate types spacing is 45 to 60 cm x 30 to 40 cm is adopted.

Nutritional management: Well decomposed FYM is recommended, added @ 20-25 tons per ha at the time of last ploughing and incorporated into soil. In general, NPK @ 120 kg: 60 kg: 50 kg per ha has been recommended for various tomato varieties. The quantity of Nitrogen to be applied varies greatly depending on the variety as well as soil conditions. However, for hybrids, higher quantity of N is applied. A high level of N at seedling stage and moderate level at flowering and fruiting stage is required. However, high level of N in plant reduces the C/N ratio resulting in unfruitfulness. Half N, entire P and K should be applied as basal dose, half N is given in 2 to 3 splits. 30, 45, 60 days after sowing. Micro nutrients like B, Zn also need to be applied and lime is essential under acidic soil. Availability of Boron is considered to be essential for production of large size fruit with high vitamin content and prevent fruit cracking, while Zinc for higher ascorbic acid content and tolerances to diseases.

Irrigation: Tomato is a deep rooted crop. Roots will grow to a depth of 120 to 150 cm and it has some drought tolerance. They require adequate moisture for their fair growth. Excess as well as insufficient moisture is harmful. First irrigation is given immediately after transplanting afterwards care should be taken not to apply to much water as it makes the plant to run and drops the blossom. However, light irrigation should be given at 3 to 4 days interval in summer and 10 to 15 day interval in winter. Furrow irrigation is the most widely used. Drip irrigation is fairly recommended as it can save more water compared to furrow irrigations.

Intercultural operations: Tomato is subjected to **pinching**, the lateral shoots are pinched to improve more bushy growth but little foliage is to be kept. Frequently shallow hoeings are necessary to improve the yield, it also reduce the weed growth. **Mulching** should be done 15 to 20 days after planting. 2 to 3 **weeding** before flowering encourages good crop growth. Application of a weedicide, basalin or pendimethalin @ 1 kg a.i./ha plus one hand weeding at 45 days after transplanting was recommended.**Staking** is very essential for indeterminate group of varieties because it improves yield and quality protection of fruits. In pest and diseases, easy harvesting and easy spraying of chemicals.

Harvesting: The stage of maturity at which tomato should be harvested depends upon the purpose for which they are used and the distance of transportation. The following stages of maturity for harvesting are recognized.

- **Immature:** Before the seeds have fully developed and before the jelly like substance around the seeds are fully formed.
- **Mature green:** The fully grown fruit shows a brown ring at stem scar. It has light green colour at blossom end and seeds are surrounded by jelly like substance.
- **Turning or breaker stage:** 1/4 th of the surface at blossom end shows pink.
- **Pink stage:** 3/4th of the surface shows pink.
- **Hard ripe:** all the surface turn to pink or red but flesh is firm.
- **Over ripe**: fully coloured and flesh is also soft.

For distant market mature green stage fruit can be harvested and for a local market, they can be harvested at hard ripe stage. Fruits at fully ripe or over ripe stages are utilized within 24 hours for processing. For seed production, red ripe tomatoes are ideal.

Grading: Fruits are graded based on size as Super A, Super, Fancy and Commercial according to IIHR.

Yield: Depends on various factors on an average an open pollinated variety will give 250 to 500 quintals per ha. Hybrids can give up to 1000 q per ha.

Post harvest management & Storage: Tomato can be stored either in mature green or breaker stage of maturity. Fruit remain firm up to 21 days when kept at $20^{O}C$ for the cultivars like Florida MH and Floradade. Temperature of $10^{O}C$ cause moderate chilling injury and Alternaria root rot.

Physiological disorders in Tomato:

1. Blossom end rot: It is more serious, ground discoloration starts. In blossom end of the fruit. Black spot develops to encompass ½ to 2/3 rd portion of the fruit. Later the tissues shrink and skin becomes dark grey to black. It may lead to secondary infection by fungus and unfit for consumption.

Causes: use of Ammonium sulphate, imbalance of Mg & K; deficiency of calcium
Remedies: cultural practices that concern soil moisture and maintain uniform moisture supply. Transplanting in early April instead of early June. Foliar spray of 0.5% $CaCl_2$. Apply Nitrogen in the form of Urea.

2. Fruit cracking: occurs for middle of the May. Reduced transpiration has increased cell turgidity and contributed to tomato fruit cracking. Reduced transpiration occurs even in summer when fruit are grown in green house. Cracking also occurs in rainy season when rains fall in long dry spell. Presence of water on the surface of fruit is more conducive in cracking than high soil moisture.
Boron deficiency in the soil also causes fruit cracking.
They are two types of cracking.

i. radial cracking: occurs mostly at ripe stage.
ii. Concentric cracking: it is common in mature green stage.

Remedies: use of resistant cultivars like Sioux, Punjab chuhara. Picking of the fruit before the full ripe stage. Soil application of Borax @ 10- 15 kg per ha. Regulation of soil moisture. Misting (spray of cool water).

3. Puffiness: commonly known as hallowness. Tomato puffs, puffy tomatoes, puffs and pockets. As the fruit reaches about 2/3rd normal site outer wall continues to develop normally but remaining internal tissue growth is retarded. Fruit become lighter in weight and partially filled. Very high or vary low temperature and low soil moisture conditions will lead to puffiness.

4. Cat facing: a large scar is formed at the blossom end portion of the fruit. Such fruits have ridges and furrows and blotches at blossom end.
Reasons: low temperature, faulty pollination, application of nitrogen during transition from vegetative to reproductive phase.
Remedies: balanced fertilizer application; regulation of temperature.

5. Sunscald: when fruits and leaves are exposed to the sun, there is appearance of yellow, white patches on green and ripen fruits. These patches may have secondary infection of fungus and start rotting varieties with sparse foliage will suffer more sunscald especially in the month of May and June.
Remedies: prefer the varieties having more foliage and follow appropriate cultural practices.

6. Flower and fruit drop: higher incidence of flower and fruit drop is resulted because of fluctuations in temperature poor water management and soil moisture.
Remedies: good package of practices should be followed. Moisture stress should be avoided. Spraying of planofix or NAA @ 1 ml in 4.5 lt of water. Control of fluctuations in temperature.

7. Blotchy ripening: greenish yellow; maintain balance between Nitrogen and Potassic fertilizers.

8. Bronzing or internal browning: also known as grey wall. Characterized by death of tissues within the fruits associated by vascular browning variety EL 235673 is found resistant to this disorder.

9. Green back: stem and portion of the fruit turns green. At high temperature ripening is inhibited and green band is expected. Reduce temperature by artificial means.

Plant protection measures

Diseases: Damping off and root rot, Late blight, Buckeye rot (fruit rot), Early blight, Fusarium blight, Powdery mildew, Verticillium wilt, Anthracnose fruit rot, Fruit rot, Black leaf mould, Bacterial wilt, Bacterial canker, Leaf curl virus, Spotted wilt virus

Pests: Tomato fruit worm, Epilachna beetles, Jassids, Tobacco caterpillar, White fly, Thrips, Leaf miner, Fruit borer, Aphids, Tomato worm, Mites, Fruit fly, Nematodes, Root-knot nematodes

Brinjal

- Botanical name: ***Solanum melongena***
- Family: **Solanaceae**
- Chromosome no. (2n) = **24**
- Origin: **Indo-Burma region**
- Common name: **Egg plant**

Importance and uses

- Brinjal can be grown in almost all parts of India except higher altitudes, all the year round.
- The brinjal is of much importance in the warm areas of far east, being grown extensively in India, Bangladesh, Pakistan, China and Philippines. It is highly productive and usually finds its place as the poor man's crop.
- In World, unripe fruit is primarily being consumed as a cooked vegetable in various ways. The white brinjal is said to be good for diabetic patients.
- Bitterness in brinjal is due to presence of glycoalkaloids (as solasodine). The discolouration in brinjal fruits is attributed to high polyphenol oxidase activity.

Origin, taxonomy and botany: The brinjal, eggplant or aubergine (French name), a normally self-fertilized annual is of uncertain origin. The cultivated brinjal is undoubtedly of Indian origin. Vavilov (1928) was opinion that its centre of origin was in the Indo-Burma region. It belongs to family Solanaceae and known under the botanical name *Solanum melongena* L. There are 3 main botanical varieties under the species *melongena e.g. var. esculentum, var. serpentine* and *var. depressum.*

1. Based on growth habit brinjal can be classified as below:
i) ***Solanum melongena var. esculentum*:** Fruit is long, round or egg-shaped and oval.
ii) ***Solanum melongena var. serpentine*** known as snake brinjal. Fruit is extra ordinarily long and slender types. Leaves are prickly.
iii) ***Solanum melongena var. depressum*:** plant is extensively short and dwarf.

2. Classification on the basis of fruit shape:
i) Long brinjal: Pusa purple long (PPL)
ii) Round brinjal – Pusa purple round
iii) Oval brinjal – Pusa kranti.

3. Classification on the basis of fruit colour:
Purple brinjal: they have no anthocyanins. Eg: PPL.
Green brinjal: more of chlorophyll. Eg: Arka kusumakar

Brinjal is an annual herbaceous plant. Roots are usually tap but on transplanting its changes as fibrous as is true with tomatoes and peppers. The above ground portion of plant is erect, compact and well branched. The leaves are large, simple, lobed and the underside covered with dense wool-like hairs. Inflorescence is often solitary but sometimes it constitutes a cluster of 2-5 flowers. The flowers are large showy with the corolla purple in colour. The flowers are hermaphrodite and stamens dehisce at the same time the stigma is receptive so that self-pollination is the rule, although there is some cross-pollination by insects. The fruit is pendant and is a fleshy berry borne singly or in clusters. There are 4 types of flowers, depending on the length of styles.

Flowers in brinjal are of different styles.
a. long style **b.** medium style **c.** short style **d.** pseudo short style.
Brinjal is a self pollinated crop.
Only **long style and medium style flowers** will set fruits. Entire plant surface is covered by 'hairy layer called 'tomentum'.
Long styled flowers: they have a big ovary, stigma is swollen, long anthers.
Medium styled flowers: it has medium, long style, anthers are of same length, ovary is also medium sized.
Short styled flowers: they have rudimentary ovary.
Pseudo short styled flowers: ovary is rudimentary. Style should be shorter than the anther. No swelling of anther is observed.

Climate: Brinjal is the warm season crop. It is susceptible to severe frost. It requires a long warm season, before fruit maturity. Optimum temperature is 20 to 30^{O}C. Late round varieties are more tolerant to frost than early long varieties. Under very cool seasonal conditions, the ovaries are split leading to the development of abnormal fruits.

Soil: Brinjal can be grown on a wide range of soils. The ideal soils should be a deep, fertile and well drained. The pH should be between 5.5 to 6.6 for better growth and development. Light soils are good for a healthy crop but heavy soils are suited for higher yields.

Varieties: Brinjal varieties are grouped on the basis of colour and shape of fruit.
Long fruit varieties: ex. **Pusa purple long**: evolved as a selction from mixed batia.
Pusa purple cluster long: is an early maturing variety.
Long green varieties: arka kusumakar, arka shirish, Krishna nagar green long.
Round purple: ex: **Pusa purple round**: is resistant to fruit borer and little leaf of brinjal. Selection-6, suphala, arka navaneet, krihsna nagar purple round, pant ritu raj, vijaya hybrid, shyamala.
Round green: banarasi gaint, round striped.
Roundish white: some varieties under this group have purplish tinge with white stripes. Ex: Manjeri, Vaisali.
Oval or Oblong fruited varieties: Junagad oblong, Bhagyamati, H4., Pusa anmol (**Pusa anmol** is a hybrid variety between **pusa purple long and hyderpur**).
Cluster fruited varieties: fruits born in cluster. Ex: pusa purple cluster, arka kusumakar, **Bhagyamathi (APAU variety).**
Spiny varieties: H-4, Manjeri

Hybrids:
Pusa Anmol: Pusa purple long X Hyderpur
Arka Navaneet: IIHR22-1 X Supreme

Time of sowing: In plains crop is grown in three seasons, summer crop is sown during February - March and *rabi* crop is October to November. In hills, seed is sown in April-May and the seedlings transplanted in May-June.

Seed rate: Seed rate varies from 350 to 500 g per hectare.

Nursery bed preparation:

- .Seeds are sown in the area of 250 m^2. A raised bed prepared by well decomposed FYM is mixed @ 4kg FYM per m^2 of nursery bed. A fertilizer dose of 0.5 kg N, P, K per bed is also mixed in the soil.
- Seeds are treated with fungicides (Thiram or Bavistin @ 2g/kg) and 40% formalin solution at 500ml/m^2 area of nursery bed sterilisation.
- During summer and rainy season, there is very heavy incidence of damping off. To protect seeds and seedlings, the beds should be treated with 10% formaldehyde. After fumigation the beds are covered with polythene for 24 hours.
- Seeds are sown 4 to 5 days after removal of polythene sheets. In line sowing 7.5cm distance is kept between the rows. The beds are covered with straw or polythene till the seeds germinate.
- Seedlings are protected against wind, exposure to sun and excess rainfall. Fungicides are sprayed weekly to avoid of damping off. Nursery can also be grown in poly house. Hardening is done by withholding water 4-5 days before uprooting seedlings.
- Adding 4,000ppm sodium chloride or spraying of 2,000ppm CCC is effective for hardening of seedlings.

Transplanting:

- Seedlings are of 8 to 10 cm height with 2 to 3 true leaves are ready for transplanting. Seedlings should be hardened before lifting for transplanting.
- The summer crop may be transplanted on ridges and furrow system for effective use of water. Hardening of seedlings is achieved by withholding water for 4 to 6 days before transplanting.
- Light irrigation should be given on due day of nursery pulling. Seedlings are pulled without any injury to the root. At the time of transplanting soil around the seedlings is pressed firmly.
- Distance of transplanting depends on soil fertility, climatic conditions and varieties. Long fruited varieties are transplanted at a spacing of 60 cm x 60 cm. Round fruited varieties at 75 cm x 75 cm.

Manuring:

- Brinjal occupies the land nearly 6 to 8 months, about 25 to 30 tons of well decomposed FYM is incorporated in the soil before transplanting in one hectare.
- NPK @ 100, 80, 60 kg per ha is generally applied, ½ of nitrogen, full quantities of P and K is applied at the time of transplanting while the remaining quantity of nitrogen may be applied either twice or thrice depending upon soil conditions at 30 days, 45 days after transplanting.

Irrigation:

- Brinjal is a **shallow rooted** crop it needs frequent irrigation. The crop is irrigated at 3 to 4 day interval during summer season 12 to 15 days during winter season. However during rainy spells irrigation is not needed. Brinjal is generally irrigated by furrow system of irrigation.
- Drip irrigation is recommended to improve water use efficiency and also to reduce weed growth.

Inter culture:

- Generally, manual weeding is done to remove weeds. Shallow cultivation is followed to put down the weed growth.
- Mulching in brinjal with black polythene film reduces weed growth, increases crop growth, early bearing and total yield.
- Weeds can be controlled by applying herbicides like fluchloralin @1-1.5 kg a.i. / ha.

Harvesting:

- Fruits are harvested when they attain good size and when the surface is bright and glossy appearance.
- If the fruit is too immature we press the fruit the pressed portion springs back.

Yield:

In case of open pollinated variety 200 to 500 q per ha. Hybrids 300 to 700 q per ha.

Chilli and Capsicum

Botanical name
Chilli : *Capsicum annum*
Capsicum: *Capsicum annum*
Family : Solanaceae
Chromosome no. (2n) : 24
Origin:
Chilli **from Peru**
Capsicum **from South America**

Importance and nutritive value:

- Green chillies are rich in proteins 2.9 g per 100 g. Ca, Mg, P, K, Cu and S. vitamins like Thiamine, Riboflavin and Vitamin C.
- Chillies are the major ingredients in curry powder. In powdered form it is mixed in red or cayenne pepper.
- Pungency of chillies is due to **capsaicin**. The pigment (colour) in chillies is due to **capsanthin** also contains many other oleoresins.

Botany and floral biology: Genus capsicum 20 wild species have been reported at only few are cultivated.

- ***Capsicum annum*** (sweet pepper and chilli): it has blue anthers, milky white corolla.
- ***C. baccatum:*** it has yellow or brown spots on corolla. Its cultivation is restricted to South America.
- ***C. fruitescens:*** tobacco pepper. It has blue anthers. Milky yellowish white corolla.

Chilli Varieties :

- **Andhra Jyothi or G5 (G2 x Bihar variety):** released from Lam Guntur. Fruits are short and called as Gundu types.
- **Bhagya laxmi (G4):** selection from thohian chillies grown largely for green chillies.
- **Sindhuri:** Tall growing and less pungent variety suit for green chillies
- **Baskar/ CA-235:** released from Lam, Guntur. It is a cross between G4 x yellow anther mutant.
- **Prakash (LCA 206):** developed from RARS, Lam Guntur.
- **Hissar sakthi:** multiple resistant variety developed at hissar.

- **N. P. 46A:** Medium, early prolific and pungent variety of IARI **(N.P. means New Pusa)**
- **Arka lohit:** highly pungent variety released from IIHR, Bangalore.

Hybrids:

- Pusa Jwala- Pusa Red X N.P 46 A
- Pusa sadabahar- Pusa jwala X IC 31339
- Punjab lal- Perennial X long red
- Kiran (x235) -G4 X anther mutant

Bell pepper Varieties:

- **Arka basant:** released from IIHR, Bangalore. It was improved from the variety Soroksari, suitable for both kharif and rabi.
- **Arka gourav:** pureline selection from golden caliwonder released from IIHR, Bangalore. Fruits are 3 to 4 lobed. Good for kharif and rabi.
- **Arka mohini:** selection from variety known as Taitan. Fruits are 3 to 4 lobed becomes red on ripening. Suitable for both kharif and rabi season.
- **California wonder:** an introduction from US. Fruits are 3 to 4 lobed.
- **Yolo wonder:** plant is dwarf and as medium flesh thickness.
- **Pusa deepthi:** released from Katrain. Suitable for both **kharif and rabi.**

Climate:

- Chilli is grown in both tropical and sub-tropical areas. It can grow up to 2000 MSL altitude. For vegetative growth, it requires warm humid climate.
- For fruit maturity, it requires warm dry weather. It requires a well distributed annual rainfall of about 800-1200 mm. Heavy rainfall leads to poor fruit set and high humidity leads to fruit rot.
- The crops continue to develop at high temperature but root development is retarded at a temperature of 30^0C. Fruit development is adversely retarded at 38^0C.
- Average night temperature favours high capsaicin content. Day length of 9 to 10 hours light stimulate plant growth. In general capsicum is grown at low temperature conditions than chillies.

Soil:

- Chilli can be grown on a wide variety of soils provided. They are well drained, well aerated and rich in organic manure.
- In ill drained soils plants shed their leaves and turn sick. Cannot tolerate water logging conditions.
- Sandy loam soil with adequate irrigation and manuring can support better crop of chilli. Black soils also preferable to grow chillies as rainfed crop.
- Strongly acid soils and alkaline soils are not suitable. Chilli can be grown in saline soils. Seed germination and plant vigour affected by salinity. Ideal pH 6 to 7.

Time of sowing:

- Chilli seeds are sown in nursery beds during May-July. Sowing is little early in the north east India.
- In south states where rainfed cultivation is in voge chillies can be in May-June and September to October. In hills it is sown during March to April.

Seed rate:

- **1 to 2 kg** seed is required to raise seedlings for hectare. Chilli seed bed are sometimes made in the dimensions of 3 x 3 m, it can accommodate 6000 seedlings and requires about 50 g of seed.
- However, generally nursery of chilli is prepared by following method. Selected area is ploughed to a fine tilth.
- Nursery bed should be prepared to a size of 6 m length 1 m width with a 15 cm raised. Raised beds are preferred than flat beds because on flat beds root development is poor and incidence of damping off is more.
- Well decomposed FYM @ 20 to 25 kg per bed is mixed thoroughly in seed beds in one month advance.
- Seeds are treated with fungicides like Capton 2 to 3 g per litre used to prevent seed borne diseases.Seeds are sown preferably 5 cm lines. Paddy straw used for mulching. Mulching is. removed as soon as seeds start germination. Phytolon 0.25 g per litre solution is used to drench the nursery beds at fortnightly intervals against damping off.

Transplanting:

- Seedlings ready for transplanting 35 to 45 days. Short thick stem seedlings are preferred for better establishment.
- In older seedling topping has to be done one week prior to transplant. Early seedlings are transplanted singly different spacing 30 x 30 cm, 45 x 30 cm, 45 x 45 and even 30 x 20 were tried in chillies.

Manuring:

- It needs good fertile soils supplied humus. Excess nitrogen lead to increase the vegetative growth and delays maturity.
- 10 to 15 tones of well decomposed FYM need to be applied in the last ploughing. Besides that 120 kg N, 60 kg P, 50 kg K per ha is to be applied.
- Entire quantity of FYM, Phosphorus, potassium and half of nitrogen is to be applied at the time of field preparation. Remaining half nitrogen is to be given as top dressing in two equal splits at one month interval of transplanting.

Irrigation:

- First irrigation is given just after transplanting for better establishment in the soil. Second irrigation is given 10 days after transplanting.
- During this time gap filling can be taken up. After wards irrigation is given as per the requirement.
- Generally 8 to 9 irrigations have given depending on rainfall, soil type, humidity and temperature. Method of irrigation adopted is ridges and furrows.

Interculture:

- Chilli is a slow growing crop cannot compete with aggressive weeds hand weeding or hoeing or application of herbicides need to be done in order to ensure weed free conditions.
- Frequent shallow conditions are under taken to facilitate soil aeration and proper root development. However deep cultivation should be avoided because, it damages roots. Herbicides like Alachlor 2.5 kg per ha can be used on chillies.

Harvesting:

- Flowering begins 40 to 60 days after transplanting depending upon variety climate, nutritional status of plant.
- Fruits starts ripening about 3 months after transplanting and picking may go on for 2 to 3 months.
- Commercial chilli variety yield 2-2.5 tonnes per ha. dry pods. and 7.5 to 10 tonnes per ha in normal conditions.
- Green chillies can be stored for about 40 days at 0^0C and 95 to 98 % RH. Dried chillies can be kept for a month in dry places well protected from insect pests.

Cucurbits

Introduction:

- Cucurbits form an important group of vegetable crops cultivated extensively during **summer season (Largest group of warm season vegetables)**
- **Family**- Cucurbitaceae
- Botanically known as **Pepo.** Majority of vegetables are Monoecious/ **Andromonecious or diecious**. These group of vegetables **have trailing habits.**
- This group consist as of wide range of vegetables which are used either as salad, pickling (cucumber) or for cooking (all gourds) or candied or preserved (ash gourd) or as desert fruits (musk melon and water melon).
- The cultural requirements of all crops in this group are more or less similar.
- Pollination is by **Insects**
- Bitter principle is due to **Cucurbitacin**
- These crops requires **dry weather and high temperature at the time of maturity**.

Crop/botanical name	**Origin**	**Varieties**
Cucumber (*Cucumis sativus*) (2n = 14)	India	Japanese Long Green, Pusa Uday, Pusa Barkha, Pant Kheera-1, Pusa Sanyog (H1) Poinsette, Sheetal, Priya
Bottle Gourd (*Lagenaria siceraria*) (2n = 22)	Africa	Pusa Naveen, Pusa Samridhi, Pusa Sandesh, Pusa Santushti, Pusa Hybrid 3, Punjab Round, Punjab Komal, Punjab Long, Arka Bahar
Bitter Gourd (*Momordica charantia*) (2n = 22)	AFRICA	Arka Harit, Pusa Do Mausami, Pusa Vishesh, Pusa Hybrid-2, Coimbtore Long, Kalyanpur Baramasi, Solan Hara, Solan Safaid
Summer squash (*Cucurbita pepo*) (2n = 40)	Central America Mexican region	Pusa Alankar, Australian Green, Punjab Chappan Kaddu1, Early Yellow Prolific
Sponge Gourd (*Lufa cylindrica*) (2n = 26)	India	Pusa Sneha, Pusa Supriya, Pusa Chikni
Ridge Gourd (*L. acutangula*) (2n = 26)	India	Pusa Nutan, Pusa Nasdar, Arka Sumeet, Arka Sujat, **Satputia** (hermophrodite flower)
Ash Gourd (*Benincasa hispida*) (2n = 24)	Japan and Jawa	Pusa Ujjawal, Co-1, Co-2, S-1 (PAU), Karikumbala, Boodikumbala, APAU Shakti
Snake Gourd (*Trichosanthes anguina*) (2n = 24)	India	Co-1, Co-4, TA-19, Chichinda
Water melon (*Citrullus lunatus*) (2n = 22)	Africa	Arka Jyoti (F_1), Arka Manik, Sugar Baby, Durgapur Meetha, Durgapur Kesar, Asahi Yamato
Musk melon (*Cucumis melo*) (2n = 24)	North west India and hot valleys of Iran	Pusa Madhuras, Pusa Sharbati, Hara Madhu, Punjab Rasila, Punjab Sunheri, Punjab Hybrid, Arka Jeet, Arka Rajhans, Hisar Madhu, Durgapur Madhu, Kashi Madhu

Climate: Cucurbits are warm season crops. They do not withstand even light frost and strong winds though cucumber tolerates a slightly cooler weather than melons. Seed does not germinate below 11°C, optimum germination occurs at 18°C and germination increases with rise in temperature till 30°C. Cucurbits grow best at a temperature range of 18-24°C. Proper sunshine and low humidity are ideal for the production of cucumber. Melons prefer tropical climate with high temperature during fruit development with day temperature of 35-40°C. Cool nights and warm days give better quality fruits in melons.

Soil: A well drained soil of loamy type is preferred for cucurbits. Lighter soils which warm quickly in spring are usually utilized for early yields while heavier soils are suitable for more vine growth and late maturity of the fruits. In sandy river beds, alluvial substrata and subterranean moisture of river streams support the cultivation of cucurbits. The soil should not crack in summer and should not be waterlogged in the rainy season. It is important that soil should be fertile and rich in organic matter. The most suitable pH range is between 6.0 and 7.0

Time of Sowing , Seed rate and Spacing

In northern plains, most of the cucurbits are sown during winter season *i.e.* in the month of November (in the riverbeds).In the garden soils, sowing is done in February. Melons are grown only when the weather is warm and dry during fruit development *i.e.* November to February.For rainy season, grow only those cucurbits which can tolerate rains. *e.g.* bitter gourd in June-July.In north-eastern states most of the cucurbits are sown from November to March when the weather is comparatively dry.In southern and central India, winters are not severe and long, therefore, these can be grown throughout the year. November sown crop is over by March-April.In Northern Indian hills, sowings start from April-May and the crop is over by August- September.In western India, sowings are done from September upto February.

Crop	Season	Seed rate (kg/ha)	Spacing (m)	Fruit yield (q/ha)
Cucumber	Summer/rainy	2.5-3.5	1.5 × 0.60-0.90	250-300
Bottle gourd	Summer	4-5	2-3 × 1-1.5	300-400
Bitter gourd	Summer/Rainy	4-6	1.5-2.5 × 0.60-1.20	150-200
Summer squash (dwarf)	Summer/rainy	8-10	0.60-0.75 × 0.45-0.60	250-300
Sponge gourd	Summer/rainy	2.5-3.0	2.50-3.00 × 0.60-1.20	150-200
Ridge gourd	Summer/rainy	3-3.5	2.50-3.00 × 0.60-1.20	150-200
Snake gourd	Summer/rainy	4-6	1.5-2.5 × 0.60-1.20	200-250
Ash gourd	Summer/Rainy	5-7	1.5- 3 × 0.6-1.2	100-150
Water melon	Summer	3-4	2.5-3.5 × 0.90-1.20	300-500
Musk melon	Summer	1.5-2.0	1.50-2.0 × 0.60-0.90	150-200

Chow –Chow (*Sechium edule***) is a perennial crops** propagated by viviparous single seed fruits.
Vivipary: Seed germinates inside the fruit while still attached to the parent tree and nourished by it

Methods of planting: Mostly in cucurbits, *in situ* method of sowing is followed. But in certain areas of Northern India and hills where the main objective is to get early fruit harvest, the seedlings are raised in polythene tubes and plantation is done in the field when the conditions are favourable without disturbing the soil ball. Transplanting is done at 2 true leaves stage.

Furrow method: Furrows are made at 1 to 1.5 m in case of cucumber and bitter gourd. The sowing is usually done on the top of the sides of furrows and the vines are allowed to trail on the ground especially in summer season.

Bed method: In some regions, bed system is in fashion where the seeds are sown on the periphery of beds. The width of the bed is almost double to the row to row spacing.

Hill method or raised beds or raised point: The hills are spaced at a distance of 0.5- 0.75m and 2-3 seeds are sown per hill, after germination retain only one or two plants per hill. This method facilitates proper drainage especially in heavy rainfall regions.

Pit Method: Generally, it is followed in southern India. The pit is lower than the normal bed surface. Training is done by Pargolla or Pandal system.

Manures and fertilizers:

Farmyard manure (q/ha)	**Nitrogen (N)**	**Phosphorus ($P_2O_{5)}$**	**Potassium (K_2 O)**
	(Kg/ha)		
200-250	60-100	50-75	50-85

Full dose of farmyard manure, phosphorus and half of potassium and N should be applied at the time of sowing. Remaining part of N should be top dressed in two equal parts after one month and at flowering stage while half of K is applied when good growth takes place.

Interculture and weed management: Thinning of plants should be done 10-15 days after sowing retaining not more than 2 healthy seedlings per hill. The beds or ridges are required to be kept weed free in the early stages before vine growth start. Weeding and earthing up are done at the time of top dressing of split application of nitrogenous fertilizers. Apply Fluchloralin or Trifluralin @ 0.75-1.0 kg/ha or Bensulide @ 5-8 kg/ha as preplant soil incorporation at 2 weeks before sowing. Butachlor @ 1 kg/ha or chloramban @ 2-3 kg/ha as pre emergence & Naptalam @ 2-4 kg/ha as post emergence after first weeding efficiently helps in controlling the weeds in cucurbitaceous crops. In general, vertical training is more helpful in increasing the yield of cucumber.

Irrigation: In spring-summer crop, frequency of irrigation is very important, while in rainy season crop, well distributed rainfall between July to September reduces the frequency of irrigations. Ridges or hills or beds are to be irrigated a day or two prior to sowing of seeds and then light irrigation is to be given 4 or 5 days after sowing. Flooding of hills is to be avoided and crust formation of the top soil should be prevented. Irrigation once in 5 or 6 days is necessary depending upon soil, location, temperature etc. Irrigation water should not wet the vines or vegetative parts, especially when flowering, fruit set and fruit developments are in progress. Wetting will promote diseases and rotting of fruits, so it is essential to keep beds or inter row spaces dry as far as possible so that developing fruits are not damaged. In rainy season, therefore, these crops are trailed over supports to prevent rotting of fruits

Sex expression and sex ratio

Cucurbits are cross pollinated vegetable crops. There are nine types of sex forms found in these crops, of which monoecious type is the most common. "Satputia" variety of ridge gourd bears hermaphrodite (bisexual) flowers. Gynoecious lines (Bears only female flowers) are used for hybrid seed production in cucumber and bitter gourd. It is of great significance in most of the cucurbitaceous crops which have monoecious plants that meansthey bear male and female flowers separately on the same plant. In the beginning, monoecious plants bear only male flowers and female flowers appear late. The female to male ratio goes on increasing with the age of the plant. Though sex expression and sex ratio are varietal characteristics but they are influenced by environmental conditions. Low fertility, high temperature, and long light periods induce maleness. Gibberellic acid (GA) at higher concentration induces maleness but at lower concentration of 10-25 ppm increases the number of female flowers. Two sprays, first at 2-leaf stage and again at 4 –leaf stage with 100 ppm of NAA, 200 ppm of etheral, 3 ppm of Boron or 3 ppm of Molybdenum can suppress the number of male flowers and increases the number of female flowers, fruit set & ultimate yield. Silver nitrate sprays induces male flowers.

Harvesting:

Harvesting of crop at right time is very important in cucurbits as in most cases, seed development is undesirable. Harvest cucumber, bottle gourd, bitter gourd, snake gourd, ridge gourd and sponge gourd when they are still young, tender and have soft seeds inside. Harvest before fruit colour changes from green to yellow.

Musk melon: It is a climacteric fruit which ripe during transportation and storage. Hence, it should be harvested before it attains fully ripe stage.

Full slip stage i.e. a crack develops around the peduncle at the base of the fruit and when fully ripe the fruit slips easily from the stem.

Half slip stage: Only a portion of the disc is removed when the fruit is pulled out. The scar on the fruit is smaller than the full slip stage.

Water melon: It is harvested at fully ripe stage. Maturity signs are withering of tendril, change in belly color or ground spot to yellow and the thumping test produce dull sound on maturity and metallic sound in unripe fruits.

River bed cultivation

It is kind of vegetable forcing being used in India where cucurbits are sown during winter season in the river beds.

- Pits or trenches are made during October-November.
- They are of convenient length, 30 cm wide and 60 cm deep or to a depth at which the sand is moist.
- A distance of nearly 2-3 m is kept between the trenches.
- Normally, 3-4 pre-germinated seeds are planted/hill in pits or trenches.
- Before sowing, the trenches are manured with FYM.
- Sprouted seeds are carefully sown. Spot watering during the initial stages is essential.
- Protection from low temperature/chilling winds during Dec-Jan (1-2 ^{o}C) is provided probably from *Saccharam* spp. on north side of the pit. It serves following purposes:
- Checks the sand drifting on dug up trenches.
- Provide protection against chilly winds.
- This grass spread over the sand later on & vines spread over this

grass.Sand does not blow off in hot months.

- Fruits from river bed are available 30-50 days before then the normal field sown crop.
- Cucurbits have following salient features which make them fit for river bed cultivation:
  - ✓ Long tap root system which makes use of subterranean moisture.
  - ✓ These are more space planted crops, less no. of plants per unit area are to be managed.
  - ✓ Hot & dry weather with maximum sunshine prevails right from March-June/July which is an essential requirement for melons.

Problems: Leaching of nutrients, Risk if floods due to winter rains, Occurrence of diseases & Fruits having undesirable quality due to inbreeding depression.

Disease management:

Powdery mildew (*Erysiphe cichoracearum*/*Sphaerotheca fuliginea*)Powdery mildew is often serious in dry weather and is the main cause of early dying of plants. White or greyish spots with powdery mass appear on the upper surface of leaves which may cover the whole plant.Spray with dinocap or bitertanol or hexaconzole @ 0.05% at the first appearance of symptoms on the leaves have been reported effective.

Downey mildew (*Pseudoperonospora cubensis*)**:** It does not attack the fruit but causes defoliation and yield loss. Symptoms first evident are as blocky, chlorotic spots that become later necrotic. Grayish fungal sporulation may be observed on the underside of the lesions. Poor air circulation and overhead watering aggravate the problem. Spray the crop with zineb (0.25%) to control this disease.

Anthracnose (*Colletotrichum orbiculare*)**:** Leaves initially show small, pale yellow or water-soaked areas that enlarge rapidly and turn tan to dark brown. These lesions may develop holes or cracks in the center. Depending on weather, spotting may occur on young plants and fruit especially in late plantings.Grow resistant varieties such as Poinsette (cucumber), Arka Manik (water melon). Sow the seed after treatment with Blitox or Bavistin (2.5 g/kg of seed).

Fruit rot: Symptoms occur on the underside and blossom end of the fruit that are in contact with soil. As the disease progresses, lesions become sunken and irregular in shape which result in rotting of the entire fruit.Treat the seed with carbendazim or thiram or captan (2.5 g/kg of seed). Avoid flood irrigation.

Cucumber mosaic: Plants have mottled yellow-green and green leaves, and may be

stunted. They may show epinasty, downward bending of the petioles. It is transmitted by aphids, so control this pest at right stage is essential.

Insect-pests management

Fruit Fly: The adult female lays egg on the flowers, buds and fruits. The maggots after hatching feed on pulp of the fruits and render them unfit for human consumption.

Field sanitation should be ensured by removal and destruction of fallen fruits and infested fruits daily to minimize the pest intensity.Growing 2-3 rows of maize as a trap crop in between the cucurbits. Trap crop act as resting site for the adult fruit fly. Any contact insecticides can be sprayed on maize during evening hours to kill adult fruit flies.

Use of pheromone traps (Palam trap @ 25 nos./ha) for monitoring pest population. Apply malathion (0.05%) as cover spray to kill the insects on contact

or a bait spray that attracts and kill the adults. Bait spray prepared by adding 50 g *gur* + 10 ml malathion in 10 litre water can be used.

Epilachna beetle: Adults and larvae (grubs) feed on leaves leaving a fine net of veins. Damaged leaves shrivel and dry up. Young plants can be entirely destroyed while older plants can tolerate considerable leaf damage. Hand picking and destruction of eggs, grubs and adult beetles is effective, if the cropped area is small. Foliar application of malathion (0.05%), carbaryl (0.1%) and lambda-cyhalothrin (0.004%) checks the pest.

Red pumpkin beetle: It is the most serious insect pest of cucurbits. The larvae and adult of this pest cause damage by eating away the young leaves and flowers at the seedling and flowering stage respectively. Creamy yellow coloured larvae feed on the roots, stem and fruits touching the soil whereas red coloured adults feed on leaf and flowers. Collection and destruction of beetles in the early stage of infestation. Spray the crop with malathion (0.05%) or dichlorvos (0.05%) or carbaryl (0.1%).

Aphids: The first sign of aphid damage is a downward curling and crinkling of the leaves. Aphids are often found on lower leaves and on flower buds and flowers. They are also involved in the spread of several viruses that affect all cucurbits. Spray cypermethrin (0.01%) or acetamiprid (0.01%) bifenthrin (0.01%) or malathion (0.05%).

Whiteflies: They can affect the crop directly by its feeding and by acting as a vector of viruses. When whiteflies are very numerous, the sticky honeydew they produce supports the growth of sooty mold on leaves. Spray acetamiprid (0.01%) or triazophos (0.04%).

Garden Pea

Botanical Name: *Pisum sativum L.*
Family: Fabaceae/Leguminosae
Chromosome no: 14
Origin: Central Asia, the near East, Abyssinia and the Mediterranean

Importance and uses:

- Pea is highly nutritive containing high percentage of digestible protein (very valuable for the vegetarians) alongwith carbohydrates and vitamins A and C.
- It is also very rich in minerals Ca and P.
- It is an excellent food for human consumption taken either as a vegetable or in soup.
- Large proportion is processed (canned, frozen or dehydrated) for consumption in the off-season.
- Being N fixing legume, it is recognized as a soil building crop
- Pea is being used in a growing snack market.
- Garden pea has white coloured flowers and wrinkled seeds whereas field/pulse pea bears purple flowers and round seeds.
- Garden pea is sweater having high sugars while field pea has more starch contents.

Varieties recommended for different regions :

1. Early wrinkle seeded: Arkel, Pusa Pragati, Matar Ageta 6, Azad P3, Pant Sabzi Matar 3 (PSM-3), VL Ageti Matar 7 (VL-7), Vivek Matar -10, Kashi Nandini (VRP-5) , Kashi Uday(VRP-6), Palam Triloki

2. Main season wrinkle seeded varieties: Bonneville, Lincoln, Azad P-1, Punjab-89, Palam Priya, Vivek Matar-6, Vivek Matar -8, Vivek Matar -9,Arka Ajit

3. Edible poded peas: Sylvia, Punjab Mithi Phali, Arka Sampoorna.

Soil: Pea can be grown on all kinds of soils but the best crop can be taken from well drained and fertile loam soil. Light soils are good for early crop whereas heavy soils are suitable for main season crop. The soil pH 6-7.5 is the best for its proper growth and development.

Climate: Pea is a cool season crop and requires frost-free weather particularly at flowering and pod formation stage though vegetative growth is not affected by the frost. The optimum temperature for its germination is about 22^{o}C and that for better growth and yield is 13-19^{o}C. High temperature reduces the pod quality as sugars in the seeds changes to hemicellulose and starch. Temperature above 27^{o}C shortens the growing period and adversely affects pollination.

Sowing time

Area	Early varieties	Main season varieties
North India	September	First fortnight of October –end November
Peninsular India	June- July	Adverse effect when sown after November

Seed Rate (kg/ha): Early varieties: 120-130 kg/ha, Main season varieties: 75-100 kg/ha
Spacing (inter-row x intra-row): Early varieties: 30cm × 5cm,
Main season varieties: 45-60cm × 10cm

Seed inoculation: Inoculation of seed with *Rhizobium* culture can be used. The culture material is emulsified in 10% sugar or jaggery solution sufficient to moist the seed. Mix the emulsified culture thoroughly with seed and dry in shade before sowing. Seed inoculation helps in quick nodulation on the roots which in turn fix atmospheric nitrogen.
Seed treatment: The seeds may be treated with fungicides like thiram or captan (3g/kg of seed) or bavistin (2.5-3 g/kg of seed) to save the crop against wilt disease. If both seed inoculation and fungicide treatments are to be given, then at first the seeds are treated with fungicide followed by inoculation with *Rhizobium* culture.

Manures and fertilizers: Full dose of farmyard manure @ 20 tonnes, 20-50 kg nitrogen, 30-60 kg phosphorus and 30-60 kg potassium per hectare should be applied at the time of sowing based on fertility status of the soil.

Interculture and weed control: First hoeing and earthing up is to be done after 2-3 weeks of sowing and second at flower initiation to get higher yield. Hoeing helps in removing the weeds and pulverizes the soil for proper aeration. Herbicides have also been found beneficial in controlling weeds. Pre-emergence application of Alachlor @ 3litres/ha or Pendimethalin @ 3litres/ha or Fluchloralin @ 2.5 litres/ha may take care of weeds in the initial growth stages

Irrigation: In general, pre-sown irrigation is essential for proper germination. It is important to apply irrigations before flowering, during flowering and at pod formation stage to obtain quality pods and good yield. It is possible to grow pea under rainfed conditions but sufficient moisture must be present in the field at the time of sowing.

Harvesting: The peas are harvested when the pods are fully green and well developed. The seeds should be fully developed but tender *i.e.* should not harden. Picking should be done as soon as green ovules are fully developed and pods still not over mature. Early varieties give 2-3 pickings while 3-4 pickings at 7-10 days interval are taken from main season varieties. Picking should be done either early in the morning or late in the afternoon. Picking during mid day deteriorates the quality of pea pod due to heat.

Yield (q/ha): Early varieties: 60-85 q/ha Main season varieties: 100-150 q/ha

Disease management:

Powdery mildew (*Erysiphe pisi*): First symptoms appear on the upper surface of the leaves as very small and discoloured spots which soon give rise to enlarge white powdery areas on the leaf, stem and pod. Multiple infection may cover the whole plant.

Management:

Grow resistant varieties like Palam Priya.

Spray Dinocap or Bitertanol or Hexaconzole @ 0.05% as the initial symptoms appear on the leaves.

Fusarium wilt (*Fusarium oxysporum* f.sp. *pisi*): Near wilt attacks young plants. The affected plants shoe yellow-orange internal discolouration in the lower internodes.

Bacterial blight: Lesions appear on all above ground parts of the plant. They begin as small, water soaked, oval spots. Multiple lesions often appear together which may cover large portions of infected plants and give blighted appearance.

Management: Slurry treatment of seed with streptomycine sulphate (2.5 g/kg of seed) or soaking seeds in streptomycine solution for 2 hours.

Ascochyta blight: Small purple spots develop on the surface of leaf, stem and pod.

Management: Use 3-4 years crop rotation. Remove and dispose off diseased plants.

Insect-pest management:

Pea aphid: It attacks young vine sucking the juice from growing tip, later covering the whole plant. It causes curling of the leaves and pods.

Management: Spray Dimethoate @ 0.01% or spray of 0.06% nicotine sulphate

Pod borer: The young caterpillars first feed on the surface of the pods, bore into them and feed the seeds.

Management: Spray Malathion or Cypermitherin @ 0.01%

Leaf minor: The greenish larvae make serpentine tunnel in the leaves and feed on it. The infested leaves wither and dry. Flowering and pod formation is drastically affected. **Management:** Spray Cypermethrin or Fenitrothion or Fenthion @ 0.01%

Pea Weevil: The elongated, yellow eggs are laid on green pods and after hatching of eggs, the larvae burrow through the pod into the seed. They develop inside pea and come out by damaging the seed in storage.

Management: Spray methiocarb @ 0.05% is effective.

French bean

Botanical name: *Phaseolus vulgaris*
Family: Leguminosae.
Chromosome no (2n) : 22
Origin: South and central America

Climate: A warm season crop, sensitive to frost and very high temperature. The seeds do not germinate in cold soil. In very hot or rainy weather, plants drop their blossoms or pods. Mean monthly temperature of 10.0 to 23.9ºC is the most ideal. The best pod setting is obtained at temperature range of 15-25ºC for 4 hours after pollination.

Soil: A well drained, fertile and sandy loam soils are preferred with pH between 5.3 and 6.0

Varieties of French bean are classified into two categories:

A. On the basis of fibres:

1. **String type:** Pods contain fibre. The indigenous beans are stringy.
2. **Stringless type:** Pods are free from fibre.

B. On the basis of growth habit

1. **Pole type:** Varieties are tall, indeterminate in growth, larger internodes & number depends upon the length of growing season. It requires support. Main shoot goes on putting growth. Branching is unlimited

2. **Bush type.** Plants are dwarf & bushy in their growth habit. It has a short, erect stem with the main axis consisting of 4-8 shortened internodes. It is popular because of compactness, easy harvest & short duration. Each vegetable stem terminates or ends in the form of terminal inflorescence.

3. **Semi-pole or summer type**: It has 4-8 internodes which are longer than those in bush type. Inflorescence is terminal but appears somewhat late & gives vine type growth. It requires staking for better growth.

Varieties recommended for cultivation in different parts of India

Dwarf varieties	**Pole type varieties**
Contender, VL Boni 1, Pusa Parvati, Arka Komal, Pant Anupama, Arka Suvidha, Arka Anoop, Phule Surekha, Kashi Param	Kentucky Wonder, SVM-1, Luxmi, KKL-1

Sowing time

Northern Indian plains	✓ Spring-summer crop: January-February ✓ Autumn-winter crop: July- September
South India	✓ September-October and crop is over by February

Soil preparation: Soil should be thoroughly prepared by employing 4 to 5 ploughings before sowing the seeds. Farmyard manure or compost should be

applied and incorporated well into the soil. Sowing is done as follows**:**

- **Flat bed:** Generally, it is followed in spring-summer and autumn-winter crop.
- **Hill method:** Maintain row to row distance between the hills. Sow 5-6 seeds per hill and then retain only 3 plants per hill. This method facilitates proper drainage especially in heavy rainfall regions.

Seed Rate (kg/ha): 80-90 kg/ha (Bush type) and 30-40 (Pole type) kg/ha

Seed inoculation: *Rhizobium* culture can be used to inoculate the seed before sowing. This seed inoculation helps in quick nodulation on the roots which inturn fix atmospheric nitrogen

Spacing (inter- row x intra-row) 45cm X 15 cm (Bush type) and 90cm X 10-15cm (Pole type)

Manures and fertilizers: Farmyard manure **@**200-250 q/ha is applied at the time of field preparation. The full dose of recommended fertilizers *i.e.* 30-50 kg N, 60-100 kg P_2O_5 and 30-60 kg K_2 O /ha should be applied at the time of sowing.

Interculture and weed control: Hoeing and earthing up are to be done after 2-3 weeks of sowing and second at flower initiation to get higher yield. Root injury should be avoided during the operation. Therefore, hoeing should be followed by earthing up to strengthen the plants and to encourage the root growth. Weeds can be controlled effectively with the pre-

emergence application of Alachlor 3litres/ha or Pendimethalin @ 4 litres/ha or Thiobencarb @ 4 litres/ha or Fluchloralin @ 2.5 litres/ha.

Irrigation: Beans are shallow rooted and are sensitive to an oversupply of water. Therefore, avoid excessive watering and water logging conditions. Pre-sowing irrigation is essential for proper germination of the seeds. The critical stages of irrigation are flowering and pod setting. Additional irrigation is to be given when needed.

Use of plant growth regulators: Spray of PCPA @ 2ppm or NAA 5-25 ppm induce fruit set when normally pods do not set at prevailing temperatures.

Harvesting: Pods are usually ready to harvest 2-3 weeks after the first blossom. The pods are picked when they are tender, immature and non-fibrous. Delay in harvesting increases the total yield but the quality falls rapidly. Bush varieties are ready for picking after 45 days of sowing where as pole types after 70 days and continue to give picking up to 6 months. Bush varieties give 2-3 pickings while pole types can be harvested in 4-6 pickings.

Yield (q/ha): 80-100 (Bush type) and 100-140 (Pole type)

Physiological disorders:

1. **Transverse Cotyledon Cracking:** This is a major disorder in French bean. It is enhanced by planting dry seeds in wet soil. White seeded varieties are more

prone. Hard seed coat is essential for resistance to this disorder and seed coat shattering. Therefore, seed containing 12% moisture has better germination.

2. **Hypocotyl necrosis:** It means death of hypocotyls tissues. It is associated with low Ca and Mg content in the seed.

Disease Management:

Anthracnose: Small, pink lesions produce on cotyledon and stem which may spread to the leaves. The typical symptoms appear on pods as ulcer like sunken lesions having reddish brown to black blemishes centers and distinct circular, reddish brown margins.

Management:

Use disease free certified seed.

Treat seed with carbendazim or captan @ 2.5-3.0 g/kg of seed.

Spray carbendazim @ 0.1% or mancozeb @0.25% to control the disease. Grow resistant varieties (Tweed wonder).

Rust: Pustules are formed on all above ground plant parts but are more frequent on underside of the leaves. Spray the crop with carbendazim @ 0.1%.

Web blight (*Rhizoctonia solani*): The first symptoms appear as small, circular, water soaked spots on stems, pods and foliage which later become tan-brown with a dark border. Plants become seriously blighted.

Management:

Spray carbendazim (0.1%) for effective management of this disease.

Bacterial blight: Irregular, , red to brown leaf spots surrounded by a somewhat narrow yellowish halo appears.

Management:

Use disease free seed.

Soak the seed in a mixture of Streptocycline (1g) and Hexacap (25g) in 10 litres of water for 4 hrs before sowing.

Common bean mosaic virus: It is transmitted by an insect vector, aphid. It produces chlorotic, crinkled and stiff young leaves as primary symptoms. This is followed by chlorosis and mottling and the compound leaves show downward curling and rolling.

Management:

- It is transmitted by vector aphids so, it is essential to control this pest. Spray recommended insecticide against vector control.

Insect- pests management:

Aphids: They are tiny soft-bodied insects. Initially, damaged leaves show general yellowing. Young leaves become curled when aphids are numerous. They often transmit virus diseases.

Management: Foliar application of dimethoate (0.03%), methyl demeton (0.025%) or malathion (0.05%) before flower initiation stage.

Jassids: In severely infested crop, it produces typical „hopper burn" symptoms. Follow same control measures as in aphid.

Red spider mite: Feeding of mites result in large chlorotic patches on leaves.

Often these damaged leaves curl when the infestation is concentrated on middle part of lower leaf surface. Severe infestation causes extensive yellowing and browning of entire leaves and eventually leaves drop.
Management: Spray azadiractin (0.03%) or malathion (0.05%) or dicofol (0.04%). Repeat sprays at 10 day intervals.

Pod borer: The larva feed on pods and also eats seed totally or partially. Spray carbaryl (0.1%) or cypermethrin (0.01%) at 15 days interval.

Bean beetle: Both larvae and adults feed on the leaves. Spray cypermethrin @ 0.01% to control the pest.

Bean bug: It is sucking pest and causes discolouration of leaves and pods. Spray cypermethrin @ 0.01% to control the pest.

Hairy catterpillar: The larvae cause damage by eating the leaves resulting in defoliation. In early stages, collect and destroy the larvae. Spray malathion @0.05% to control caterpillar.

Bean weevil (*Bruchus spp.*): The eggs are laid on green pods and after hatching of eggs, the larvae burrow through the pod into the seed. They develop inside seed and come out by damaging the seed in storage. It is a storage pest. Put 1-2 tablets of Celphos/tonnes of material.

Okra

Botanical name: *Abelmoschus esculentus* (L.) Moench)
Family: Malvaceae
Chromosome no (2n): 70 -130 (Presence of polyploidy)
Origin: Ethiopia

Importance and uses: Okra is rich in vitamins, Ca, K and other minerals.It is grown for its green, tender and nutritive fruits which are cooked in curry and are also used in soups besides being processed as canned and frozen.

Soil: Okra grows best in light soils ranging from sandy loam to loam though it gives good crop in heavy soil with efficient drainage facility during rainy season. The soil should be well drained as it is sensitive to water logging. The most ideal pH range for its cultivation is 6.0 to 6.8.

Climate: It is a warm season crop, sensitive to fluctuating environment and grows luxuriantly in warm and humid weather. The optimum temperature for better seed germination should be atleast 18^{o}C, optimum temperature being 25-30^{o}C. Optimum temperature for its better growth is 24-27^{o}C and temperature above 42^{o}C causes flower drop. A temperature range of 30-35^{o}C is desirable for improved pollination and subsequent seed setting.

Varieties recommended for cultivation in different parts of India
Parbhani Kranti, Punjab Padmani, Arka Anamika, Arka Abhay, Pusa A-4, Varsha Uphar, Hisar Unnat, Hisar Naveen, HBH-142(Hybrid) Azad Kranti, Azad Bhindi1,Kashi Pragati, Kashi Vibhuti, Kashi Kranti,Phule Utkarsh,

Gujarat Anand Okra-5 Kerala: Kiran, Salkeerthi, Aruna , SusthiraPusa Sawani, Parbhani Kranti, Varsha Uphar and Pusa A-4 varieties find favour for export.

❖ **Sowing time**

Indo-Gangetic plains	✓ Spring-summer crop: February-March ✓ Autumn-winter crop: July- September
Eastern India	✓ January-February
Western & South India	✓ November to March-April. and crop is over by February
Hilly regions	✓ April-June
Most parts of India	✓ Rainy season crop: June-July.

Soil preparation: Okra should be planted in well pulverized field by ploughing first with soil turning plough and afterwards with 4 to 5 ploughings with country plough. Ploughing should be followed by levelling.

Seed Rate (kg/ha): 15-20 **(Spring-summer crop) and** 10-12 **(Rainy season)**

Seed germination can be enhanced by soaking the seed in water for 12-24 hours or GA3 at 10 and 50 ppm or immersing the seeds for 5 minutes in pure acetone

Spacing : 30-45cm × 15 cm(Spring-summer) and 60cm × 20-30 cm (Rainy season)

Manures and fertilizers: FYM @200-250 quintals per ha should be applied at the time of field preparation. In addition, apply 60-75 kg N, 50-60 kg phosphorus (P_2O_5) and 50-60 kg potassium (K_2O) kg per hectare depending upon the fertility status of the soil. Apply half of nitrogen and full dose of phosphorus and potassium at the time of sowing and remaining nitrogen can be top dressed after one month of sowing.

Interculture and weed control: Weeds cause more than 50% reduction in the marketable yield of okra. Frequent weedings are necessary to keep the crop weed free. First weeding may be done at 15-20 days and second at 40-45 days after sowing to keep the crop weed free at critical stages. Pre-emergence application of Pendimethalin @1 kg ai/ha or Alachlor @ 4litres/ha or Fluchloralin @ 2.5 litres/ha + 1 hand weeding is effective to keep crop weed free.

Irrigation: Pre-sowing irrigation is necessary especially in spring-summer crop which ensures adequate germination and uniform crop stand. Then, next irrigation is to be provided after seed germination and the subsequent irrigations at 4-5 days interval during summer crop. Drainage of water is required as per frequency and intensity of rains during monsoon season.

Harvesting: The fruits attain marketable maturity in about 45-60 days after sowing. Only tender and small fruits (6-10cm long) should be harvested preferably in the evening or morning. Frequent pickings are necessary for

getting better quality fruits and handsome prices in the market. Delayed harvesting though increase yield but reduce the quality and profit margin, and even sometimes the entire produce is rendered unfit for marketing. For export purpose, dark green fruits about 6-8cm long should be harvested.

Yield: 80-100q/ha (Spring-summer) and 120-150q/ha (Rainy season)

Post-harvest management: For local markets, fruits are cooled and packed in jute bags or baskets, covered or stitched and then water is sprinkled over the bags, which helps in cooling as well as maintaining the turgidity of fruits thereby saving the produce from bruises, blemishes and blackening. For export, 5-8 kg size perforated paper cartons are ideal wherein pre-cooled fruits are packed and transported preferably in refrigerated vans.

Storage: Fresh okra fruits can be stored at 7-9^{o}C at 70-75% relative humidity for a couple of days without much loss of colour, texture or weight. Fruit can be stored for 2 weeks at 8-10^{o}C at 90% relative humidity.

Disease Management:

Powdery Mildew: White powdery growth on both sides of the leaf. The diseased leaves drop off from the plant.
Management: The disease can be controlled effectively by spray Sulfex (0.2%) or dinocap (0.05%) at 10 days interval.

Cercospora Leaf Spot: There is appearance of spots in the leaf with grey centers and red borders. When the disease is severe, complete defoliation occurs.
Management: Seed treatment with is effective to manage the disease.
Spray mancozeb (0.2%) or Captan (0.2%) or carbendazim (0.1%) at the appearance of the disease incidence to check the infection.
Yellow Vein Mosaic Virus: The veins of diseased leaves become yellow resulting in homogenous interwoven net work of yellow veins.
In extreme cases, the infected leaves become totally yellow or cream colour. Infected plants remain stunted and bear very few deformed and small fruits. The disease causes heavy loss in yield if the plants get infected within 20 days after germination. It is transmitted by white fly.
Management:
Disease incidence can be reduced by checking the development of insect vector by the application of 4 to 5 foliar sprays of recommended insecticides.
Infected plants must be removed from the field
Grow resistant varieties like P-8, Varsha Uphar, Arka Anamika, and Parbhani Kranti.
Root rot (*Fusarium solani*): Severely infected plants die as their roots turn dark brown. The fungus perpetuates in the soil or in the infected plants debris.
Management:
Seed treatment with carbendazim @ 3g/kg of seed Soil drenching with carnebdazim @ 0.1%,
Follow long crop rotation.

Insect- pests:
Fruit borer: The insect larvae are light yellow with black spots. They bore into the shoots during vegetative stage and feeds inside as a result of which the shoots droop

down and dry-up. In the later stages, it infests the fruits which become disfigured and show holes.

Management:

Grow tolerant varieties like Perkins Long Green, Varsha Uphaar.

Remove and destroy damaged shoots and fruits. Application of carbaryl (0.1%) and malathion (0.05%) is effective.

Flower feeding beetle/ Blister beetle: Beetles feed on pollen, petals of flowers and flower buds, thus affecting fruit set adversely.

Management

Hand collection and destruction of beetles. Application of 0.1% carbaryl or 0.05% malathion or 0.01% cypermethrin is effective.

White fly: It causes chlorotic spots on leaves. The insects secrete a sticky substance known as honeydew, which covers leaves and flowers. As a result, the sooty mould develops and plant growth is reduced.

Management

Plants affected by viral disease must be uprooted and destroyed.

Monitoring the adult population with yellow sticky traps for early prediction and timely application of insecticide.

Cole Crops

This group of vegetables includes cauliflower, cabbage, broccoli, knolkhol, kale and Brussels‟ Sprout. The word "cole" seems to have derived from the abbreviation of the word "caulis" meaning stem. It is a group of highly differentiated plants originated from a single wild ancestor *Brassica oleracea* var. *oleracea* (*sylvestris*), commonly known as wild cabbage. Cole crops are the most popular vegetables grown during winter season and among these, cauliflower and cabbage are the important ones. Broccoli is also gaining popularity due to its high medicinal value.

Cauliflower

Botanical Name: *Brassica oleracea* var. *botrytis* L.,
Family: Brassicaceae/Cruciferae
Origin: Mediterranean region
2n: 18
Edible portion: Curd

Cultivars: Cauliflower cultivars grown in India can be classified in two broad groups:

1. Indian Cauliflower/tropical/hot weather/heat tolerant.
2. European types/ Early temperate type known as Snowball or late cauliflower

Indian Type/Tropical types	European /Temperate Type
Annual and tolerant to heat	Biennial and not tolerant to heat
Curd formation at and above 20ºC.	Curd formation at 5-20ºC
Yellow to creamish curds, loose with strong flavour.	Snow white curds with very mild or no flavour (better quality curds).
Plants are short having long stalk and loosely arranged leaves.	Steady plants and long leaves giving protective jacket to curd.
Early in maturity	Late in maturity
More variable (heterozygous)	Less variable (homozygous)
More self-incompatible.	Less self incompatible.
Small juvenile phase.	Long juvenile phase.
No need of vernalization but needs cold treatment at 10-13 oC.	Needs vernalization at 7 o C for 8-10 weeks.

Soil: Cauliflower can be grown in all types of soil with good fertility and good water holding capacity. The mid season and late crop grow very well in medium, medium heavy and heavy soils. For early crop, a light to light medium soil should be preferred so that the drainage is easier in the rainy season. The water stagnation checks the growth, which leads to disappointment to the growers. It prefers a soil reaction ranging from pH 6 to 6.5.

Climate: Climatic factors play an important role during transformation from vegetative to curding and curd development stages. Temperature 10-21ºC is good for germination. It is highly sensitive to temperature *i.e.* temperature influences growth from vegetative to reproductive stages. Transformation from vegetative to curding takes place when plants are exposed to 5ºC to 28-30ºC, depending upon the cultivar of a particular maturity group. Optimum temperature for growth of young plant is 23ºC in initial stages while for growth in later stages, favourable temperature range is 17-20ºC. Plants continue to grow vegetatively without any curd formation if temperature remains higher than optimum for curding. Late group cultivars require 15-20ºC for optimum growth but the same temperature would cause curd formation in the early cultivars.

Conclusion: Temperature higher or lower than optimum for curding results in physiological

disorders like riceyness, leafyness, blindness, loose and yellow curd. Accordingly, varieties of cauliflower have been divided into four different maturity groups (I-IV) on the basis of their temperature requirement for curd formation under the northern Indian plains

Maturity group	Nursery sowing	Transplan-ting time	Opt. temp. range for curding	Varieties
Early I (A) Sept. maturity (mid Sept-mid Nov.)	Mid May	July beginning	20-25 ^{o}C	Early Kunwari, Pant Gobhi-3, Pusa Meghna, Pusa Kartik Sankar
Early I (B) Oct. maturity (Mid Oct-mid Nov)	May end to Mid June	Mid July	20-25^{o}C	Pusa Katki, Pusa Deepali, Pant Gobhi-2
Mid Early (II) Nov. maturity (Mid Nov-mid Dec)	July end	Sept beginning	16-20^{o}C	Improved Japanese, Pusa Hybrid-2, Pusa Sharad, Pant Gobhi-4
Mid late (III) Dec maturity (mid Dec-mid Jan)	Aug end	Sept end	12-16 ^{o}C	Pusa Synthetic, Pusa Subhra, Palam Uphar, Pant Subhra, Pusa HimJyoti, Pb Giant 35, Pusa Paushja, Pusa Shukti
Late (IV) Snowball (Jan-March)	Sept end to mid Oct	Oct end-mid Nov	10-16 ^{o}C	Snowball 16, Pusa Snowball-I, Pusa Snowball K-1, Pusa Snowball KT-25,Dania, Ooty-1,

Nursery sowing

Seedlings become ready for transplanting in 4-6 weeks time. Seedlings 5mm in diameter and about 10-12cm in length are appropriate for transplanting in the field as they have better crop stand with low mortality.

Seed Rate: The seed requirement for raising nursery for one hectare area is as under:

Early varieties	600-750g
Mid-Early season varieties	500g
Mid-late varieties	400 g
Late varieties	300g

Soil preparation and transplanting: The soil should be well prepared by ploughing first with soil turning plough and afterwards with 4 to 5 ploughings with country plough. Ploughing should be followed by leveling and bringing the soil to a fine tilth. The manure should be applied at the time of field preparation. Drainage is a problem for early and some times for mid season crop when rains coincide with cropping period. Therefore, early crop should be transplanted on ridges or raised beds while the mid and late cultivars can be planted on flat beds.Transplanting should be done during late afternoon to avoid losses due to sun heat.

Spacing:

Early varieties	45cm × 30cm
Mid and Late season varieties	60cm × 45cm

Manures and fertilizers: Manures and fertilizer requirements in cauliflower depend upon fertility of soil. Mix 200-250 q/ha farmyard manure thoroughly at the time of field preparation. Application of nitrogen, phosphorus and potash @ 120-180: 75-80: 60-75 kg per hectare,respectively is required to raise a healthy crop of cauliflower. Full dose of phosphorus and one-third of N and half of potassium should be applied at the time of transplanting.

Interculture and weed control: Cauliflower is a shallow rooted crop, so it is essential to do shallow hoeing to remove weeds and to avoid any injury to the roots. Regular hoeing operations keep crop weed free and provide aeration to the root system. Earthing up is important in rainy season as roots get exposed after every shower and should be done after 4-5 weeks of transplanting. Critical period for crop- weed competition is between 30-50 days after transplanting. Use herbicides in initial stages followed by hand weeding in later stages of plant growth along with fertilizer top dressings. Application of Alachlor (Lasso) @ 2kg a.i./ha before transplanting is beneficial for controlling annual and broad leaved weeds. Pendimethalin (Stomp) @1.2 kg a.i./ha or Oxyflurofen (Gol) @ 600 ml/ha) can also be used before transplanting if there is problem of annual weeds only.

Irrigation: Cauliflower needs very careful irrigation that should be applied at right time and in sufficient quantity as both overwatering and insufficient irrigation are harmful to the standing crop. First light irrigation is given immediately after transplanting of the seedlings. Regular maintenance of optimum moisture is essential during growth and curd development.

Use of growth hormones: NAA 10ppm treatment to cauliflower seedlings as starter solution has been found effective in respect of plant stand in the field and vegetative growth. Application of GA4 + GA7 @ 80 mg/l of water shortened the period from transplanting to the harvest.

Harvesting: The harvesting of curds is to be done as soon as the curds attain prime maturity and compactness. It is better to harvest little early than late if there is any doubt about the maturity. Delayed harvesting leads to the elongation of flowering stalk, loose, ricey, fuzzy and over matured curds which deteriorates the quality of the curd. Such curds should be eliminated from the consignment to be sent to the markets as they wilt rapidly and spoil the appearance of the consignment. The curd should be cut-off with stalk along with sufficient number of jacket leaves to protect the curd. Severe trimming of leaves is to be done after unloading or before marketing.

Yield (q/ha):

- Early varieties: 100-150 q/ha
- Mid and late season varieties: 150-225q/ha
- Snowball group may produce yield upto 500 q/ha.

Physiological disorders:

1. **Buttoning:** It means development of small curds or buttons. The general basis is that any check in the vegetative growth of the seedlings may induce buttoning. Buttoning is the result of planting of over-aged seedlings which do not get sufficient time to initiate vegetative growth before transformation to curding or selection of wrong cultivars means planting early variety late or root injury by insects or diseases. Planting suitable variety at appropriate seedling growth stage and at optimum time helps in managing this disorder.
2. **Riceyness:** A premature initiation of floral buds or elongation of peduncle stalk of inflorescence is characterized by riceyness. The curds are considered to be of poor quality for marketing. Temperature higher or lower than the optimum required for curding or high application of nitrogen result in riceyness. Manage proper soil moisture and fertility during curd development stage.

3. **Fuzzyness:** It is the elongation of pedicels of the individual flower. Almost all the prefloral bud which develops precociously on the curd surface give the fuzzy appearance. The possible reasons for the occurrence of this disorder are same as that of receyness in cauliflower.
4. **Blindness:** Blind plants are those, which are without terminal bud. They do not form curd. It is due to poor fertility of the soil or damage to the terminal portion during handling at the time of planting or by insects, diseases *etc*. Healthy and vigorous seedlings with terminal portion intact should be planted.

5. **Bracting:** The bracts are underneath the prefloral meristem which corresponds to axillary buds. These bracts or leaves come out of the curd resulted in poor quality of curds for marketing as they turn green or purple in colour on receiving the direct sunlight at the surface of the curd. Temperature higher than the optimum during curding leads to this disorder.

6. **Purple colouring:** Some time various pigmentations develop on the curd which deteriorates the quality of the final produce. Fluctuations in the temperature are the main reason for this disorder.

7. **Whip tail:** It is caused by the deficiency of Molybdenum (Mo). Young plants become chlorotic and turn white particularly along the leaf margins. In older plants, the lamina of the newly formed leaves is irregular in shape and leaves have only a large bare midrib. This is because of this condition, the disorder is called as "Whip tail". Apply molybdenum @ 1kg/ha to manage the deficiency.

8. **Browning (Red or Brown rot):** It is caused by boron deficiency. The stem become hollow with water soaked tissues surrounding the walls of the cavity. In more advance stages, a pinkish or rusty brown area develops on the surface of the curd

Cabbage

Botanical name: *Brassica oleracea* var. *capitata*
Family: Brassicaceae
Origin: Mediterranean region
2n: 18
Edible portion: Head

Varieties: White cabbage cultivars are divided into three groups on the basis of maturity of heads after transplanting. These are as under:
Early Group: It takes 55-70 days for maturity. The commonly grown varieties are Golden Acre, Pride of India, Copenhagen Market, Pusa Ageti,Pusa Mukta, Pusa Cabbage Hybrid-1 (KGMR-1).
Mid season Group: The **c**ultivars fall between early and late maturity groups. September, and Pusa Drum Head are the common varieties from this group.
Late Group: It takes about 85-130 days for maturity *e.g.* Late Large Drum Head

Cabbages are classified into three broad groups:
White cabbage: It is the most commonly cultivated. Pointed, Round and Flat or Drumhead
Red cabbage – Leaves have distinct coat of wax and tolerant to diamond back moth.
Savoy cabbage – Blistered leaves and the shape is pointed round and flat

Soils: The soil requirement for cabbage is almost same as that of cauliflower. On heavy soils, plant grows slowly and the keeping quality is improved because of compactness. Most cabbages are somewhat tolerant to salt.

Climate: It can withstand extreme cold and frost better than cauliflower. It thrives best in a relatively cool and moist climate. The optimum seed germination is obtained at 12.6-15.6^{o}C soil temperature. The optimum temperature for growth and head formation is 15-20^{o}C whereas, the growth is checked above 25^{o}C.

Planting time: In the Northern Indian plains, transplanting of different varieties can be done from October –January.

Seed Rate: For raising nursery for one hectare area, **e**arly season varieties needs 600-800 g/ha whereas the seed requirement for main season varieties is 200-500 g/ha.

Soil preparation and transplanting: Prepare the field for transplanting in the same manner as described for cauliflower.

Spacing: The spacing depends upon the head size to be produced as per the demand in the market. For getting small sized heads, transplanting is done at closer spacing while plants are transplanted at larger spacing for producing big size heads. General spacing which is recommended is as under:

Early varieties: 45cm × 30cm or 30 cm × 30 cm (round & smaller heads)
Late varieties: 60cm × 45cm or 60 cm × 60 cm

Nutrient management: Manures and fertilizer requirements in cabbage depend upon fertility of soil. Mix 200-250q/ha farmyard manure thoroughly at the time of field preparation. Application of 120-180 kg nitrogen, 75-80 kg phosphorus and 60-75kg potassium per hectare is required to raise a healthy crop of cabbage. Half quantity of nitrogen and full quantity each of phosphorus and potash is applied at the time of transplanting. Remaining quantity of nitrogen is applied after 30-45 days of transplanting.

Intercultural operations: Similar to cauliflower, cabbage is a shallow rooted crop, so it is essential to perform shallow hoeing to remove weeds and to avoid any injury to the roots. Regular hoeing operations keep crop weed free and provide aeration to the root system. Crust formation in medium heavy and clay soils hinder water and air penetration in root system. The crust should be broken otherwise it adversely affects plant growth. Earthing up is important in rainy season as roots get exposed after every shower and should be done 4-5 weeks after transplanting. Critical period for crop-weed competition is between 30-50 days after transplanting. Use herbicides in initial stages followed by hand weeding in later stages of plant growth along with fertilizer top dressings. Application of Alachlor (Lasso) @ 2kg a.i./ha or Trifluralin@ 0.5 kg/ha or Fluchloralin @ 0.5 kg/ha before transplanting is beneficial for controlling annual and broad leaved weeds. Pendimethalin (Stomp) @1.2 kg /ha or Oxyflurofen (Goal) @ 600 ml/ha) can also be used before transplanting if there is problem of annual weeds only.

Water management: Cabbage is very sensitive to soil moisture. Maximum growth and yield can only be obtained when sufficient quantity of water is available to the plants. First irrigation is given just after transplanting of seedlings. Irrigation may be applied at 10-15 days interval according to the season and soil but optimum soil moisture should be maintained regularly. Cabbage is usually irrigated by furrow method of irrigation. Heavy irrigation should be avoided when the heads have formed, as it results in cracking of heads.

Harvesting: In general, the heads are harvested when they are firm and solid. The heads are cut with a knife, frequently attached with some non-wrapper leaves. These non-wrapper leaves give protection to the heads from bruising injury.

Yield (q/ha): Early varieties: 250-300 q/ha, Late season varieties: 400-500 q/ha

Knol Khol

Botanical name: *Brassica oleraceae* var. *gongylodes*
Family: Brassicaceae/Cruciferae
Chromosome No (2n): 18
Origin: Mediterranean region (Northern Europe)
Edible Part: Tender Knob
Common names: Kohl rabi, kohlrabi greens, Novalkol, GunthGobhi, GanthGobhi

Knol Khol also known as,is characterized by the formation of tuber, which arises as thickening of the stem tissue above the cotyledons. This tuber or knob develops entirely above the ground. It is this portion that is used for vegetable, though young leaves are also used. It is excellent vegetable if used at early stage before it becomes tough and fibrous. The edible portion is globular to a slightly flattened stem. The cultivation of knolkhol or Kohlrabi in India is not very popular except in Kashmir, West Bengal and some parts of the south. In India, mainly two cultivars are commonly cultivated.

Varieties: White Vienna, Purple Vienna, Large green, Grand Danuke, Early Purple Vienna, Early White Vienna

Climate and Soil: It is mainly grown as a winter vegetable crop and thrives well in relatively cool moist climatic conditions. Seeds germinate well at 15-30^{o}C. Optimum temperature requirement for its growth is between 15-25^{o}C depending upon cultivars. It can be grown on all types of soil but sandy loam and clay loam are best soils for cultivation. It doesnot grows in acidic soil. pH of soil should be 5.5-5.8

Sowing and transplanting

Planting time under North eastern plains is September -October. Seed rate of 800-1000 g/ha is required to raise a crop of broccoli in one hectare area. The seedlings are transplanted at 30- 40 cm between the rows and at 20-25 cm between plant-to-plants in a row. Proper moisture should be maintained during its growth. Pre-planting application of herbicides followed by hoeing and weeding in the later stages keep the crop free of weeds. Any check in the growth results in the development of fibrous knobs. Mix 200-250q/ha farmyard manure thoroughly at the time of field preparation.

Manure and Fertilizers: Application of nitrogen, phosphorus and potash @ 75-100: 60- 80: 60-80 kg per hectare, respectively is required to raise a healthy crop of knokhol. Half quantity of nitrogen and full quantity each of phosphorus and potash is applied at the time of transplanting. Remaining quantity of nitrogen is applied after 30 days of transplanting.

Harvesting and yield: Tubers are harvested before they are fully developed as delayed harvesting make tubers fibrous. Generally bright colour tubers of 5-8 cm

diameter along with the foliage are favoured in the market. For its marketing, the main root is cut off and the enlarged stem along with the leaves are tied up. Individual tuber may weigh 200-250 g while the yield may vary from 12- 25 t/ha under Indian conditions.

Diseases and Insect-pests of cole crops

The important diseases and insect-pests of cole crops are described as under:

Black leg: (*Phoma lingam***):** It occurs in areas with continuous rainfall during the growing period. It is a seed borne disease and hence infest crop plants at an early stage. Stem of the affected plant when split vertically shows severe black discolouration of sap stream. Whole root system decays from bottom upwards. Often, the affected plants collapse in the field.

Management:

Use disease free seed.

Hot water treatment of seed before sowing Spray the seed crop with copper oxychloride,

Variety, Pusa Drum Head of cabbage is tolerant under field condition.

Black rot (*Xanthomonas campestris):* The tissue at the leaf margin becomes yellow; chlorosis progresses towards leaf center creating a V-shaped area at the mid rib.

Management: Use disease free certified seed.Spray Streptocycline @ 5g and Blitox @ 10g per 10 litre of water after transplantation.

Insect- pests:

Diamond back moth: Spindle shaped pale yellowish green caterpillars feed on the lower side of leaves but later feed on the exposed leaves and enter the head/ curd affecting the produce as well as quality.

Management: Indian mustard is effective as a trap crop in suppressing the incidence of diamondback moth and cabbage aphid. Release *Trichogrammatoidea bactrae* @ 0.5-0.75 lakh eggs per ha at weekly intervals for its effective control.

ONION

- **Botanical Name:** *Allium cepa* L.
- **Family:** Amaryllidaceae
- **Chromosome No**: 16
- **Origin:** Central and South Western Asia

Uses:

- The green leaves, and immature and mature bulbs are eaten raw.
- It is used in preparation of sauces, soups and seasoning of food on accounts of its special characteristic pungency.
- Also used in processed form *e.g.* flakes, powder and pickles.
- Onions are diuretic, applied on bruises, boils and wounds.
- It relieves heat sensation.
- Bulb juice is used as smelling on hysterical fits in faintness.
- It is used to relive insect bites and sour throat.
- Onions play a part in preventing heart diseases and other ailments.
- Onions are given in jaundice, spleen enlargement and dyspeptic after cooping in vinegar.
- Roasted onions mixed with cumin, sugar candy and butter oil are a demulcent of great benefit in piles.
- The essential oil contains a heart stimulant, increases pulse volume and frequency of systolic pressure and coronary flow and stimulates the intestinal smooth musculature and the uterus.
- It reduces blood sugar & has lipid lowering effect.
- **Pungency in onion** is due to allyl-propyl- disulphide.

Varieties: The onion varieties have been classified on the basis of size and skin colour. Further, onion has been classified as common and multiplier onion. There are 4 classes on the basis of colour of bulb**:** White, Yellow, Red and Brown. Red colour is due to anthocyanin pigment and yellow is due to **quercetin** pigment

- **Red Coloured:** Agrifound Dark Red, Agrifound Light Red, Arka Niketan, Arka Kalyan, Pusa Madhavi, Pusa Ratnar, Pusa Red, Pusa Riddhi ,Udaipur 101, Udaipur 103, Bhima Raj, Bhima Red
- ***Kharif* Onion**: Arka Kalyan, Arka Pragati, N-53, Arka Niketan
- **White skinned varieties**: Pusa White Flat, Pusa White Round, Punjab-48, Udaipur-102
- **Yellow skinned varieties:** Brown Spanish (Long day variety, suitable for growing in hills), Early Grano (Good for salad, suitable for green onions).
- **Multiplier Onion:** Agrifound Red, CO-1, C-2 (resistant to purple blotch), CO-3 (resistant to thrips), CO-4 (moderately resistant to thrips), MDU-1.
- **Small Onion:** Agrifound Rose (pickling type, suitable for export), Arka Bindu

- **Rabi season varieties**: Palam Lohit, Patna Red, Agrifound Dark Red, Palam Lohit
- N-53 (Kharif onion variety),
- Brown Spanish (long day variety)

Soil: Soil should be friable, fertile, well drained and have an abundant supply of humus. A heavy soil is not desirable that bakes and crusts after irrigation. Sandy loam and silt loams are best suited to it. The soil pH should be in the range of 5.8-6.5. It is sensitive to high acidity and alkalinity.

Climate: It grows in mild climate without extremes of high and low temperature. The optimum temperature for seed germination should be 20-25^{o}C. Low temperature and short photoperiods are required for vegetative growth, while relatively high temperature and long photoperiods are needed for bulb development. It requires 13-21^{o}C temperature for vegetative growth before bulb initiation and 16-25^{o}C for bulb development and 25-30^{o}C for bulb maturation.

Sowing time

Season	Time of sowing	Time of transplanting	Harvesting time
Northern India			
Rainy(*Kharif*)	May- June (July)	July- Aug (Mid Aug)	Nov-Dec
Winter (*rabi*)	Oct-Nov (Nov)	Dec-Jan (Jan-early Feb)	May-June
Maharashtra and parts of Gujrat			
Rainy (*kharif*)	May-June	July Aug	Oct-Dec
Late rainy (*kharif)* or early winter (*rabi*)	Aug-Sept	Sept-Oct	Jan-March
Winter (*rabi*)	Nov-Dec	Dec-Jan	April-June
Tamilnadu, Karnataka & Andhra Pradesh			
Early rainy (*kharif*)	April-May	May-June	August
Rainy (*kharif*)	May-June	July-Aug	Oct-Nov
Winter (*rabi*)	Sept-Oct)	Nov-Dec	March-April

Seedlings become ready for transplanting in 8-10 weeks time. Seedlings must be about 15-20cm in length at the time of transplanting.

Seed Rate:8-10 kg/ha
Spacing: The onion seedlings are planted at a spacing of 15-20 cm between rows and 5-10 cm between plant-to-plant. Transplanting on ridges is ideal for *kharif* onion crop.
Soil preparation and transplanting: Onion should be planted in well-pulverized field by ploughing first with soil turning plough and afterwards with 4 to 5 ploughings with country plough. Leveling should follow ploughing. Onion is normally planted in flat beds however *kharif* onion is planted on ridges. Transplanting should be done during late afternoon

Manures and fertilizers: Apply well rotten farmyard manure@200-300 q/ha, nitrogen @ 60-150 kg, phosphorus @ 35-150 kg and potassium@ 25-120kg per hectare depending upon the soil test, cultivar and growing season. FYM is applied at the time of field preparation. Apply 50% nitrogen and entire quantity of phosphorus and potash at the time of transplanting or bulb sowing. Remaining half of the nitrogen is top dressed 5-6 weeks after transplanting.

Interculture and weed control: Onion is a closely planted and a shallow rooted crop and thus, hand weeding is difficult to be performed which may damage the crop. Therefore, use of chemical weedicides at initial growth stage followed by 1-2 hand weeding is beneficial. The critical period of crop-weed competition is between 4-8 weeks. Application of Alachlor (Lasso) @ 2 litres/ha or Pendimetalin (Stomp) @ 3 litres/ha in 750 liters of water before transplanting is beneficial for controlling weeds. Three hand weedings are sufficient to harvest economic crop if done at 30, 50 and 75 days after transplanting.

Irrigation: Onion needs very careful and frequent irrigation as it is a shallow rooted crop. Water requirement of the crop at the initial growth period is less and increases during later growth stages. Irrigation should be applied at an interval of 10-15 days in cool weather and at a weekly interval during hot weather. Bulb formation and bulb enlargement stages (70-100 days after transplanting) are critical for water requirement. Insufficient moisture tends to slow down bulb growth while over supply causes rotting. Generally, 10-12 irrigations are given in *rabi* season. Stop irrigation when the tops mature and start falling down.

Harvesting: Onions are ready for dry bulb harvesting when the tops get dried (or at neck fall stage) and bulbs are mature. Harvesting at this stage results in higher yield, longer storage life of bulbs and less neck rot. The green onions can be harvested when they reach pencil size until bulbing begins. It is desirable to leave 1.5-2.0 cm of the tops attached to the bulb as it helps to close neck and reduce storage losses.

Curing: Onion bulbs should be adequately cured because curing or drying of bulbs is an important process to remove the excess moisture from the outer skin and neck of onion bulb. Curing helps to reduce the chances of disease infection, minimizes shrinkage due to loss of moisture from the interiors and helps to develop good skin colour. Bulbs are either cured in field or in open shades before storage. Onions are considered cured when neck is tight and the outer scales are dried until they rustle. Bulbs are cured in field for 3-5 days in wind row method. Then bulbs are placed in shade and cured for 7-10 days to remove field heat. This shade curing improves bulb colour and reduces losses during storage.

Yield: *Rabi* crop: 250-300q/ha, *Kharif* crop: 200-250q/ha

Curing:

- Curing or drying of bulbs is an important process to remove the excess moisture from the outer skin and neck of onion.
- This helps in reducing the infection of diseases and minimizes shrinkage due to removal of moisture from the interiors. This is, further, an additional measure for the development of skin colour.
- Bulbs are either cured in field or in open shades before storage. Onions are considered cured when neck is tight and the outer scales are dried until they rustle. Bulbs are cured in field for 3-5 days in wind row method. Then bulbs are placed in shade and cured for 7-10 days to remove field heat. This shade curing improves bulb colour and reduces losses during storage.

Yield: *Rabi* crop:250-300q/ha, *Kharif* crop: 200-250q/ha

Storage: Onion bulbs have a rest period for about 2 months. Proper storage is important as higher temperature induces sprouting. Thorough ventilation, uniform comparatively low temperature, low humidity, proper maturity, optimum application of fertilizer (s), freedom from diseases and insect-pests is essential for successful storage.

Growing *kharif* onions by sets:

- Onion sets are small bulbs (around 0.25-1.0 inch in diameter) grown in the previous year.
- These sets are used as the propagating material for the production of dry bulbs and bunching onions.
- Varieties recommended for this crop are N-53, Arka Kalyan, Arka Niketan *etc*.
- 5-7.5 kg seed is enough to raise sufficient number of sets to plant one hectare area.
- Sowing of seed is done during end of January or beginning of February (left plants at same place till April).
- In April, plants form small sets due to close spacing. The plants are uprooted and tops are removed.
- The sets having 1.5-2.0 cm in diameter and disease free are selected and stored till July.
- About 10q sets are enough to plant one-hectare area.
- Sets are planted at 10cm apart in rows on both sides of ridges spaced 35-45 cm.
- Sets are normally planted by July-August to get an early crop by early November.
- These are commercially used to produce early green onions but also used for dry bulb production.

Physiological disorders

1. **Bolting:** It means emergence of seed stalk prior to time of bulb formation and adversely affects the formation and development of bulbs.

Reasons:

- Transplanting of aged seedlings
- Early sowing of seeds in the nursery beds, which result in the formation of small sets.
- Late transplanting of seedlings
- Low temperature (10-12^{o}C) for prolonged period.

Management: Time of planting should be adjusted in such a way that the crop may expose to moderate temperature at bulbing. Sow nursery at proper time.

2. **Sprouting:** An important disorder in storage of onion and results in huge losses. It is associated with excessive moisture at maturity and supply of nitrogen.

Management: Adjust time of planting in such a way that harvesting can be done in dry period. Stop irrigation as soon as bulbs reach maturity. Spray iron sulphate or borax @ 500- 1000 ppm 2-3 weeks prior to harvesting.

Disease Management

Purple blotch (*Alternaria porri):* Small white sunken spots develop on leaves. The lesions enlarge and turn purple under moist condition. The bulb tissue becomes papery.

Management: Three summer ploughings reduce the disease severity. Spray Mancozeb or copper oxychloride (2g/liter) at 10 days interval, if required.

Downy Mildew (*Peronospora destructor*): There is violet growth of fungus on the surface of leaves and flower stalks which later become pale-green yellow and finally collapse.
Management: Follow crop rotation with a 4 year break in onion cultivation.
Maintain field hygiene and sanitation. Remove primary infected onion plants. Spray Zineb @ 0.2%

Onion Smut (*Urocytis cepulae):* It is a soil borne disease and infects cotyledon and seedlings which result in heavy mortality. Management: Treat nursery soil with Thiram or Captan (0.2%) along with Methocal sticker. Treat the seed before sowing with Thiram or Captan (3 g/kg of seed).

Insect- pests
Onion thrips: It is the major pest of onion and garlic. Onion plants infested with thrips develops spotted appearance on the leaves which turn into pale white blotches due to drainage of sap. The adults hibernate in soil, on grass and other plants in the onion field.
Management: Application of malathion (0.05%) or cypermethrin (0.01%) is effective.
Onion maggot: Maggots enter the bulbs through roots and attack the tender portion. Infested plants turn yellowish brown and finally dry. The affected bulbs rot in storage as infestation leads to secondary infection by pathogenic organisms.
Management: Crop rotation should be followed. Application of phorate @ 10 kg/ha

Mites: They suck sap and plants turn yellow with sickly appearance.
Management: Infested bulbs should be exposed to sun for 2 days. Dusting of sulphur in the onion fields @ 22 kg/ha can be helpful.

Garlic (*Allium sativum* L)

Botanical name : *Allium sativum* L
Family: Amaryllidaceae
Origin: Central Asia
Chromosome No(2n): 20
Pungency in garlic is due to the compound diallyl-disulphide**.**

Cultivars: GHC-1, Agrifound Parvati, Large Segmented, Solan Selection, Selection 1

Soil: Soil should be friable, fertile, well drained and have an abundant supply of humus. A heavy soil is not desirable that bakes and crusts after irrigation. Loam soils are best suited to it. The soil pH should be in the range of 6-7. It is sensitive to high acidity and alkalinity.

Climate: It is a winter season crop requiring cool and moist atmosphere (12-18^{o}C) during growth and relatively dry weather (20-25^{o}C) during bulbing and 25-30^{o}C at bulb maturity. It is a frost hardy plant. Low temperature and short days are congenial for proper bulb formation and hence the pre-requisites for higher yield. Adequate vegetative growth promotes bulb formation

Sowing time

Region	**Sowing time**
North India	September- November
Mah., Karnataka, AP	August-November
WB, Orrisa, Gujarat	October-November

Planting material: Vegetatively propagated by cloves. Healthy cloves should be selected and **500-700 kg/ha** of bulbs are required. For large cloved varieties like GHC-1, the seed rate is 15-20q/ha. Bulbs are separated into single segment i.e. cloves at planting time.

Soil preparation and transplanting: same as onion

Spacing: 15-20cm between rows and 10 cm between plants to plant**.** Sowing depth is 2-4 cm.

Planting methods:

1. Dibbling: Cloves are dibbled 5-7.5 cm deep keeping their growing ends upwards.

2. **Furrow planting:** Cloves are dropped in the furrows by hand and covered lightly by loose soil.

Manures and fertilizers, Interculture and weed control: same as onion

Irrigation: In general, irrigation at an interval of 8-10 days during vegetative growth and 10- 15 days during bulb formation and development. Critical stages are bulb formation and bulb enlargement.

Harvesting: Crop is ready for harvesting when the tops turn yellow or brownish and shows signs of drying up and begins to fall over. Bulbs are taken out alongwith tops manually.

Bulbs are cured in field for one week. The bulbs are covered alongwith the tops of each other to avoid damage from the sun. Then, these bulbs are cured in shade for 7-8days either with tops or after cutting tops, leaving 2.5cm of the stalk. Roots are also trimmed leaving 1cm of root.

Yield: 100-150q/ha.

Curing: Curing or drying of bulbs is an important process to remove the excess moisture from the outer skin and neck of Garlic. This helps in reducing the infection of diseases and minimizes shrinkage due to removal of moisture from the interiors. This is, further, an additional measure for the development of skin colour. Bulbs are either cured in field

or in open shades before storage. Garlic are considered cured when neck is tight and the outer scales are dried until they rustle. Bulbs are cured in field for 3-5 days in wind row method. Then bulbs are placed in shade and cured for 7-10 days to remove field heat. This shade curing improves bulb colour and reduces losses during storage.

Storage: Thoroughly cured bulbs keep fairly well in ordinary ventilated room. Cold storage at 0-2.2ºC and 60-70% RH is congenial. The storage life is prolonged and loss in weight is reduced by spraying maleic hydrazide @ 2000-3000 ppm, 2-3 weeks before harvesting.

Diseases: Purple blotch, Downy mildew

Insect-pests: Mites, Aphids, Thrips.

CARROT

Botanical name: *Daucus carota* L.
Family: Umbelliferae
Chromosome no (2n):18
Origin: Afghanistan

Importance and Uses:

- It is valued as a nutritive food mainly because of high carotene contents.
- It is used as a cooked vegetable, salad, soups and stew etc.
- It increases the quality of urine and helps in the elimination of uric acid.
- Black carrots are used for the preparation of a soft beverage called *Kanji*, which is supposed to be a good appetizer.
- Red type is good for preparation of various types of sweets especially *Gajar Halwa* in northern India.

Classification of roots: Roots can be classified on the basis of shape as

1. **Long rooted:** 25 cm or more in length, generally tapering.
2. **Half-long rooted**: Does not exceed 20 cm.
   i. Roots cylindrical with straight or sloppy shoulder e.g. Nantes
   ii. Roots tapering with blunt or semi-blunt type e.g. Chanteney or Imperator.
3. **Short-stump rooted**: These are suitable for growing in heavy soils.
   i. Heart shaped: e.g. Oxheart. **ii. Oval:** Early Scarlet Horn. **iii. Round:** French Forcing.

VARIETIES: The varieties of carrot are divided into two groups

Asiatic or tropical type	European Type or Temperate Type Varieties
1. It produces seed in plains. 2. It does not require low temperature treatment for flowering. 3. Roots are long and red in colour with white or creamy core. 4. Rich in lycopene	1. It produces seed in hills 2. It requires chilling (4.8-10 ^{o}C) for flowering. 3. Roots are medium in size and orange in colour with centre core. 4. Rich in carotene

Varieties	
Pusa Kesar, Pusa Meghali, Pusa Vristi, Pusa Rudhira, Pusa Ashita (black coloured), Hisar Gairic, Black Beauty	Pusa Yamdagini, Jeno, Imperator, Chantaney, Danvers, Early Nantes, Nantes, Nantes Half Long, Ooty, Pusa Nayanjyoti(hybrid)

Soil: Carrots prefer deep, loose, well-drained, sandy loam to loam soil with a slightly acidic reaction. The edible roots become misshapen due to poor soil structure or obstructions such as stones, clods or trash.

Climate: It is predominantly a cool season crop. A temperature range of 7.2 to 23.9^{o}C is suitable for seed germination and 18.3 to 23.9^{o}C for better root growth. The optimum temperature for better colour development of roots is 15.6-21.1^{o}C.

Sowing time: In north Indian plains, sowing can be taken up from middle of August to beginning of December.

Seed Rate:6.25 kg/ha

Seeds are to be mixed with fine sand before sowing to facilitate even distribution.
The seeds should be rubbed to remove fine hair before sowing.

Soil preparation: The soil should be thoroughly pulverized so as to obtain fine tilth for getting the best crop, otherwise roots get deformed in shape.

Spacing:30cm × 8-10cm.

The seed should be sown at a depth of 1-1.5 cm deep on the ridges and after germination maintain distance of 8-10cm between the plants with in row by following thinning of plants.

Manures (q/ha) and fertilizers (kg/ha):

Farmyard manure 100 q/ha	50-90 N:	40-80 P_2O_5	: 40-80 K_2O

The nutrient dose depends upon the nutrient status of the soil. Full dose of farmyard manure, phosphorus, potassium and half dose of N should be applied at the time of transplanting. Remaining nitrogen should be top dressed in two equal installments at an interval of one month each.

Interculture and weed control: Carrots grow slowly at the seedling stage, therefore, the removal of weeds is quite essential especially at an early stage. For effective weed control, a pre-emergence application of Propazine @ 1.12 kg/ha has to be done. Earthing up is also essential for better growth and development of roots.

Irrigation: A pre-sowing irrigation is to be given to ensure better seed germination. Carrots require abundant and well-distributed water supply. Cracking of roots occur due to exposure to dry weather followed by wet weather. Carrots should be irrigated before any wilting of leaves takes place. It should not be irrigated heavily as it leads to excessive vegetative growth and thus the quality of roots gets deteriorated along with delay in maturity.

Harvesting: Carrots for fresh market are harvested before plants reach full maturity in order to assure quality, while those for processing are allowed to grow longer in the season to maximize yield. For fresh market, smaller, tender, milder in flavour and uniform in appearance are to be harvested for getting good returns. The common Asiatic varieties attain the marketable stage at 2.5-4.0 cm dia at the upper end. A light irrigation before 2-3 days of harvesting is to be given to facilitate the pulling of the roots from the soil without any damage. Roots harvested with top are called **bunch carrot** while those without the tops are called **bulk carrots**. Most carrots for fresh market are now topped which greatly reduces water loss from the roots and increases storage life.

Yield: Asiatic types: 250-300 q/ha. **European Types:** 100-150 q/ha

1. **Root splitting:** Splitting or cracking of carrot roots is a major problem.
   Possible reasons:
   - Wider spacing as larger roots tend to split more.
   - Dry weather followed by wet weather is conducive to cracking of roots.
   - High nitrogen application
2. **Cavity spot:** It appears as a cavity in the cortex. In most cases, the subtending epidermis collapses to form a pitted lesion.

   Possible reasons: Calcium deficiency associated with an increased accumulation of K and decreased accumulation of Ca.
3. **Forking:** It is a common disorder in carrot and radish formed by the enlargement of secondary root growth.

   Possible reasons: Excess moisture during the root development. It occurs on heavy soils due to soil compactness.

Diseases: The important disease are leaf blight, leaf spot or Cercospora blight, powdery mildew, watery soft rot, black rot, and bacterial soft rot.

Insect-pests: The serious pests are rust fly and turnip moth

RADISH

- **Botanical Name:** *Raphanus sativus* L.
- **Family:** Brassicaceae/ Cruciferae
- **Chromosome No (2n):** 20
- **Origin:** Western Asia (China)
- **Edible Portion:** Modified roots (Fusiform) basically primary root hypocotyl
- **Winter season vegetable crop**
- Popular in both **tropical and temperate countries** of the world
- **Quick growing** crop, easily can be grown as **companion crop**, **intercrop** between rows of different vegetable crops**, can be grown along the ridges of beds (vacant areas around other vegetable crops)**

Uses:

- The roots and leaves are consumed both **as salad and as cooked vegetable.**
- The leafy tops are very rich in **vitamin A, B, C and minerals particularly Ca and Fe.**
- The roots are good appetizer, effective in curing liver**, gall bladder and urinary disorders, piles and gastrodynia.**
- It has **cooling effect** and prevents **constipitation**
- **Red colour** is due to presence of **Anthocyanin**
- Pungency in Raddish is due to **isothiocyanate**

Varieties

Asiatic/tropical/subtropical type	**European/temperate Type**
These produce seeds in plains	Seed production is limited to high hills.
Pusa Desi, Pusa Reshmi, Pusa Chetki, Japanese White, Pusa Mridula, Punjab Safed, Punjab Pasand, Arka Nishant, Chinese Pink, Hisar Mooli No. 1, Kalyanpur No. 1, Kalyani White, CO-I, Jaunpuri Mooli, Kashi Sweta, Kashi Hans	Pusa Himani, White Icicle, Rapid Red White Tipped, Scarlet Globe, Scarlet Long, Silver Queen, French breakfast, and Palam Hriday

Soil:

- **Light, friable loamy or sandy loam soil** containing high amount of humus are suitable for radish cultivation.
- Usually, **the heavy soils** produce **rough ill shaped roots with small fibrous laterals**.
- **Heavy soils** results in **mis-shapening of roots and** make it unfit for cultivation.
- The optimum soil pH is **5.5-7.0.**
- Ploughing and 3-4 planking should be done to bring soil to the fine tilth and make it fertile

Climate:

- It is predominantly a **cool season crop** and best adapted to **cool or moderate climate**.
- The optimum temperature for best flavour, texture, root growth and development is **10-15^{o}C.**
- However, different varieties respond to varied range of temperature. This is the fact that radishes are available **throughout the year by growing different varieties in different months.**
- **Indian types with greater temperature** adaptation can resist heat better than the European types.
- **The Asiatic types** are tolerant **to high temperature than European types**. During the

- hot weather, the roots become tough, pithy and pungent before reaching the edible type.
- **Long days coupled with high temperature** leads to premature bolting without adequate root formation.

Sowing time: In Northern plains, time of sowing is as under:

1. European type: September-March
2. Asiatic type: August-January
3. Mild Climate areas: Through out the year

Low Hills: August-September **Mid Hills:** July – October **High Hills:** March- August

Schedule of growing radish throughout the year in the plains

Variety	Sowing time	Harvesting time
Pusa Chetki	Early April-Mid August	Early May- September
Pusa Desi	Mid August- Mid October	Last week of September-Early December
Pusa Reshmi	Mid September- Mid November	Last October- early January
Japanese White	Mid October- Mid December	Mid December- Early March
Pusa Himani	Mid October- Mid February	Mid February- Mid April
White Icicle	Last October-end February	Late November- Early March

Seed Rate: 9-12 kg/ha

Asiatic type – 10 kg/ha European type – 12-14 kg/ha

Soil preparation: The soil should be thoroughly pulverized so as to obtain fine tilth for getting the best crop, otherwise it results in deformed roots.

Spacing: European type - 30cm × 5-10cm

Asiatic types – 45 cm × 6-8 cm

The seed should be sown at a depth of 1.5- 3cm deep on the ridges for semi-long type and 1.25cm for round cultivar sand after germination maintain the distance of 5-10cm between the plants with in row by following thinning of plants.

Manures and fertilizers:

Farmyard manure (q/ha)	**N**	**P_2O_5**	**K_2O**
		(Kg/ha)	
100	50-90	50-80	40-80

Full dose of farmyard manure, P, K and half of N should be applied at the time of transplanting. Remaining part of N should be top-dressed in two equal instalments at an interval of one month.

Interculture and weed control: Weeding and hoeing are necessary after 20-35 days of sowing in mid maturity group of Asiatic type, while temperate and early Asiatic types require weeding after 15-20 days of sowing. Earthing up is also necessary to get well developed, quality and elongated roots as generally the growing roots tend to push out of the soil. Application of Pendimethalin 1.2 kg a.i./ha or Alachlor 1.5 kg a.i./ha or Fluchloralin (Basalin)@ 0.9 kg a.i./ha or Isoproturan 1.0 kg a.i./ha or metalachlor @ 1.0 kg a.i./ha in 750 litres of water as pre-emergence is very useful for effective weed control.

Irrigation: A pre-sowing irrigation is to be given to ensure high seed germination. Irrigation frequency and amount of water required depend upon the planting season and available soil moisture. The soil should have sufficient moisture to obtain tender and attractive roots. During summer, frequent irrigation is necessary otherwise the growth will be checked and root will be pungent making them unfit for market.

Harvesting: The roots are harvested when they are of usable size and relatively young. The roots are washed and graded according to size and are tied into bunches alongwith tops for marketing. European types are ready to harvest in 25-30 days. Asiatic types require longer period *i.e.Chetki* type 30-40 days and mid maturity group 40-60 days.

Yield:

European type	50-80q/ha
Asiatic type	200 –500 q/ha

Physiological disorders:

Pore extent or pithiness: It affects the marketable value of radish roots. Pores develop due to excessive root growth. Pores development is a sign of senescence. Delay in harvesting is the main reason for this disorder. Therefore, harvesting should be done at an appropriate time.

Elongated root or Forking: It is the secondary elongating growth in the root. It is due to excessive moisture during root development in heavy soils which leads to soil compactness. Use well decomposed organic manure to overcome this problem and ensure irrigation at proper time.

Diseases and insects:

Problem	**Management**
Damping off	Seed treatment with bavistin/thiram/captan
Alternaria blight	Seed treatment with bavistin/thiram/captan
White Rust	Arka Nishant is reported to be resistant
Aphids	Use systemic pesticides

Beet Root

Botanical Name:	*Beta vulgaris sp vulgaris*.
Family:	Chenopodiaceae
Origin:	Europe, North Africa & West Asia
Varieties:	Detroit Dark Red, Crimson Globe

Roots are served as boiled, pickled or as a salad. Beet root is rich in protein, carbohydrates, Ca, P, Fe and vitamin C. Red colour of table beets is due to ***betacynin*** and yellow pigmentation is due to ***betaxanthin*.**

Climate: It is a cool season crop that can tolerate mild frosts and light freezes. It grows best in the winters in the plains of India. Optimum seed germination occurs between 65 and 75^{o}F. Beets are very sensitive to low temperature and if exposed to 4.5^{o}C – 10^{o}C for 15 days, bolting occurs even if the roots have not attained marketable size. It grows well in warm weather but the best colour, texture and quality are achieved in a cool weather condition. Excessive hot weather causes **zoning** – the appearance of alternating light and dark red concentric circles in the rot.

Sowing is taken up during September- November in north India and from July to November in South India. The seed balls are planted at a rate of 7-9 kg/ha in rows 45-60 cm apart and thinned later to an in-row spacing of 8-10 cm. Beet root has multigerm seeds in a fruit containing usually 2-6 seeds.

Thinning is an essential operation in beet cultivation because the seed ball is actually a fruit containing 2-6 seeds each of which may germinate and produce a plant. Generally, the plants emerge in groups unless segmented seed or monogerm seed is used.

Manures and fertilizers:

Farmyard manure (q/ha)	**N**	**P_2O_5**	**K_2O**
		(Kg/ha)	
100	50-90	50-80	40-80

Full dose of farmyard manure, P, K and half of N should be applied at the time of transplanting. Remaining part of N should be top-dressed in two equal instalments at an interval of one month.

Interculture and weed control: Weeding and hoeing are necessary after 20-35 days of sowing. Earthing up is also necessary to get well developed, quality and elongated roots as generally the growing roots tend to push out of the soil. Application of Pendimethalin 1.2 kg a.i./ha or Alachlor 1.5 kg a.i./ha or Fluchloralin (Basalin)@ 0.9 kg a.i./ha or Isoproturan 1.0 kg a.i./ha or metalachlor @ 1.0 kg a.i./ha in 750 litres of water as pre-emergence is very useful for effective weed control.

Irrigation: The soil should be kept sufficiently moist until emergence of seedlings. Three irrigations are sufficient when there are winter rains.

Harvesting and Yield:

The marketable maturity is just depending on the size ranging from 3-5 cm diameter. Usually, the top is removed for marketing the roots. Yield varies from **250-300 q/ha.**

Physiological Disorder

Internal black spot, a physiological disorder is associated with boron deficiency. Plant usually remains dwarf or stunted

Potato

Botanical Name: *Solanum tuberosum* L.
Family: Solanaceae
Origin: Peru and Bolivia in South America
Chromosome no(2n) : 48

Importance and Uses: Potato is the staple food of many European countries of the world and has proved its worth in feeding the nation in emergency. It is an important source of starch. It is a rich source of body building substances such as carbohydrates, vitamins (B_1, B_2, B_6 and C), minerals (Ca, P and Fe) and protein. It contains all the dietary substances except fat.

Soil: It can grow in almost all types of soil. The well drained clay loam soil is considered as ideal for its cultivation. On sandy loam soil, crop can be successfully grown provided manuring is done heavily and the crop is irrigated properly and timely. It produces best when soil reaction is 6.0-6.5

Climate: It is a cool season crop and can tolerate moderate frost. It requires 20^{o}C soil temperature for better germination. Young plant growth is good at 24^{o}C but later growth is favoured by a temperature of 18^{o}C. No tuberization takes place when the night temperature exceeds 23^{o}C. Maximum tuberization occurs at 20^{o}C. Tuber formation stops completely at about 29-30^{o}C.

Varieties: The varieties of potato are categorized into three groups on the basis of their maturity. The Central Potato Research Institute (CPRI) is the premier institute working on research on potato and is situated at Shimla in Himachal Pradesh. The varieties released from CPRI have Kufri‟ as their first name.

Early varieties: These varieties are ready for harvest in 70-80 days such as Kufri Ashoka, Kufri Chandermukhi, Kufri Jawahar, and Kufri Lauvkar.

Main season varieties: They are ready for harvest in 90-95 days. Among the white coloured varieties, Kufri Jyoti, Kufri Sutlej, Kufri Pukhraj, Kufri Megha, Kufri Badshah, Kufri Anand, Kufri Bahar, Kufri Sadabahar, Kufri Deva, Kufri Sherpa, Kufri Swarna, Kufri Shailza, Kufri Surya, Kufri Himalini, Kufri Girdhari and Kufri Khyati are important.

Late varieties: Kufri Jeevan, Kufri Neelamani, Kufri Khasigaro, Kufri Naveen

Varieties for processing: Kufri Chipsona 1, Kufri Chipsona 2, Kufri Chipsona 3, and Kufri Himsona

Soil preparation and planting: A well prepared soil provides sufficient room for the development of tubers and also helps to retain moisture. The fields are ploughed to a depth of

20-35 cm first with soil turning plough and afterwards by 4 to 5 ploughings with country plough/disc harrow. Clods must be broken to make the field well pulverized and levelled.

Planting time

Region	Season	Planting time	Harvesting time
North western hills			
Very high hills	Summer	April-May	Sept-Oct
High hills	Summer	Mid-March-April	Sept-Oct
Mid hills	Spring	Jan-Feb	May-June
North central high hills	Summer	Mid Feb-March	August-Sept.
North eastern high hills	Spring	Mid Dec-Mid Jan	July-August
Shillong hills	Summer	March-April	July-August
	Autumn	March-April	Dec-Jan
	Winter	Jan-Feb	May-June
North western plains (Jammu, Punjab, Western U.P., Haryana, Rajasthan, Plains of M.P)	Early	Mid-Sept	Mid Nov-Dec
	Autumn	Mid-Oct	Feb-March
	Spring	Jan	April
North Central Plains	Winter	Mid-Oct	Feb-March
North eastern plains			
Bihar	Winter	Oct end to 2nd week of Nov.	Jan-Feb
W.B.	Winter	Early Nov	Jan-Feb
Orissa	Winter	Early Nov	Jan-Feb
Plateau regions	*Kharif*	June-July	Sept-Oct
	Rabi	Oct-Nov	Feb-March

Seed Rate:25-35 q/ha.

Potato is traditionally propagated through tubers. The eyes on the tuber surface contain axillary buds. The tubers have a dormancy of nearly 8-10 weeks after harvesting. The axillary buds on the tubers start germinating by producing sprouts only when this dormancy is over. The sprouted tubers put up fast and vigorous growth when planted in the soil.

Breaking of Dormancy: Hill tubers can not be used for autumn crop immediately because of dormancy period of 2-3 months in tubers. This dormancy can be broken by using some chemicals; Thiourea (Sodium Potassium thiocynate) @ 1-2% solution which is used as a treatment to cut tubers for $1\text{-}1^1/_2$ hours and about 1 kg of thiourea is sufficient for 10 quintals of seed tubers. Tubers are kept in 5ppm solution of GA_3 for 10 seconds. orTreat the tuber with aqueous solution of thiourea for one hour followed by dipping in 2 ppm solution of GA for 10 seconds. The tubers from cold storage are warmed up at 60°F for 10-14 days before sowing which sprout quickly and give good germination stand.

Seed size and Spacing

Proper combination of seed size and spacing is essential to get the required number of stems per unit area. It can be obtained by planting 40-50 g tuber with 40-50 mm diameter at a spacing of 45-60 cm between rows and 20-25 cm between the tubers with in the rows. Large tubers are cut into pieces and each should contain atleast 1-2 eyes. Tuber cutting is not recommended especially for the production of a seed crop as it transmits viruses and bacteria.

Treatment of cut seed tubers

Cut tubers should be treated with 0.2% solution of Dithane Z-78 which help in improving tuber size and crop yield.The cut pieces should be allowed to heel at 18-21ºC and 85-90% relative humidity for 2-3 days which prevents rotting of cut tubers as seed (this process is known as suberization/healing).Do not treat the tuber with any of the chemicals if sprouts are coming out.

Methods of Planting: Ridge and furrow method is the most popular method carried out manually or mechanically. Care should be taken that seed tubers should not come in direct contact with fertilizers. In mechanical method, furrows are made with the help of tractor drawn 2-4 row marker cum fertilizer drills so as to apply fertilizer in one sequence. This is followed by planting of tubers with the help of 2-4 row planter-cum-ridger.

Manures and fertilizers: Apply farmyard manure **@**100q/ha at the time of field preparation. Fertilizer dose varies depending upon the fertility of the soil. However, fertilizers are applied @ 120:80:60 kg N: P_2O_5: K_2O /ha, respectively. Full dose of farmyard manure, phosphorus and potassium and half of N should be applied at the time of planting. Remaining part of N should be top dressed at the time of earthing up for effective utilization by the crop.

Interculture and weed control: Mulching helps in conserving soil moisture, reducing soil temperature and inducing quick germination. Local available materials such as pine needles or leaf litters are quite effective in controlling run off losses and conserving moisture. Weeds are effectively managed by cultural or chemical methods or combination of both methods. Weeds can be managed by hoeing and weeding when the crop is about a month old followed by earthing up. Pre-emergence application of fluchloralin@ 1 kg *a.i.* per ha or alachlor @ 1 kg *a.i.* per ha or pendimethalin @ 1.8 kg *a.i.* per ha or atrazine @ 1.0 kg *a.i.* per ha can effectively control the weeds. Post emergence application (only 5-10% plant emergence) of paraquat @ 0.36 kg *a.i.* per ha is also effective. Application of Tok-e-25 @ 2.5kg *a.i.* per ha as post emergence application at about 2-3 leaf stage is also helpful in managing the weeds.

Irrigation: Pre-planting irrigation is advantageous for uniform germination. Second irrigation is given after about a week and subsequent as and when required. Light and frequent irrigations are better than heavy and less frequent irrigations. Water is applied effectively and economically at critical stages in crop development *i.e.* stolon formation, tuber initiation and tuber development stages of the crop. Irrigation is stopped about 10 days before harvesting of crop to allow firming of tuber skin.

Harvesting: The crop is harvested when it is fully matured which can be characterized by

Yellowing of haulms and no pulling out of skin on rubbing of tubers. At the time of harvesting, field should not be too wet nor too dry. Tractor operated potato diggers are available for digging the tubers from the fields.

Yield:

Early varieties	200 q/ha
Late varieties	300 q/ha

Post harvest handling

Grading: The tubers are, generally, categorized into 3 grades according to the size and weight of the tubers.

1. **Grade A (Large):** Tuber weight more than 75g
2. **Grade B (Medium):** tuber weight between 50-75g
3. **Grade C (Small):** Tuber weight less than 50g

Value added products: Potatoes can be easily processed into dehydrated and canned products like Chips, Flakes, French fries, Finger chips, Granules, Disc, Cubes, Flour etc. Processing industry is also picking up in the recent past. It is desirable to avoid glut and consequent difficulty of storing large quantities of potatoes during period of high temperature after harvest in the plains.

PHYSIOLOGICAL DISORDERS

1. **Hollow heart:** It is caused by rapid growth of tubers. Tubers become oversized and remain empty inside leading to the formation of cavity in the centre with the death of the small area of pith cells. This results in adjacent cracks and hollowness as the centre expands during the growth of the potato. Maintain soil moisture conditions to the optimum level. Avoid over fertilization particularly nitrogen. Grow those varieties which are less prone to this defect.
2. **Black heart:** It is caused by sub-oxidation conditions under potato tuber storage as there is no aeration in the centre of the piles. Due to high temperature and excessive moisture, blackening of tissues in the centre occur. The appearance of the tuber affect the consumers otherwise there is no decay. Provide proper ventilation. Keep potato tubers in layers. Do not store tubers in the heap.
3. **Greening:** The various factors which increase the glycoalkaloid contents are mechanical injury, premature harvest, and excessive application of fertilizers or exposure of tubers to sunlight. High glycoalkaloid contents lead to solanin production which is slightly poisonous. Proper earthing up of tubers as the tuber formation takes place. Store tubers in darkness after digging up.

4. **Knobbiness**: It occurs due to uneven growth of tuber cells/tissues. Uneven watering conditions lead to an obstruction in tuber growth. Heavy irrigation after a long dry spell leads to fast growth of some cells and as a result knobs are formed. Ensure frequent and optimum irrigation.
5. **Cracking**: It is due to boron deficiency or uneven water supply. Application of Borax @ 20kg/ha. Ensure frequent and optimum irrigation.
6. **Sun scalding**: It occurs, generally, in the autumn crop when both the temperature and sunshine are high. Emergence of sprouts and leaflets is drastically affected at that time leading to tip burn. It appears when temperature is more than 30^{o}C. Water should be passed through the furrows to lower the soil temperature.
7. **Black spot:** It means the internal browning of potato tubers. It occurs in vascular tissues with in 3 days of mechanical injury. Phenols are related to black spot in potato tubers. Genetic make up of the varieties. Provide proper storage and growing conditions.
8. **Freezing injury:** It occurs due to the exposure of tubers to freezing temperature during or after harvest. It takes place at -1.5^{o}C or below temperature. There is discolouration of the tissues and affect the vascular tissues at the ring and this is called as called ring necrosis and when fine elements or cells of vascular ring are affected, then it is called as net necrosis. Freezing injury render tubers unmarketable. Tubers show more damage towards proximal end. Avoid exposure of tubers to freezing temperature during storage or harvest.
9. **Sprouting:** It is often a serious problem in storage. It can be inhibited by spraying borax or iron sulphate @ 1000-1500 ppm about 2-3 weeks before harvesting. Chemicals like Chloro IPC (N-tetra chloro isopropyl carbonate) @ 0.5% and/or nomyl/amyl alcohol @ 0.05-0.12mg/ha also help in inhibiting sprouting.

Diseases:

1. **Early Blight (***Alternaria solani):* Spots with concentric rings of brown to black colour are formed on the leaves. Heavily infected leaves fall off after drying. Spots also appear on stems.

   Management:
   - Destroy crop debris by burning.
   - Spray mancozeb or zineb @ 2g/l or 0.3% copper oxychloride at fortnight intervals 3-4 times.
   - Grow resistant varieties *e.g.* Kufri Naveen and Kufri Jeevan.

2. **Late Blight** (*Phytophthora infestans*)*:* Lower leaves are infected generally from margin or apex and having cottony growth on the lower side. Water soaked lesions appear on the margins. Tubers decay under severe infection.

   Management:
   - Use disease free certified seed.
   - Follow crop sanitation.
   - Spray Ridomil MZ 72@ 2g per litre of water.
   - Grow resistant varieties like Kufri Griraj and Kufri Himsona.

3. **Brown Rot** *(Ralstonia solanacearum):* Wilting and stunting of plants occur. The disease is soil and seed borne.

   Management:
   - Follow crop rotation with maize and wheat.
   - Use disease free tubers.

4. **Black scurf** *(Rhizoctonia solani):* Sprouts are killed before emergence. Cankers cause wilting of plants. Black crust on tubers gives ugly appearance.

   Management:

- Use disease free certified seed.
- Seed tubers should be treated with recommended fungicides.
- Follow crop rotation.

Other common diseases

Disease	**Management**
Common Scab	Seed treatment with 0.5% Agalol-3 for 30 minutes. Grow scab resistant varieties.
Verticillium Wilt (Soil borne)	Use disease-free seeds. Follow long crop rotations.
Charcoal Rot	Surface disinfection with some fungicides.
Wart disease	Soil sterilization by steam, mercuric chloride, copper sulphate or 5% formalin. Grow resistant varieties–Kufri Jyoti, Kufri Sherpa and Kufri Kanchan
Black Leg and Soft Rot	Use disease-free seeds. Long crop rotations.
Bacterial Soft Rot	Remove diseased tubers from healthy ones before storage. Treat seed tubers with 0.5% solution of Agalol-3/Aretan-6/Emisan-6 before storage for 30 minutes
Viral diseases	
Latent Mosaic	Virus is mechanically transmitted (PVX, PVS or PVM). Use disease free seeds. Local quarantine
Mild Mosaic	Use disease free seeds. Grow resistant varieties.
Rugose or Vein-banding Mosaic	Use disease free seeds. Grow resistant varieties.
Purple top leaf roll	It is transmitted by leaf hopper. Use of certified disease-free seed. Control insect vectors by spraying systemic pesticides

Rot knot nematode Keep land fallow for a quite long time. Follow crop rotation. Nematicides like DD @ 225 l/ha should be injected in the soil. Place between the rows EDB @ 175 kg/ha 2 weeks before planting.

Insect-pests:

1. Cut worm (*Agrotis ipsilon):* Creamy white, dome-shaped Eggs, laid singly on lower surface of the leaves. Newly emerged young larva is yellow in colour. Dark brown pupae are found in earthen cells lying underground in the potato fields. Adult moth is dark with some grayish patches on the back and dark streaks on the forewings.

Symptoms of damage

- Young larvae feed on the epidermis of the leaves.
- Older larvae come out at night and feed young plants by cutting their stems
- They also damage the tubers by eating away part of them.

Management

- Flood the infested fields.
- Hand pick and destroy the larvae during morning and evening hours on cracks and crevices in the fieldPlough the soil during summer months to expose larvae and pupae to avian predators Set up light trap @ 1/ ha, Pheromone traps @ 10/ ha to attract male moths. Spray insecticides or chlorpyriphos 20EC @ 1 lit/ha or neem oil 3% @ 5.0ml/ lit.

2. Potato tuber moth (*Phthorimaea operculella):* Eggs are laid singly on the ventral surface of foliage and exposed tubers. Larva is yellow coloured and caterpillar has dark brown head. Pupation occurs within a cocoon among the trash and clods of the earth in the field. Adult is small narrow winged moth with greyish brown forewings and hind wings are dirty white.

Symptoms of damage

It is a pest of field and storage

Larva tunnels into foliage, tubers Galleries are formed near tuber eyes

Management

- Select healthy tubers
- Avoid shallow planting of tubers. Plant the tubers at depth of 10 - 15 cm. Install pheromone traps@ 15 in numbers/ha.
- Collect and destroy all the infested tubers from the field
- Do earthing up at 60 days after planting to avoid egg laying on the exposed tubers Spray NSKE @ 5% or quinalphos 25 EC @ 2ml/lit of water to manage foliar damage Spray *Bacillus thuringiensis* @ 1 kg /ha at 10 days interval
- Store the tubers under 3 cm thick layer of sand Fumigate the stores with carbon disulphide

Sweet Potato

Botanical name: *Ipomoea batatas*
Family: *Convolvulaceae.*
Chromosome no (2n):*90*
Origin: *Tropical America*

It is important tuber crop of tropical and subtropical climate and belongs to family ***Convolvulaceae***. Tubers are generally used for human consumption. It is used in preparation of alcohol and starch. It contains 16% starch & 4% sugar i.e. 20% alcohol producing material.

Climate: It requires a long, warm growing period both days and nights (frost free 4 months) and plenty of sunshine and moderate rainfall. It is the most draught resistant vegetable. The Optimum temperature requires for its better growth and development is 21-27 ^{o}C. The optimum soil temperature is 20-30 ^{o}C, above this the vines grow at the expense of tuber formation.

Soil: Well drained sandy loam rich in organic matter is considered the best. Roots tend to be long and slender on deep soil, so deep ploughing is not advocated. Optimum pH is 5.8-6.7 (Slightly to moderately acidic).

Varieties: Varieties are grouped according to their colour:

1. White

1. Pusa suffaid
2. Pusa Lal (skin red, flesh white)
3. Pusa Sunchari (flesh orange)
4. Jawahar Sakarkand-115 (early var.)
5. Jawahar Sakarkand-145
6. Rajendra Sakarkand-35
7. Rajendra Sakarkand-5
8. Rajendra Sakarkand-43
9. Sree Nandani

2. Golden

3. Orange to Red

10. Sree Vardhani
11. Kal Megh
12. OP-23 (Kiran)
13. Cross-4
14. H-41
15. H-42
16. H-268 (Varsha)
17. Konkan Ashwini

Propagation: It is grown from sprouts or draws produced from tubers and from vine cuttings. The vine cuttings are generally used as a propagation material in India. The cuttings are obtained from previous crop or sometimes by sprouts obtained from tubers. It is desirable to propagate sweet potato in the nursery to obtain good yield. 100 kg tubers are sufficient to raise the cuttings for one hectare. Selected tubers (125-150 g) are planted at a spacing of 45 x 30 cm & 5-6 cm deep that covers an area of 100 m^2. After 40-45 days, cut the sprouts having 20-30 cm length & raise in the secondary (another) nursery for further growth which covers an area of around 500 m^2. Ultimately when the nursery vines reach a sufficient length, cuttings are made & planted at about 60 x 30 cm spacing. 40000-50000 cuttings are required to plant one hectare. The length of cutting depends upon the length of internode i.e. at least 4 nodes/cutting. The cuttings from the upper portion of vine should be preferred for getting more tuberous roots. General practice is to bury the two middle nodes & expose the two extreme ones.

Planting time:

- In northern India, the vine cuttings are planted during June-July.
- Cuttings for rabi season are planted in Oct-Nov. in south India and Central India (MP, AP, Maharashtra & Gujrat).

Manures and Fertilizers: Farmyard manure -100-150 q/ha. 90: 60: 90 kg N: P_2O_5 and K_2O per ha. Half of dose nitrogenous fertilizer is applied as basal and half dose 40 days after planting.

Interculture and Weed Control: In the early stages the field should be inter-cultured often to keep down the weeds. It establishes within 10 days of planting and starts growing vigorously after 3 weeks when it is given the first weeding. Two manual weedings at 20 and 45 days after planting are sufficient to keep the weeds under control. Earthing up is done at second weeding to prevent exposure of roots (particularly during rainy season). Incorporation of EPTC (Eptam) @ 1-2 kg/ha) or Fluchloralin @ 1.0 kg/ha) in the soil as pre-planting to control the weeds is effective. Also, application of EPCC @ 1.5-3.0 kg/ha as pre-plant soil incorporation and chloramban @ 3.0 kg/ha after planting control the weeds.

Irrigation: Planting should be done when monsoon rains are received or at the time of drizzling. Rainy season crop generally does not require irrigation except long dry spell. In rabi season, apply irrigation at 8-10 days interval depending upon the type of soil to ensure better root development and yield. Newly planted cuttings need watering frequently for 1-3 weeks. Once new growth begins watering can be reduced to that needed when visible wilting is seen. Very little water will be necessary the 4th and 5th month.

Turning of vines: The plant has a tendency to develop roots from all the nodes which come in contact of soil. So, during early stages, it is essential to lift and turn the vines to disconnect then from soil to increase the availability of nutrients to the main root. It is important to avoid turning of vines at later stages since it results in uprooting of developing tubers.

Harvesting: Depending upon variety , the crop is ready to harvest in 120-180 days after planting. Harvesting is done when the leaves turn yellow and start to shed. The surface of mature tuber is cut and exposed to the air, dries up soon, while the immature ones remain moist and turn dark in colour. Irrigate the field 4-6 days before harvesting to facilitate digging of tubers. After harvesting, keep the tubers at 29-40^{o}C temperature & 80-90% RH for 5-7 days for healing the wounds & to increase the storage life.

Yield: 100 q/ha in rainfed conditions, It is possible to get yield as high as 300-400 q/ha under better growing conditions.

Diseases Management

1. Stem Rot or Wilt: Dip cutting in 0.2% solution of Aretan or Agallol before planting.
2. Black rot: Dip cutting in 0.2% solution of Aretan or Agallol before planting.

Insect Pests

1. Sweet potato weevil: Spray malathion/carbaryl.
2. Leaf eating caterpillar: Spray Carbaryl (0.01%)

Spinach
Botanical Name: *Spinacea oleracea* L.
Family: Umbelliferae
Chromosome number 2n=12
Origin: Central Asia

Spinach beet or vilayati palak is an important leafy vegetable commercially grown in Himachal Pradesh .Among vegetable crops, it ranks second only to broccoli in total nutrient concentration. Though, it is rich in Ca, but the element is said to be unavailable owing to the fact that it unites with oxalic acid to form calcium oxalate.

Importance and uses: Normally consumed as cooked vegetable and sometimes as a salad in company with lettuce and other vegetables. It is not commercially grown in India except hilly areas. It ranks next to broccoli in total nutrient concentration among vegetable crops. Rich source of vitamin A, Fe, Ca and also contain appreciable quantity of ascorbic acid, riboflavin and small quantity of thiamine. Ca is unavailable since it unites with oxalic acid to form calcium oxalate.

Plant growth and development: Spinach is an annual. Plants are usually dioecious. Some monoecious plants may develop rarely in certain cultivars. Dioecious types produces two different kinds of male plants:

1. **Extreme males:** small with very little vegetative development and tend to bolt quickly.
2. **Vegetative males and females:** slower to flower and produces considerably more foliage, making them the preferred plants type for commercial cultivation.

Eliminate the extreme males from commercial strains by selection.
Cultivars: These are classified in two groups;
On the basis of seed: Further in 2 groups :a) Prickly seeded b) Round seeded
On the basis of leaf: a) Smooth leaved eg Early Smooth Leaf b) Savoy leaved: Virginia Savoy

Soil: This crop is susceptible to injury by high acidity
Climate: It is a hardy, cool season crop that does best at temperature of 60-65^{o}F. Withstands hard frost and temperature as low as 20^{o}F, but the growth is depressed below 35^{o}F. The plant is very intolerant of warm temperature above 77^{o}F which in combination with long days causes plants to bolt. Seed germination at 10-15.5^{o}C (50-60^{o}F) and decreases at higher temperature
Sowing time: North Indian Plains September-October

Himachal Pradesh

Low Hills	Mid Hills	High Hills
October-November	September-October	March- July

Seed Rate: 30-35 kg/ha (37-45 kg/ha)
Spacing: 30cm X 5-10cm (thinning is done to maintain the spacing within the rows)

Harvesting: The crop will be ready for harvest about 4 weeks after sowing. It gives about 3-4 cuttings in the season. Harvesting by hand gave higher yield than mowing. A plant with seed stalk is considered unmarketable.

Yield:100 q/ha

Diseases: Damping off, Leaf spot (spray 0.2% Blitox at 15 days interval), White rust, Downy mildew: (0.2% Dithane-M-45)

Insects: Aphids and Catterpiller

Beet leaf
Botanical name: ***Beta vulgaris var. bengalensis***
Family: Chenopdiaceae
2n-18
Origin: Indo-China
Varieties: Pusa Bharti, All Green, Jobner green

Sowing time: In plains of India can be grown 3 times in a year i.e. Early spring, In the beginning of rainy season and as main crop during Sept.- Nov.Throughout the year in places with mild climate.

- The seed rate for raising crop in one hectare area is 25-30 kg/ha.
- The crop is planted at a spacing of 30cm × 5-10cm (thinning is done to maintain the spacing within the rows).
- Farmyard manure @ 100q/ha can be added at the time of field preparation.
- The recommended dose of fertilizer is 40-70:30-50:30-50 kg NPK/ha, respectively depending upon the nutrient status of the soil.
- Full dose of phosphorus, potassium and half of N should be applied at the time of sowing. Remaining part of N should be top dressed in two equal installments at an interval of one month.
- To keep the fields weed free and to loosen the soil for proper aeration, 2-3 hoeings-cum-weedings are required.
- A pre-sowing irrigation is done to help the seeds to absorb moisture and germinate properly.

- The spring summer crop need frequent irrigation at 6-7 days interval whereas autumn winter crop requires irrigation at about 10-15 days interval.
- The crop is ready for harvesting in about 3-4 weeks after sowing. Subsequent cuttings are done at 15-20 days interval.
- Only well grown green succulent and tender leaves should be trimmed.
- Winter crop gives more cuttings than spring-summer crop.
- The average yield is 150-200q/ha

Difference between beet leaf and spinach

Beet leaf	Spinach
Beta vulgaris var. *bengalensis.*	*Spinacea oleracea.*
Chr. No. 2n=18.	Chr. No. 2n=18.
Leaves with entire margins.	Leaves with lobed leaf margin.
Produces bisexual flowers.	Produces staminate/ pistillate and/or hermaphrodite flowers.
Tolerates high temperature and grows well in hot weather.	Purely a cool season crop and cannot tolerate high temperature. In warm season and long days, it quickly tends to flower.

Amaranthus

It is a common leafy vegetable grown during summer and rainy season. The important characteristics are rapid growth, quick rejuvenation after each harvest, high yielding capacity and high nutritive value. There are 8 cultivated species of amaranthus, of which only two are most common belong to family Amaranthaceae
Amaranthus blitum**:** *chhoti chaulai*
Amaranthus tricolor**:** *Badi chaulai*

Varieties: The varieties recommended for cultivation are Pusa Chhoti Chaulai, Pusa Badi Chaulai, Pusa Kirti (most suitable for summer), Pusa Kiran (for rainy season), Pusa Lal Chaulai (red pigmented variety), Arka Suguna, Arka Arunima

Climate: Warm humid climate is congenial. It responds well to full sunlight.Sandy loam soils with slight acidic pH are preferred. It is susceptible to water logging.

Sowing: Direct sowing is followed in north India for which 2.0-2.5 kg seed/ha is sufficient. Transplanting is done in Kerala and Tamil Nadu for which 1.0-1.5 kg seed is required to raise seedlings for one hectare area. It can be sown throughout the year except May-June in Northern plains. It should be planted at a spacing of 20cm × 15 cm

Irrigation: It requires plenty of water for its fast growth and high yield. Frequent irrigation may therefore be applied at 5-7 days interval depending on the soil, weather and season. Proper drainage must be provided during rainy season.

Weeding: Two to three weedings or hoeings are sufficient to keep the weeds under control and to ensure good aeration.

Harvesting: First cutting can be taken about 25-30 days after sowing and subsequent harvestings can be done at 8-10 days. Normally 6-8 cuttings are can be taken till the crop starts flowering or becomes unfit for consumption.

Yield : 60-80 q/ha.

Perennial vegetables

Moringa

Botanical Name : ***Moringa oleifera***
Family: Moringaceae
Origin: India

In India, it is grown for its tender pods and also for its leaves and flowers. The pods of moringa are used for preparation of many cuisines in South India and are valued for distinct flavour. It has a lot of medicinal value. It is fast growing and drought tolerant crop which can be grown under varied agro-climatic conditions.The cultivation of moringa in India is done mainly in the southern states of Tamil Nadu, Karnataka, Kerala, and Andhra Pradesh.

Varieties: There are two types of moringa cultivated in India

Perennial: Jaffna (yazhpanam), Chavakacheri murungai, Chemmurungai, Palmurungai and Puna murungai

Annual moringa: PKM-1, PKM-2, GKVK-1, GKVK-2, GKVK-3, Dhanaraj

Climate: It can grow from sea level to 1800 amsl. Dry, warm and semi-arid conditions are congenial for its growth. It performs best at 26-36^{0}C. It is highly susceptible to frost and high temperature exceeding 40^{0}C.

Soil: Sandy loam soils are most suitable for its

cultivation with pH around 6.5 and good drainage. Water logging and heavy clay soils are not suitable.

Sowing: Perennial moringa is propagated by stem cuttings (limb cutting). Limb cuttings 100-150cm in length with a diameter of 14-16 cm are planted *in situ* during the rainy season. Elite trees are cut down, leaving a stump with a 90cm head from which 2 to 3 branches are allowed to grow. From these shoots, cuttings 100 cm long and 4 to 5 cm in diameter are selected and used as planting material. The limb cuttings are planted in pits of 60×60×60 cm at a spacing of 5x5 m, during the months of June to August.

Annual moringa is a transplanted crop. It is raised through seed. Seed rate is 600g/ha is sown in nursery. Seedlings of 15-20 cm height are ready for planting in 6-8 weeks of sowing. The seedlings are transplanted in pits of 45×45×45cm at a spacing of 2.5×2.5 m, during the months of June to July, giving a plant population of 1600 plants/ha. The seeds of annual moringa may be directly dibbled in the pit to ensure accelerated and faster growth of the seedlings. The best suited season for sowing the seeds is September under Southern Indian conditions.

Manures and fertilizers: Moringa trees are generally grown successfully without fertilizers. FYM 12-15t/ha (8-10 kg/plant), crop requires 44 : 16 : 30 g NPK/ tree at the time of pinching (75 days after sowing). Nitrogen @ 44g / tree must be top dressed at first flowering (150-160 days after sowing) stage.

After care: Pinching the terminal bud on the central leader stem is necessary when it attains a height of 75cm (two months after sowing). This promotes the growth of many lateral branches and reduces the height of the tree. In addition, pinching reduces the damage due to heavy winds and makes harvesting much easier.

Irrigation: It is hardy and drought tolerant crop. Irrigation is required only in hot summers.

Ratooning/Pollarding: Cutting down the plant to a height of one meter from the ground level can be practised after one year to allow ratooning of the crop. Pollarding or pruning following harvesting is recommended to promote branching, increased pod production and easy harvesting. This is done during winters (November-December) when no fruit production is seen and start bearing four or five months after ratooning. Crop can be retained for 3-4 years with regular pruning once in a year. During each ratooning operation, the plants are supplied with the recommended level of N, P and K nutrients along with 20-35 kg of FYM. Perennial types are also pollarded back to a height of 0.3-0.45m from ground level during October-November, followed by manuring with organic matter (25kg) and the recommended input of fertilizers.

Harvesting and yield: The pods are harvested mainly between March and June. A second crop is normally harvested from September to October. Perennial types raised through cuttings take nearly a year to bear fruit. In general, the yield during the first two years of fruit-bearing is low (80-90fruit/year) and gradually increases to 500-600 fruit/tree/ year by fourth to fifth years. The annual moringa tree bears 250-400 fruit depending on the type.

Insect-pests and diseases: Fruit fly *Gitona distigmata* is a major pest while no major disease in India has been reported

Ivy gourd (*Coccinia grandis*)

- It is grown for its young and tender green fruits which are used as salad or cooked.It requires warm and humid climate with an ideal temperature of 20-30^{0}C.
- It produces fruits through out the year in South India but plants remain dormant during winter in Northern India.It can be grown on well drained light, medium (loam).
- Important varieties are Indira Kundru 5 and Indira Kundru 35
- It is propagated by stem cutting. Stem cutting should be 12-15 cm long with pencil thickness having 5-6 leaves.
- It is planted in basins which are 60 cm in diameter and are dug 3 m apart. Add 5 kg farmyard manure in each pit.
- Planting is done in June-July or February- March
- Plant population should have atleast 10% male plants.
- Vines are often trained on bower or bamboo structures.
- The recommended dose of fertilizer is 60:40:40 kg NPK/ha, respectively. Half dose of N plus full P and K are applied at planting time and rest of N in four equal splits.
- It requires good quantity of water but cannot withstand water logging conditions.
- Pruning of vines is most important. Repeated pruning of vines must be done when the plant seems to be weak and leaves turn yellow *i.e.* after every 3 to 4 months to maximise yield (newly developing vines produce more flowers and yield).
- Flowering starts after 50-60 days of planting and average yield is 10-15 t/ha.
- Harvesting of fruits is determined by change of colour from dark green to bright or light green.

FENNEL

Botanical name of fennel is *Foeniculum vulgare*. It is a stout and aromatic spice crop which is commercially cultivated as an annual herb. In Hindi, fennel is known as 'saunf' and in Tamil it is known as 'perungeerakam'. Major production centers of fennel in India are Rajasthan, Andhra Pradesh, Punjab, Madhya Pradesh, Uttar Pradesh, Gujarat, Karnataka, and Haryana.

Essential oil extracted from fennel seeds is used for manufacturing cordials and as a fragrant agent in toiletries such as soaps and shampoos. Fennel oil is extensively used as a flavouring agent in baking and confectionary industries. Fennel water is commonly given to infants as medicine. The root of fennel plants may be used as a purgative. Fennel seeds are used as stimulant and as a carminative. Fennel is extensively used in cure of colic pains also. Fennel seeds alone or in combination with sugar are used as a mouth freshener in India.

Climatic

Cool and dry climate is best for the cultivation of fennel crop. Dry and cool weather during the seed set increases seed yield as well as the quality of the produce.

Soil

Fennel can be cultivated in all types of soils that are rich in organic matter. Shallow sandy soils are not suited for fennel cultivation. Best soils for fennel cultivation are black cotton soil and loamy soil containing lime. Proper drainage is also an important requisite for commercial cultivation of fennel crop.

Commercial Varieties

RF 101

Tall, erect and with stout stem; long, and bold grains; matures in 150–160 days; average yield is 15.5 q/ha.

RF 125

Short plants with compact umbels; long, bold grains; matures in 110–130 days; yield is 17.3 q/ha of seed

RF 35

Tall, spreading plats with medium-sized, hairless and green seeds; tolerant to sugary disease, leaf-spot and leaf-blight; matures in 225 days; average yield of 12.8 q/ha.

Gujarat Fennel 1

Tall and bushy plants with oblong, medium-bold and dark green seeds; tolerant to sugary disease and leaf-spot; matures in 225 days; average yield is 16.5 q/ha; suitable for early-sowing; tolerant to drought.

Cultivation Practices

Fennel seeds can be directly sown in the main field or seedlings can be raised in nursery beds and later transplanted in the main field.

Sowing

Ideal sowing time for fennel is Mid-September to mid-October. Delay in sowing reduces the yield. Seed rate required for direct sowing is 10–12 kg/ha. Sowing should be done deep in rows with spacing of 45–60cm apart. The field is irrigated after sowing.

Transplanting

Seedlings are raised during June or July on well-prepared nursery beds. Afterwards, 7–8 weeks old seedlings are transplanted in the field in August.

Fertilization Schedule

At the time of field preparation FYM (farmyard manure) is added @ 10–15 tons/ha. Afterwards, apply 90kg N/ha in three equal splits– first as basal dose along with 40kg/ha P_2O_5, second and third applications at 30 and 60 days after sowing.

Weed control

Weed infestation is a serious problem in commercial cultivation of fennel crop. First hoeing and weeding is recommended at 30 days after sowing. Both mechanical and chemical control of weeds can be practiced. If herbicides are used for weed control, Pendimethalin is most effective. Pre-emergence application of Pendimethalin @1.0kg/ ha supplemented with one hand-weeding 50 days after sowing controls weeds effectively.

Irrigation

First irrigation is done soon after seed sowing and thereafter one or two light irrigations are required until seed germination. Afterwards, the crop is irrigated at an interval of 15–25 days. Water stress must be avoided during flowering and seed formation as water stress during this phase may adversely affect the seed formation and grain yield.

Harvesting

Fennel matures in 170–180 days. Harvesting is done by plucking the umbels when seeds are fully developed and mature but still green. Harvesting duration lasts for a month with plucking being done twice or thrice at 10 days intervals.

Yield

On an average, fennel yields 9–10q/ha.

PESTS

Aphids:

Spray 1.6 ml Monocrotophos or 2 ml Dimethoate per liter of water.

Caterpillars (Helicoverpa sp. and Spodoptera sp.)

Spray 1.6 ml Monocrotophos or 2 ml Quinolphos or 2.5 ml of Chloripyriphos in one liter of water twice in 10-15 days interval.

DISEASES

Damping off

Drenching with Copper oxy chloride @ 3g/lt of water.

Powdery mildew

Spray 3 gm Wettable sulphur or Kerathane 1 ml or 1 gm Carbendazim per liter.

Blight :

Spray Mancozeb @ 2.5 g/l.

CUMIN

Cuminum cyminum.

In India, it is known as 'Jeera' or 'Zeera' in Hindi. It is an important spice used in Indian kitchens for flavoring various food preparations. The flavor of cumin seeds is due to the presence of a volatile oil. In indigenous varieties of cumin, this volatile oil is present up to 2.5–3.5%. Cumin seeds are extensively used in various ayurvedic medicines also especially for the conditions like obesity, stomach pain and dyspesia. Nutritional value of cumin seeds is as follows: 17.7% protein, 23.8% fat, 35.5% carbohydrate and 7.7% minerals. In India, cumin is mainly cultivated in western Indian states like Rajasthan and Gujarat.

Climatic Requirements

Moderate sub-tropical climate is ideal for cumin cultivation. Moderately cool and dry climate is best. Cumin crop does not stand high humidity and heavy rainfalls.

Soil Requirements

Well-drained, loamy soils that are rich in organic matter are best for cumin cultivation. For commercial cultivation of cumin, a field in which cumin crop has not been taken up at least during last 3 years should be selected.

Commercial Varieties

RZ 19

A tall variety of cumin with erect stems, pink flowers and bold pubescent grains; tolerant to wilt as well as blight; matures in 120–140 days with an average yield of 5.6 q/ha.

RZ 209

An erect-growing variety of cumin with pink flowers and bold, grey, pubescent grains, resistant to wilt and blight diseases; matures in 140–150 days with an average yield of 6.5 q/ha.

Fertilizer Schedule

10–15 tons of farmyard manure/ha is added at the time of land preparation. Afterwards, a dose of 20kg P2O5/ha should be applied at the time of sowing, 30 kg N/ha may be applied as top P2O5 dressing either in single dose 30 days after sowing or in 2 equal splits.

Weed control

Weed is a severe problem in cumin cultivation. Weeding at 30 and 60 days after sowing is necessary. Thinning should also be done during first hoeing and weeding to remove the excess plants. Chemical weed control by the application of herbicides may also be practiced. Application of pre-emergent Terbutryn or Oxcadiazone @ 0.5–1.0kg/ha or pre-plant Fluchloralin or pre-emergent Penimethalin @ 1.0kg/ha is very effective.

Irrigation

A light irrigation is done soon after sowing and thereafter second irrigation should be applied 8–10 days after first irrigation. Depending upon the soil type and climatic conditions the subsequent irrigations may be given at 15–25 intervals. Last heavy irrigation must be given at the time of seed formation. Avoid irrigation at the time of active seed filling because it increases the incidence of powdery mildew, blight and aphid infestation.

Harvesting

Field is cleaned and wilt affected plants are uprooted before harvesting. Harvesting is done by cutting the plants with sickle. The plants are stacked on clean threshing floor for sun-drying. After drying, seeds are separated by light beating with sticks by winnowing.

Yield

An average yield of 5 q/ha is obtained under proper management. Improved varieties may yield up to 7 – 8 Q/ha.

Coriander

Coriander *(Coriandrum sativum L.)* is an annual herb, mainly cultivated for its fruits as well as for the tender green leaves. It is native of the Mediterranean region. In India, it is grown in Andhra Pradesh, Tamil Nadu, Karnataka, Rajasthan and Madhya Pradesh. Major portion is though consumed locally; a small quantity is being exported now.The fruits have a fragrant odour and pleasant aromatic taste. The odour and taste are due to the essential oil content, which varies from 0.1 to 1.0 % in the dry seeds. These essential oils are used for flavouring liquors, coca preparations in confectionary and also to mask the offensive odours in pharmaceutical preparations.

The dried ground fruits are the major ingredients of the curry powder. The whole fruits are also used to flavour foods like pickles, sauces and confectionary. The young plants as well as the leaves are used in the preparation of chutney and are also used as seasonings in curries, soups, sauces and chutneys. It has medicinal properties too. Fruits are said to have carminative, diuretic, tonic, stomachic and aphrodisiac properties.

Coriander belongs to the family Apiaceae. It is a smooth, erect annual herb 30 to 70 cm high, lower leaves broad with crenately lobed margins, upper leaves finely cut with lineary lobes, flowers small, white or pink in compound terminal umbels, fruits – schizocarp, globular, yellow-brown, ribbed, 2 seeds, ripe seeds are aromatic

Climate and Soil

It is a tropical crop and can be grown throughout the year (except very hot season i.e. March-May) for leaf purpose, but for higher grain yield it has to be grown in specific season. A dry and cold weather free from frost especially during flowering and fruit setting stage favours good grain production. Cloudy weather during flowering and fruiting stage favours pest and disease incidences. Heavy rain affects the crop. As an irrigated crop, it can be cultivated on almost all types of soils provided sufficient organic matter is applied. Black cotton soils with high retentivity of moisture is best under rainfed conditions.For raising a rainfed crop, the land is ploughed 3 to 4 times following rains and field must be planted immediately to break the clods and to avoid soil moisture. For irrigated crop the land is ploughed twice or thrice and beds and channels are formed.

Sowing

In the North and Central parts of India and Andhra Pradesh, it is mostly grown as a Rabi season crop and hence sowing is done between middle of October and middle of November. In certain pockets of the above area, late kharif crop is sometimes sown in August-September. In Tamil Nadu, as an irrigated crop, coriander is raised in June-July and September-October. A seed rate of 10 to 15 kg per hectare is required. Seeds stored for 15 to 30 days record better and early germination than freshly harvested seeds. Seeds soaked in water for 12 to 24 hours before sowing also enhances better germination. The seeds are split into two halves by rubbing and generally done in rows spaced at 30 to 40 cm apart with 15 cm between hills. Soil depth should not exceed 3.0 cm. Three to five seeds are sown in seeds are broadcast and covered with country plough. Germination takes place in 10 to 15 days.

Manures and fertilizers: 10 tonnes of FYM is applied at the time of preparation.30 kg of nitrogen, 30 kg P205AND 20 Kg of MOP is recommended.

Irrigation

First irrigation is given 3 days after sowing and thereafter at 10 to 15 days interval depending upon the soil moisture available in the soil.

Interculturing

The first hoeing and weeding and weeding are given in about 30 days. Thinning the plants is also attended simultaneously, leaving only two plants per hill. Depending upon the growth one or two more weeding are done.

Harvesting and yield

The crop will be ready for harvest in about 90 to 110 days depending upon the varieties and growing season. Harvesting has to be done when the fruits are fully ripe and start changing from green to brown colour. Delaying of the harvest should be avoided lest shattering during harvest and splitting of the fruits in subsequent processing operations. The plants are cut or pulled and poled into small stacks in the field to beating with sticks or rubbing with hands. The produce is winnowed, cleaned and dried in partial shade. After drying, the produce is stored in gunny bags lined with paper. The rainfed crop yields on an average 400 to 500 kg/ha and the irrigated crop 600 to 1200kg/ha.

Plant protection

At the seedling stage coriander is often attacked by the leaf eating caterpillars and semi-loopers and at the flowering stage by the aphids. Spraying the crop with methyl demeton (0.05%) is recommended to control the aphids but a flowering stage

Powdery mildew (*Erysiphe polygoni*) is a serious disease, which ruin the crop if allowed unchecked in the initial stage itself. Spraying wettable sulphur 0.25% or 0.2% solution of Karathane twice at 10 to 15 days interval is recommended.

Black Pepper
Botanical name: *Piper nigrum*
Useful plant part: Fruits / Berry

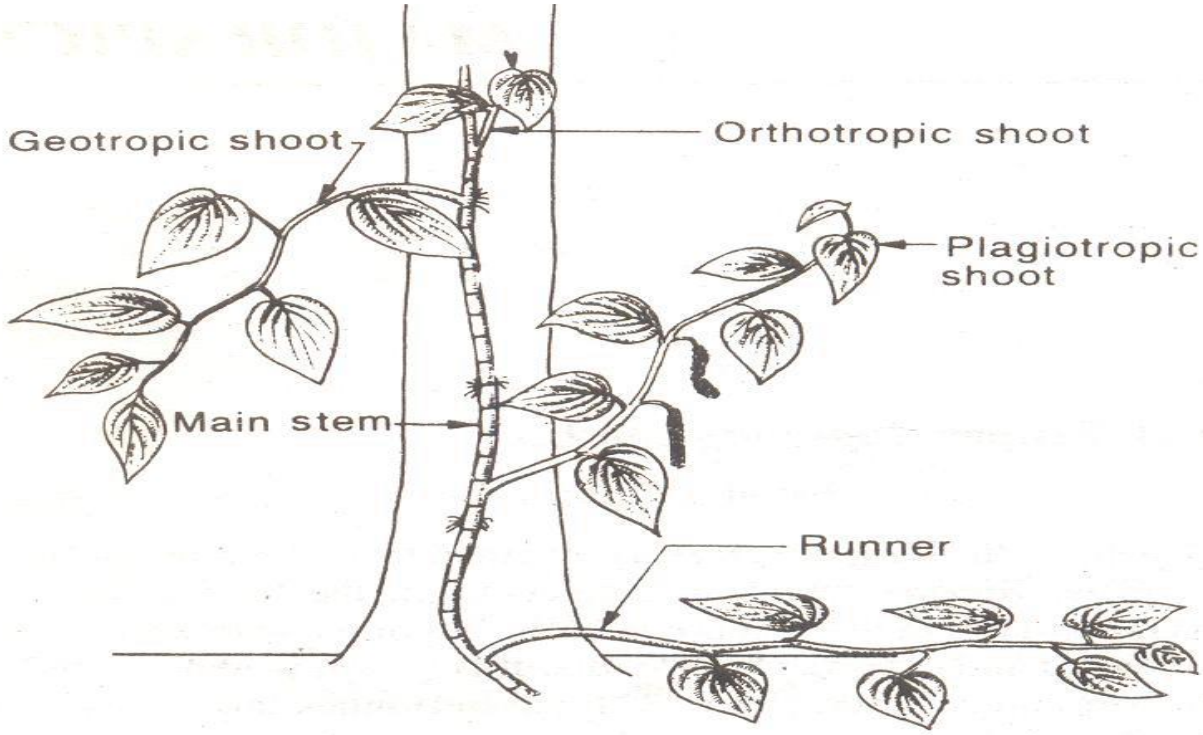
Introduction: Pepper is the most important of all spices and popularly known as the "*king of spices'*. Black pepper is a dried mature fruit of perennial ever green climbing woody vine. It is one of the most important earliest known spices produced and exported from India. It is the most valuable and important foreign exchange earner among the important spices earning nearly 50% of the total export earnings from all the spices. Because of its importance in the spices and unique position in trade and large share in export earnings, it is popularly referred as ***king of spices*** **and** ***black gold*** in trade.

Uses: Black pepper is used for a variety of purposes. One of the principal values of Pepper is its ability to enhance the seasoning of dishes. It is valued for its characteristic aroma, hot pungent and biting taste and is mainly used for flavouring and seasoning. It is largely used as preservative by meat packers and in canning, pickling and baking confectionery and preparation of beverages. Oil and black pepper is a valuable adjunct in flavouring of certain beverages and liquors. The oil absorbed in soaps and in perfumes. It is considered as a powerful remedy for various disorders such as dyspepsia, malaria, and delirium treatments. The aromatic odour of pepper is due to an essential oil, while the pungency is due to oleoresin. The Egyptians used it for embalming. The Asians are said to have used it as an aphrodisiac. It is extensively used in Ayurvedic medicines and pharmacological studies. Alcoholic extract of black pepper was found to be highly toxic to several weevils on stored food products. Pepper extract acts as an effective repellent. The alkaloid *'piperine'* is considered to be the major constituent responsible for the bitter taste of black pepper, it is absent in the leaves and stems. *Piperine* has insecticidal effect on its own.

Area and production: Outside India it is grown in Srilanka, Malaysia, Indonesia, Brazil Mexico, China, Thailand and Madagscar. India accounts for 54% of the total area under pepper in the world but its share of production is only 26.6% whereas the other countries like Brazil, Indonesia, Malaysia accounts for lesser percentage of area but with more share in the total production due to their higher productivity. In India pepper cultivation is confined to southern states only. It is grown mainly in Kerala (96% area), Karnataka, Tamil Nadu and Pondicherry. Since, ancient times pepper is exported from India. On an average of 85% of the pepper produced in the country is exported to USA, Canada and Italy. Till 19th century India enjoyed monopolistic position in the world market. However now India lost its top position due to low productivity, poor yield and raise of Indonesia and Malaysia countries.

Botany and taxonomy
Family: Piperaceae
Genus: *Piper*
Species: *nigrum* Linn.
Chromosome No. : 2n=2x=52
Origin: western Ghats of South India (Malabar)

Botany: Black Pepper is an evergreen perennial woody climber reaching to a height of 10 m or more. It has extensive but shallow root system. The vines branch horizontally from the nodes but do not grow longer. Based on the growth habits, morphological characters and biological functions, five *distinct types* of stem portions can be defined in the shoot system of a pepper vine.



Branching in Pepper

1. Main stem: It originates from a seed or from a stem cutting. It climbs on a support with the aid of aerial or adventitious roots.

2. **Runner shoots:** They are produced from the basal portion of the main stem, growing at right angle to the main stem, usually restricted up to 50 cm from the ground.

3. Fruiting branches (plagiotropics): They are produced from the nodes of the main stem and they grow laterally more or less at right angles to the main stem, bearing the spikes.

4. Topshoots (orthotropics): Vegetative shoots which arise on the top portion of the main shoots. It gives a bushy appearance with stouter, thicker internodes and with large number of adventitious roots at the nodes. They are used for the *propagation.*

5. Hanging shoots (geo tropics): In a fully grown vine, some of the plagiotropics at the top portions are seen to give rise to special type of shoots which hang down and grow geotropically. Leaves are broadly lanceolate, alternate, simple, dark green and shiny above, pale green and gland dotted under neath. Size and shape vary according to the variety. The inflorescence is a *catkin*. Born on opposite side to the leaves on plagiotropic branches, 5-15 cm long, bearing 50-150 minute flowers. The flowers are monoecious or dioecious or hermaphrodite (bisexual) forms occurs in different varieties.

High yielding forms should have more percentage of bisexual flowers and in cultivated varieties these plants will be more than 80%. Male flowers are very few 1-19% in different varieties. The fruit is a single seeded berry, sessile, small globose or oval. It has thin pulpy pericarp around the seed. It takes approximately 6 months to mature after flowering. Each spike produces 50-60 fruits. The skin (exocarp) turns from green to red on ripening and black on drying.

Soil: Pepper can be grown in a wide range of soils such as clay loam, red loam, sandy loam and lateritic soils with a pH of 4.5 to 6.0. It thrives better in soils rich in organic matters.

Climate: Pepper is a tropical plant it requires warm & humid climate for commercial production. It grows successfully between 200 N and South latitude and from sea level up to 1500 m above MSL. The crop tolerates temperature between 10^0C to 40^0C. But it requires an

optimum temperature of 25 to 35 degrees Celsius. A well distributed annual rainfall of 125 to 200 cm is considered ideal for pepper. Prolonged droughts stop the vegetative growth of the vines.

Varieties: More than 75 cultivars of pepper are being cultivated in India. Majority of the cultivated types of Pepper are monoecious.
Karimunda: Most popular variety throughout Kerala. A prolific and regular bearer. Dry recovery is 35%. Yields good quality of Pepper. Suitable for *intercropping as well as for high density cropping.*
Kalluvally: This is grown in North Kerala. It is hardy and regular bearer. It withstands water stress and is *moderately tolerant to Phytophthora wilt.* Spikes are medium long and have a characteristic twisting due to very thick setting. Driage is 40%. It is grown either alone or mixed with other cultivars.
Recently a number of improved cultivars have been evolved and released. They are Panniyur 1, 2 (Krishna), 3 (Shima), 4, 5, 6 and 7: released from Kerala Agricultural University, Pepper Research Station, Panniyur.
IISR Thevam, IISR Malabar Excel, IISR Girimunda, IISR Sakthi, PLD-2

- Lower elevation and less shady areas- Panniyur 1
- Higher elevation and more shady areas - Karimunda
- Inter cropping in Arecanut – Panniyur 5

Improved varieties of black Pepper: Name of hybrid / variety

	Parentage	**Parentage Yield / vine(Kg)**
Panniyur-1	F1 hybrid Uthirankotah x Cheriyakaniakadan	2.5
Panniyur-2 Krishna	Open pollinated seedlings of Balankottah	4.5
Panniyur-3 (Shima)	F1 hybrid of Uthirankotah x Cheriyakaniakadan	4.4
Panniyur-4	Selection from Kuthravally II	2.3
Panniyur-5	Open pollinated progeny of Perum kodi	2.75
Sreekara	Selection from Kanmundu (KS 14)	4.8
Subhakara	Selection from Kariamunda (KS27)	4.2
Panchami	Selecton from Aimpiriyan Coll . 856	5.2
Pournami	Selection from Ottaplackal Type coll. No.812	4.7

Sreekara, Subhakara, Panchami, Pournami – Released from NRCS, Calicut.

Malabar types: grown in Malabar region in Kerala. Examples are Kalluvally, Balankottah. They are suitable for *shade*, Cheriyakody, uthirankottah have high percentage of pistillate flowers.
Malnad types: grown in malnad of Karnataka. Workaiamarata variety is preferred for white pepper other examples include Doddagya, Karimarata, Arasilamarata, Malligesara, Tisara.
Travancore types: These are hardy; the cuttings root easily and climb the support without external help. e.g.**.** Karimunda, veluthanamban (tolerant to wilt), kuthiravally, chola.

Propagation: Pepper is invariably propagated vegetatively (**stem cuttings**). This is because of variation shown by the seedling progenies and also that the seedlings become dioecious and come to bearing very late (7-8 years). Pepper is propagated by *cuttings raised mainly for the runner shoots*. Cuttings from lateral branches are seldom used, because reduced number of fruiting shoots, short living and bushy in habit.
The selection of mother vine for perpetuation is done as follows;

1. A variety suitable for locality should be selected for instance *Panniyur-1* for open place and *Ballankottah* for shady location.

2. A variety should be selected depending upon the system of cultivation to be followed for instance, *Kalluvally, Panniyur-1* for monocrop system. *Balankottah, Karimunda* for mixed cropping.

3. A high yielder with high % of bisexual flowers should be selected. The runner shoots are separated from the vine in February – March and after trimming in leaves, cuttings of 2-3 nodes each are planted either in nursery beds or polythene bag filled with fertile soil. Cuttings from middle 1/3rd of the shoots are desirable as they are high yielding. Adequate shade is provided and irrigated frequently. The cutting will be ready for planting in May – June.

Rapid multiplication technique in pepper

A rapid multiplication technology has been developed by NRCS, Calicut. In this a trench of 0.75 m deep 0.3 m wide having convenient length is made. The trench is filled with rooting medium (preferably forest soil, sand, cow dung 1:1:1). Split halves of bamboos with septa having 8 – 10 cm diameter and 1.25 to 1.5 m length are fixed at 45^0 angle on a strong support. The bamboos can be arranged touching one another. Rooted cuttings are planted in the trench at the rate of one cutting each for one bamboo. The 10 cm portion of the bamboo are filled with a rooting medium (coir dust and cattle manure at 1 : 1 ratio) and the growing vine is tied to the bamboo in such a way as to keep the nodes pressed into the rooting medium. The tying could be done with dried banana sheath fibre. The vines are irrigated regularly. As the vines grow up, filling up the bamboo with rooting medium and tying each node, pressing it down to the rooting medium are to be continued regularly. For rapid growth each vine is fed at 15 day interval with 0.25 litres of nutrient solution prepared by dissolving Urea (1kg), 0.75 kg SSP, MOP (0.5 kg) and Megnesium sulphate (0.25 kg) in 250 litres of water. When the vine reaches the top in about 3 to 4 months, the terminal bud is nipped off and the vine is crushed at about 3 nodes above the base, in order to activate the axillary buds. After about 10 days, each vine is cut at the crushed point and removed from the rooting medium and each node is separated. Such cuttings with bunch of roots intact are planted in poly bags filled with pot mixture and kept in cool humid place. Care should be taken to keep the axil above the soil. The buds start developing in about 3 weeks when the poly bags can be removed and kept in semi shade. Subsequent harvesting can be had at every 2 – 2 ½ months time.

Advantages:

- Multiplication is rapid
- The root system is well developed.
- Better field establishment and more vigorous growth as a result of better root system

Selection of site: Well drained, leveled land and hill slopes are suitable for growing pepper. When they grown on a sloppy land, the slopes facing south should be avoided and the lower half of north and north eastern slopes are preferred for planting. So that the vines are not subjected to the scorching effect of the sun during summer.

System of cultivation: Pepper cuttings are generally planted with onset of South West monsoon. When pepper is grown as pure crop, pits of 0.5 m^3 are dug at a spacing of 2.5 x 2.5 m. Erythrina stem cuttings of 2 m length from 2 year old seedlings are planted on receipt of early monsoon showers. Certain other trees like silver oak, *Ailanthus excelsa* and *Garuga pinnata* are also used. With onset of regular rains, 2 or 3 rooted cuttings are planted around the base of the standard nearly 30 cm away. But in case of coconut and areca nut which have a thick intercoiled root not close to the trunk. Pepper cuttings are to be planted 100 to 120 cm away from the tree trunk. Initially the vines may be allowed to climb on a stick or pole about

2 m tall which is tied to the trunk in a slanting position. After one year when the vine has attained sufficient length it may be separated from the temporary stake and the lower leaves may be nipped off. A narrow trench of 15 cm deep and wide should be prepared from the base of the vine to the base of the tree trunk. The vines may be placed in the trench in such a way that the growing tip is tied to the trunk while other parts of vine are covered with soil. A small ridge is formed over the trench, which should not be disturbed while doing intercultural operations to the palm.

Irrigation
Protective irrigation in basins during December - May at 10 days interval.

Cultural operations: The pepper vines are tied firmly as and when they grow. The tying is done around the node, so that the nodal region is firmly attached and pressed against the standards so as to allow the roots to cling to the standards. This is an important operation which has to be attended to carefully as otherwise the vine will have no support. The another practice is that when vine reaches at a height of 75 to 100 cm without branches all the leaves are removed except the terminal 3-4 leaves. The defoliated portions are covered with friable fine soil. This aid in establishing a well developed root system and lateral branches may arise out of them.

Training and Pruning: The vines are trimmed at the top and prevented from growing too tall for convenience of picking. In Tamil Nadu, pepper vines trained on Silver oak standards are pruned at 6 m height from ground level for easy picking. The vines are trained up the support to give one main shoot and two lateral orthotropic shoots. These are pruned regularly to encourage the development of lateral fruiting branches but these lateral branches should not be tied to support, as this would discourage the bushy side growth. The vines are first pruned back to 15-20cm from the ground level, when they developed to 8-9 nodes length. Second pruning is done when further 9-10 nodes have been produced, to a height of 3-4 nodes of the previous cut. In this way vines are pruned 7-9 times until they reach the top of the support about 3 m high. When this is achieved, the terminal growth of vine is arrested by frequent pinching. The lower portion of vine is kept clean and unbranched at least a meter from ground level.

Regulation of shade: In Pepper plantation, shade is given to the pepper vines, especially during the hot weather to keep the soil cool and moist and to allow sun light during cool weather to encourage production of flowers and fruits. The young vines should be protected from hot sun during the summer months by providing them with artificial shade. Regulation of shade by lopping the braches of standards is necessary not only for optimum light to the vines but also for enabling the standards to grow straight. Excessive shading during flowering and fruiting encourages pest infestation. Adequate mulch with green leaves, saw dust or coir dust or organic matter should be given towards end of the North East monsoon. The base of the vine should not be disturbed to avoid root damage. During the second year, practically the same cultural operations are repeated. Lopping of standards should be done carefully from 4th year onwards. From the 4th year, usually 2 diggings are given one during May – June and the other towards the end of South West monsoon in October and November. Growing cover crops like *Calapogonium mucanoides*, *Mimosa invisa* are also recommended under west coast conditions to provide an effective cover to prevent soil erosion during rainy season. Further, they dry away during summer leaving thick organic mulch.

Manuring: Judicious and regular manuring is necessary to get good yields. About 10 kg of well rotten cattle manure or compost is given in April – may. Fertilizers to supply 100 g

Nitrogen, 40 grams phosphate and 140 grams of Potash per standard for vines at 3 years and above age may be applied annually in 2 split doses in April-May and August – September. During the first year of planting 1/3rd of above dose and in second year 2/3 rd of the above dose may be given. Manures are applied around the vines at a distance of 30 cm and forked in to the soil. Lime may be applied at the rate of 500 grams per standard. During April in alternate years .

Harvesting: Pepper vines start yielding usually from the 3rd or 4th year. The vines flower in May-June. It takes 6-8 months from flowering to ripening stage. Harvesting is done from November to February in plains and January to March in hills. When one or two berries on spike turn red in early the whole spike is plucked. Yields vary with the variety and season. A full bearing vine yields one kg of dry pepper. However, individual vines recorded yields up to 3-5 kg of dried pepper. Harvesting of pepper is carried out according to the purpose for which it is harvested. For preparation of white pepper the berries are harvested at a slightly advanced stage of ripeness i.e. when the berries turn red (bright orange). To get black pepper the berries are gathered at younger stages.

Yield: Pepper vine attain full bearing stage in the 7^{th} or 8th year after planting and yield starts decline after 20-25 years and replanting has to be done thereafter. 7^{th} or 8^{th} year old pepper vine gives 800 to 1000 kg of Black Pepper per ha.

Fruit drop

The spike shedding can be reduced by foliar spray of Diammonium Phosphate 1.0 % four times *viz.*, before flower initiation (May), during new leaves and flower emergence (June) before spike initiation (July) and pinhead stage of berries (August).

Plant protection

Pests

Pollu Beetle and Leaf Caterpillars

Spray Quinalphos 25 EC 2 ml/lit once in July and again in October.

Leaf gall and thrips

Spraying Monocrotophos 36 WSC 1.5 ml/lit or Dimethoate 30 EC @ 2 ml/lit or Chlorpyriphos 2 ml/lit or Dichlorvos 76 WSC 1 ml/lit or Phosphomidan 40 SL @ 2 ml/lit three rounds at monthly intervals starting from new flush formation.

Top shoot borer

Top shoot borer can be controlled by spraying Monocrotophos or Quinalphos (0.05%) on terminal shoots at monthly intervals (during July – October) to protect emerging new shoots.

Diseases

Foot rot

Nursery

Apply *Trichoderma viride* @ 1g/kg of pot mixture. Mulch the pot mixture with 150 gauge polythene sheet for 30 days and inoculate with Pseudomonas.

Main field

Any of the following formulation can be drenched in the soil twice (May –June and October - November).

- Neem cake 1/2 kg per vine + Swabbing of Bordeaux paste upto 1 m from the ground level.
- *Trichoderma viride* @ 20 g/vine + FYM or Bordeaux mixture 1 % or Metalaxyl-Mancozeb @ 2 g/lit.

- Neem cake 2 kg per vine + 0.1% Metalaxyl (pre monsoon foliar spray and soil application).
- *Pseudomonas fluorescens* (50 g) (pre and post monsoon) + neem cake (2 kg) (post monsoon) + metalaxyl 0.1 %.

Slow decline (Slow wilt): causal organism- nematodes. Apply Phorate 10 G @ 30 g or Carbofuran 3G @100g per vine (May–June and September - October) + Copper oxy Chloride @ 0.2 % (Soil drenching) or Potassium phosphonate @ 0.3% or Metalaxyl @ 0.1 %.

Anthracnose: Foliar spray with Bordeaux mixture @ 1 % or Mancozeb @ 0.2 %.

Nematode: Soil application *Bacillus subtilis* (BbV 57) or *Pseudomonas fluorescens* @ 10 g/vine is recommended for the management of root knot and reniform nematode population in Black pepper.

Processing of pepper: Almost all the produce in India is processed in to black pepper and only a very limited quantity is converted in to white pepper.

Black pepper: It consists of fully developed, but unripe dried berries of Pepper. The harvested spikes are sun dried for 7 to 10 days on cement floor or mats, until the outer skin becomes tough black, shrink and wrinkled. Drying is carried till the moisture content gets reduced to 10-15%. Then the dried berries are separated from the spikes by beating or rubbing between hands or trampling them under the feet. For making good quality of Black pepper of uniform colour, the separated berries are collected in a perforated bamboo basket or vessel and the basket with the berries is dipped in boiling water for 1 minute. The basket is then taken out and drained. The treated berries are sun dried on a clean bamboo mat or cement floor. The recovery of black berry is about 33 % **(**26 to 36% depending upon the variety).

White Pepper: This consists of dried ripe fruits without pericarp (skin). It is prepared by removing the outer skin along with the pulp before drying. White pepper is prepared by one of the two methods.

I. Water steeping technique (traditional method)

II. Steaming or boiling technique (improved method)

I. Water steeping technique: It is a traditional and slow method. It involves *5* ***steps***.

1. ***Steeping:*** Spikes with fully ripe berries are filled in gunny bags and are steeped in flowing water for about 7 -8 days. During this steeping process, the skin gets loosened from the seed. **2.** ***Depulping:*** At the end of steeping, the berries are taken out and the skin with the pulp is removed either by rubbing between hands or by trampling under feet.

3. ***Washing:*** These depulped seeds are then washed and cleaned with fresh water repeatedly (3-4 times)

4. ***Drying:*** The cleaned seeds are sun dried for 3-5 days on cement floor or mats till they become white and the moisture gets reduced to 10-15%.

5. ***Polishing:*** The dried seeds are now dull white with colour. They are further cleaned by winnowing or by rubbing with a cloth. The percentage of recovery of white pepper is about *25% of ripe berries.*

II. Steaming or boiling technique: This is an improved and quick method developed at CFTRI, Mysore. It involves *4 steps.*

1. Boiling: Freshly harvested spikes or berries are boiled for about 15 minutes.

2. Depulping: The boiled berries are then pulped mechanically. Boiled berries passes through motorized fruit pulping machine.

3. Bleaching: The depulped berries are washed thoroughly by using bleaching powder or any bleaching agent.

4. Drying: The cleaned berries are sun dried for 3-5 days on cement floor or mats till they become white and the moisture gets reduced to 10-15%.

Cardamom

Origin: western Ghats of South India (Kerala)

Useful plant part: Fruit (capsule)

Introduction: Cardamom is popularly known as the *Queen of Spices* and also *Green Gold*. It is one of the ancient species of India and is also one of the most valued spices of the world. It is next only to black pepper as the largest foreign exchange earner among various Indian spices. Cultivation of Cardamom is mostly concentrated in the evergreen rainy forests of Western Ghats in South India. Besides India, Cardamom is cultivated in Guatemala, Tanzania, Srilanka, Vietnam, Combodia and Newguinea. Among three cardamoms small one is the most popular species. India has the largest area (90% of the world area) and is also largest producer (70%). But of late India is facing still competition from *Guatemala* in the world market for the top position. In India the cultivation of small cardamom is mainly confined to the southern states viz., Kerala (60%), Karnataka (30%), Tamilnadu (10%). Among the different spices, exported from India cardamom ranks *second* after black pepper. Nearly 40% of the production is exported to more than 60 countries.

Importance/ uses: Cardamom is used for flavouring and seasoning various food stuffs, confectionery, beverages and liquors. In Arab countries, a beverage of cardamom flavoured coffee is prepared called **'***Gawa'.* It is generally offered to guests at social and religious functions. In Srilanka cardamom is used in manufacturing liquors. The essential oil of cardamom is used for medicinal 28 purposes both in alllopathy and in Ayurveda. It is used as powerful aromatic stimulant, carminative, stomachic and diuretic. Cardamom seeds are chewed to prevent the bad bread, indigestion, nausia and vomiting. Eating one cardamom daily with a table spoon of honey improves eye sight and strengthens the nervous system and keeps one healthy. It is believed by some people that excessive use of cardamom causes impotency.

Botany and taxonomy

Genus: *Elettaria*
Species: *cardamomum*
Botanical name: Small Cardamom: *Elettaria cardamomum* (L.) Maton (Malabar cardamom)
Large Cardamom: *Amomum subulatum* (native to Eastern Himalayas)
Bengal cardamom: *Amomum aromaticum*
Family: Zingiberaceae
Cultivated cardamom has chromosome number 2n = 48**.**

Out of the above species, most popular species occupying a premier position is small cardamom. Large cardamom is mainly cultivate in Darjeeling, Assam, Himalayas, Nepal, Bhutan, Thailand, Indonesia. Bengal cardamom is grown in Northern Bengal.

Botany: Cardamom is an herbaceous perennial plant having underground rhizomes. A fully grown plant is about 2- 4 m height. The real stem of the plant is the underground rhizome. The aerial pseudo stem is made up of leaf sheaths. Leaves are lanceolate with dark green colour. It has shallow root system; inflorescence is a long panicle with racemose clusters arising from the underground stem but comes up above the soil. Flowers are bisexual, pale white fragrant flowers. Fruit is trilocular capsule. Flower initiation takes place in March – April and from initiation to full bloom it takes nearly 30 days; from bloom to maturity it takes 5 – 6 months. Honey bee is the principle pollinating agent.

Varieties

Based on the size of the fruit, two varieties are broadly recognized viz., ***Elettaria cardamomum*** var. ***major*** consisting of wild indigenous types and var. ***minor*** comprising the cultivated types viz., Mysore, Malabar and Vazhukka (natural hybrid between Mysore and Malabar). The cultivated types are identified mainly based on the nature of panicle shape and size of the fruits as follows.

Sl. No.	Particulars	Mysore type	Malabar type	Vazhukka type
1	Plant stature	Robust	Medium sized	Robust
2	Panicle	Erect	Prostrate	Semi-erect
3	Capsule	bold, elongated	round to oblong	round to oblong
4	Adaptability	high altitudes (900 – 1200m)	low altitudes (600 – 900 m)	wide range
5	Productivity	More	Less	Less
6	Resistance	Withstand to Winds	More tolerant to thrips and less susceptible to drought	More tolerant to thrips and less susceptible to drought
7	Fruits shape	Pods are bold and elongated	Roundish or egg shaped	Roundish to Long

Malabar: Mudigree 1, Mudigree 2, CCS 1, PV 1, ICRI 1, ICRI 3, TKD 4, IISR Suvarna, IISR Vijetha, IISR Avinash, **Mysore:** ICRI 2, **Vazhukka:** PV2, Njallani (Green gold)

Improved varieties:

Coorg cardamom Malabar selection– 1 (CCS– 1) (Malabar type): it yields 408 kg per ha dry capsules under rainfed conditions. It was released by National Cardamom Research Station (NCRS), Appangala.

Mudigere– 1 (Malabar type): it yields 250 to 300 kg per ha of dry capsules. It was released by Regional Agricultural Research station, Mudigere (Karnataka).

ICRI– 1 (Malabar type): it yields 265 to 650 kg of dry capsule/ha.. Released by Indian Cardamom Research Institute, Myladumpara.

ICRI– 2 (Mysore type): it yields 375 to 760 kg of dry capsule/ha. Released by Indian cardamom Research Institute, Myladumpara.

PV– 1 (Malabar type): it yields 500 kg of dry capsule. Released by Cardamom Research Station, Pampadumpara.

SKP– 14 (Malabar type): it yields 430 to 590 kg dry capsule per ha. Released by ICRI Regional station, Saklespur, Karnataka.

Soils: Grows best on well drained humus rich forest soils. Water logging and excessive soil moisture conditions are detrimental. Moisture level should be 40 to 50% of the field capacity of the soil. An ideal site is a sloppy land with good drainage. In India cardamom is grown on red, deep and good textured laterite forest soils having plenty of humus and leaf mould. Ideal pH is 5.0 to 6.5

Climate: Small cardamom is a humid tropical plant. It is grown under natural conditions of ever green forests at an elevation from 600 to 1500 m above MSL. Optimum elevation is 900 to 1200 m. The plant prefers temperature of 10 to 35^0C and a well distributed rainfall of 1500 mm per annum. Summer showers are essential during summer i.e. February – April for panicle initiation. Otherwise it affects yield. It does not stand drought and is highly sensitive to winds. Under exposed conditions, the plant does not attain its full vegetative growth because of sun scorching. It grows luxuriantly under shade. Shade trees besides providing

shade create a congenial micro climate in the plantation. It keeps the surroundings humid and cool. Moderate shade, high humidity, cool surroundings, well distributed rainfall and wind less areas is very essential for the satisfactory performance of Cardamom.

Propagation: Cardamom can be propagated by seeds, rhizomes and suckers. Out of which seed propagation is most preferred because of certain advantages over vegetative propagation.

By seed: Propagation by seeds prevents spread of *khatte disease*. This is the most common and widely prevalent method. A large number of seedlings can be raised within a short time. The main disadvantage is that the progeny is highly variable with no uniformity in the yield. The seeds also do not remain viable for longer time.

By rhizomes: Planting material of rhizomes is collected by uprooting 2 to 2 ½ year old clumps. These materials are noted for their high yields. The advantage of this material is greater uniformity and earlier bearing habit compared to 30 seedlings. One of the very serious disadvantage is that Cardamom Mosaic Disease spreads through rhizomes. Plantations raised by vegetative means are short lived. Getting adequate plant material is another difficulty. If rhizomes are used for propagation continuously. The plants tend to loose their vigour after a few generations. Due to these limitations farmers use seedlings only.

Nursery site and planting: Seedlings are normally raised in primary and secondary nurseries. The nursery site should be selected on gentle sloppy lands, having an easy access to a water source. Raised beds are prepared after digging the land to a depth of 30- 45 cm. The beds of 1 m width and of convenient length raised to a height of about 30 cm are prepared. A fine layer of humus rich forest soil is spread over the beds. Seeds are to be collected from well ripe capsules. Immediately after harvesting, the husk is removed and seeds are washed repeatedly in water for removing the mucilaginous coating. After draining the water the beds are to be mixed with wood ash and dried in shade for a day. In order to ensure uniform and early germination, seeds should be sown immediately after extraction. If the sowing is delayed, pre sowing treatment of seeds with 25% Nitric acid for 10 min is advisable to get a quick and higher germination. One kg of capsules may produce 5000 seedlings.
Sowing may be taken up during November – January and is done in rows. Deep sowing should be avoidesd for better and quick germination. Seeds are mulched to a thickness of 2 cm with paddy straw or any locally available material and are watered regularly. The germination commences in about 30 days and may continue to a month or two. After germination the mulch is to be removed.

Seed rate: 10 g per m^2 of nursery bed area. An over head pandal with a height of 2 m is quite desirable. Materials like coir mat, coconut leaves or tree species which do not shed their leaves easily may be used but the coir mat is prepared as it allows uniformly filtered light. The excess seedlings are to be thinned out of it after 75 – 80 days sowing. When the seedlings attain 5-6 leaf stage light earthing up is to be done. This would encourage better tillering and proper growth of seedlings. Generally in Kerala and Tamil Nadu the seedlings are transplanted to the secondary nursery when they attain 4 – 6 leaf stage. The beds are prepared in the same manner as that of primary nursery. Seedlings are transplanted in the secondary nursery in March – May at a spacing of 20 x 20 cm and mulched. Immediately beds are to be covered with an over head pandal and should be watered regularly. Recently instead of secondary nursery beds, the seedlings are also raised in poly bags containing rich forest soil. Manuring at the rate of 90 g N, 60 g of P, and 120 g of K per bed of 5 x 1 m size

in 3 equal split doses at an interval of 45 days is recommended to produce healthier seedlings. The first dose of fertilizers may be applied 30 days after transplanting in the secondary nursery.

Rapid Clonal multiplication technique developed by Cardamom Research Centre, Appangala:

Cardamom is propagated mainly through seeds and also through suckers each consisting of at least one old and a young aerial shoot. The suckers are commonly used for gap filling but suckers may not be available in larger numbers. Therefore rapid clonal multiplication technique evolved by *NRCS-Cardamom Research Centre, Appangala* is proved to be quick, reliable and economical for production of large number of quality planting materials. The site selected for their method should have a gentle slope and must be nearer to the water source. Trenches of 45 cm width 45 cm depth and of any convenient length may be taken across the slope or along the contour at 1-8 m apart. The top 20 cm depth soil is excavated separately and heaped on the upper side of the trench. The lower 25 cm soil is excavated and heaped on lower side of the trenches all along the line.

The top soil is mixed with equal portions of humus rich jungle soil, sand and cattle manure and filled back by leaving a depression of 5 cm at the top to facilitate mulching for retention of soil moisture. Suckers each consisting of one grown up tiller and a growing young shoot are placed at a spacing of 0.6 m in the trenches during march – October. Regular cultural operations are to be followed including a high fertilizer dose of 100: 50: 200 kg NPK / ha in 6 split doses at 60 days interval along with neem cake at 250 g per plant. Irrigation should be provided at least twice a week. Overhead pandal at a height of 3.6 m covered with coir mat or leafy twigs of any shade tree may be provided during non-rainy season. Within a period of 12 months, a plant could produce at least 32-42 suckers which may yield at least 16-21 planting units i.e. about 1.5 lakh planting units per ha.

Planting: The best season of planting seedlings or suckers is May- June after the receipt of monsoon showers. The seedlings or suckers are planted in the pits up to collar region for better growth. Cloudy days with light drizzle are ideal for panting.

Shade and shade regulation: Cardamom is a shade loving plant *(pseophyte)***.** Shade helps to regulate soil moisture as well as temperature and provides congenial micro climate for cardamom. Shade protects plants from sun-scorching, rains and winds. Shade trees provide mulch material through fallen leaves on the surface and prevent soil erosion through their root system. Excess shade is also quite detrimental and shade has to be regulated so as to provide 50-60% filtered sunlight.

In South India, many trees are available in the natural habitat to provide shade but an ideal shade tree should have a wider canopy, minimum side branching and it should not shed the leaves during flowering phase of Cardamom, so as not to affect pollination. Some of the common shade trees in cardamom estates are karimaram (*Diospyros ebenum and D. elongi)*, *Mimusops elangi,* Balangi (*Artocarpus fraxinifolius),* Jack, Red cedar (*Cedrella toona)*. The temporary shade trees like *Erythrina lithosperma* and *E. indica* are the most unsuitable but they compete for nutrients and soil moisture and hence not suitable as permanent shade trees. In order to provide adequate light during monsoon, shade regulation may be taken up before the onset of monsoon. A two tier canopy with a height of not more than 3m between the lower and higher canopy may be maintained. Areas exposed to western side should have adequate shade.

Manuring: Cardamom is a surface feeder and its growing areas are usually subjected to heavy rain fall conditions, the top soil is subjected to frequent leaching, resulting in the loss

and plant nutrients, even though there is annual replenishment of nutrients through the incorporation of fallen leaves of shade trees and cardamom plants. Therefore manuring is very essential.

Under irrigated conditions – 75 kg N; 75 kg P and 150 kg K per ha.
Under rain fed conditions – 30 kg N + 60 kg P and 30 kg K per ha.
Organic manures may be applied at the rate of 5 kg per plant.

Two split doses one during May – June for production of suckers, Second during September to October for initiation of panicle. Half dose can be applied during first year. Full dose can be applied from second year onwards. Being a surface feeder deep placement of fertilizer is not advocated. These fertilizers are applied 30 cm away from the plant.

Irrigation: Cardamom is generally raised as rain fed crop. However, it responds well to irrigation. It is necessary to irrigate the crop during dry periods to get increased yields. Since, cardamom is raised under evergreen forests and on undulated terrain, conventional irrigation methods are not useful.

Intercultural operations:

Weeding: 2-3 weedings per year may be necessary during May-June, August–September and December – January. Paraquat @ 625 ml in 500 litres of water may be sprayed.

Mulching: it is an important cultural operation in Cardamom. Fallen leaves of the shade trees and up rooted weeds are utilized for mulching. Mulches should be applied during November – December to reduce ill effects of drought conditions during ensuing summer.

Trashing or clearing: It consists of removing old and drying shoots of the plant once in a year with the onset of monsoon under rain fed conditions and 2-3 times in high density plantations. The plantation is provided with irrigation facilities. Weeding and clearing may be done simultaneously during May- June and August – September.

Packing and digging: At the end of the monsoon rains a light raking or digging of soil should be given around the pant up to a radius of 60-75 cm to conserve the moisture to the ensuing dry period particularly in low rainfall areas.

Earthing up: After the completion of monsoon, a thin layer of fertile soil rich in organic matter may be earthed up at the base of plant up to collar region to encourage new growth.

Cropping: Cardamom plants start bearing in about 3 years after planting. Flowering starts in April – May and continues up to August – September. Peak flowering will be in the month of May- June. From flowering to maturity the fruit takes 5-6 months.

Harvesting: Only ripe capsules are harvested at 25-30 days interval, the harvesting is completed in 5- 6 pickings. Pick only those fruits which are just ripe but not fully ripe. Fully ripe fruits tend to split on drying and do not develop the desirable dark green colour. In most of the areas the peak period of harvest is during October – November.

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Yield: Although the Cardamom plant start bearing from 2^{nd} or 3^{rd} year of planting, an economic crop can be obtained only from 4^{th} or 5^{th} year. Yield varies with variety and age. Optimum average yield is 50-70 kg of dry capsule per ha. Yields decline from 10^{th} year to 12^{th} year.

1^{st} year of bearing – 25-50 kg per ha (dry capsules)
2^{nd} year of flowering 50-70 kg per ha (dry capsules)
3^{rd} year of flowering 70-100 kg per ha (dry capsules)

Processing: The commercial product of Cardamom is the dried capsules. At the time of harvesting the capsules are juicy and fleshy, so they must be cured before sending them to the market.

Bleaching: Green colour of the cardamom capsules plays a vital role in the market. Green colour of the capsules can be preserved by *alkali treatment.* So freshly harvested cardamom capsules are soaked in *2 % washing soda (Na_2CO_3)* solution for 10 min.
Drying: After bleaching, the capsules are dried either by sun drying or in fuel kilns and electric driers. The capsules are sun dried for 3-5 days. These capsules get bleached and does not store well. Hence, now a day's capsules are dried artificially in which drying is complete and the green colour remains. In electrical drier in capsules are dried at 45 – 50^0C for 18 hours.
Fuel kilns: Temperature is set at 50 – 60^0C over night. The capsules kept for drying are spread thinly and stirred frequently to ensure uniform drying. The dried capsules are rubbed with hands or coir mat or wire mesh and winnowed to remove any foreign matter.
Storage: Then they are stored according to size and colour and stored in black polythene lined gunny bags to retain green colour during storage. These bags are then kept in wooden chamber. **Sorting:** The dried capsules are stored according to their size, colour and stored in black polythene lined gunny bags to retain green colour during storage.

Plant protection
Pests
Thrips
Monocrotophos 36 % SL @10 ml/10 lit. Quinalphos 25 % EC @12 ml/10 lit.
Shoot and fruit borer
Setup pheromone trap @ 12 Nos/ha to attract and destroy the female moths.
Nematode
Fumigate the primary and secondary nursery beds using Methyl Bromide (@ 500 g/10 sq.m) or Ethylene-di-bromide (@ 20 lit/ha) or Durofume (@ 30 lit/ha) under polythene cover for 2-3 days or drench the nursery beds with 2 % Formalin.
Apply Carbofuran 3 G @ 5 kg a.i/ha

Diseases
Mosaic or Katte disease
This is a serious disease affecting the productivity of Cardamom. This is transmitted by banana aphid which can be controlled by regular spraying with Methyl demeton 25 EC or Dimethoate 30 EC or Phosphomidon 86 WSC at 750 ml/ha.
Damping off or clump rot or rhizome rot
Drench nursery with 1 lit of Formaldehyde in 50 lit water for 3 sq.m. before sowing. Prophylactic drench with 0.25% Mancozeb or 1% Bordeaux mixture immediately after germination to control *Pythium* and 0.05% Carbendazim after 15 days to control *Rhizoctonia*.
Capsule rot or panicle rot or Azhukal
Three sprays with 1% Bordeaux mixture or 0.25% Copper oxychloride or 0.2% Mancozeb just before onset of South West monsoon in early August and in September. Drench the soil with 1% Bordeaux mixture.

Large cardamom or Nepal cardamom or Greater Indian cardamom is the dried fruits of ***Amomum subulatum*.** It is native of Eastern Himalayan region and is now cultivated in Sikkim, Darjeeling and Assam hills.

It is a perennial crop, propagated from the seeds or cut bits of the dried rhizome. It starts bearing in 3 to 5 years after planting and the economic age of the plantation is 12 to 15 years. The fruits are about 2.5 cm long, ovoid and triangular in shape brown or pink in colour when ripe. They contain 40 to 50 seeds. Average yield is 300 to 1000 kg per ha from 4^{th} or 5^{th} year.

Turmeric

Turmeric is the dried rhizome of *Curcuma longa*, a herbaceous perennial plant with a thick underground rhizome giving rise to primary and secondary rhizomes called **fingers**, native to tropical South East Asia. The rhizome has 1.8 to 5.4 per cent ***curcumin***, the pigment and 2.5 to 7.2 per cent of essential oil. It is used as an important condiment and as a dye with varied application in drug and cosmetic industries.

Botany and taxonomy

Family: Zingiberaceae

Genus: Curcuma

Species: longa

Botanical Name: ***Curcuma longa* Lin.**

Ch. No. 2n= 3x=63

Origin: South East Asia or India

Botanical Features

Habit: Plant is herbaceous perennial with a thick under ground rhizome.

Root

It is herbaceous perennial but being grown as annual crop with a thick under ground rhizome giving rise to primary and secondary rhizomes called fingers.

Stem Modified under ground stem i.e. rhizomatous.

Leaf Leaves are borne in a tuft and are about 60 cm long, broadly lanceolate, acceminate with a lon leaf stalk.

Inflorescence Flowers scanty, borne on a separate peduncle arising directly from the rhizome.

Flower Flowers white with pinkish splash on the apex, zygomorphic, bisexual, bracteates and epigymous nature.

Fruit Capsule

Seed Arillate.

Varieties

CO1 (X-ray induced mutant from Erode Local), BSR 1 (X-ray induced mutant from Erode Local), BSR 2, Suguna, Suvarna, Sudharshana, Krishna, Sugandham, Roma, Suroma, Rajendra Sonia, Ranga, Rashmi, Allepy finger turmeric (AFT), IISR Prabha, IISR Prathiba, IISR Alleppey Supreme and IISR Kedaram.

Soil and climate

Turmeric is grown under diverse tropical conditions from sea level to 1500 m in the hills, at a temperature range of 20-30^{o}C with a rainfall of 1500 to 2250 mm per annum. It is grown in different type of soils from light black, sandy loam and red soils to clay loams, but thrives in best a well drained sandy loam soil rich in humus content. It can be grown It is also grown as an irrigated crop.

Preparation of land

The land is ploughed four times deeply. Weeds, stubbles, roots etc. are removed. Immediately after the receipt of pre-monsoon showers, beds of 1 to 1.5m width, 15cm height and of convenient length are prepared. Planting is also done by forming ridges and furrows.

Spacing

40 to 50cm x 25cm.

Planting time (Season)

May-June is suitable. Since turmeric is a shade loving plant, castor or *Sesbania grandiflora* may raised along with the border lines in the field.

Propagation

Mother rhizome & finger rhizomes are used for planting. 25-30 g weight rhizomes are to be dibbled at a depth of 4 cm. Seed rate of finger rhizome – 2500 kg/ha.

Seed Treatment

- Seed rhizomes treated with 0.3% Copper oxychloride for 30 min or
- Seed treatment with *P. fluorescens* 10 g/kg and *T. viride* as 4 g/Kg.

Manures and manuring

Basal: FYM - 25 t /ha, neem or groundnut cake - 200 kg/ha, 25:60:60 kg of NPK per ha; 30 kg of $FeSO_4$ and 15 kg of $ZnSO_4$, 10 kg in each of Azospirillum and Phosphobacteria per ha to be applied at the time of planting.

Top dressing: 25: 60 kg of N and K/ha applied on 30, 60, 90 and 120 days after planting. Beds are earthed up each time after top dressing.

Mulching

The crop is mulched immediately after planting with green leaves or banana psuedostem or sugarcane trash at the rate of 12 to 15 tonnes per hectare.

After cultivation and growing as intercrop

Weeding may be done thrice at 60, 120 and 150 days after planting depending upon weed density. It can be grown as an intercrop in coconut and arecanut plantations. It can also be raised as a mixed crop with chillies, colocasia, onion, brinjal and cereals like maize, ragi etc. in some places, double inter cropping viz., Fenugreek + Onion in turmeric field is followed. Depending on soil types, irrigated crops require 15 to 20 irrigations in heavy soils and 35 to 40 in light soils.

Harvesting

Depending upon the variety, the crop becomes ready for harvest in seven to nine months. Usually, it extends from January-March. The plants will start lodging, yellowing and drying on crop maturity. The rhizomes are dug with spade or digging forks.

Yield

Fresh rhizomes : 25-30 t/ha

Cured rhizomes : 5-6 t/ha

Storage of seed rhizomes

Seed rhizomes can be stored after heaping under the shade of a tree or in well ventilated shed and covered with turmeric leaves.

Plant protection

Pre planting treatment

The seed rhizomes are dipped in Carbendazim 1 g/lit and Phosalone 35 EC 2 ml/lit for controlling rhizome rot and scales.

Pests

Thrips

Thrips can be controlled by spraying Dimethoate 30 EC or Methyl demeton 25 EC 2 ml/litre.

Rhizome scale

Rhizome scale can be controlled by applying well rotten sheep manure @ 10 t/ha in two splits (once basally and other at earthing up) or Poultry manure in 2 splits followed by drenching Dimethoate 30 EC 2 ml/lit or Phosalone 35 EC 2 ml/lit.

Nematode

Avoid planting turmeric after Banana or other solanaceous vegetables. Plant only after taking suitable control measures. Apply Carbofuran 4 kg a.i./ha twice on the third and fifth month after planting the rhizomes.

Diseases

Rhizome rot

- Treat the seed rhizomes with 0.3% Copper oxychloride for 30 min or Drench with Bordeaux mixture 1 % or Copper oxychloride 0.25 % or Ridomil 0.1 % or
- Seed treatment with *P. fluorescens* 10 g/kg and *T. viride* 4 g/ Kg and soil application of 2.5 Kg/ha each of *P. fluorescens* and *T. viride* in 50 kg of FYM as basal and top dressing on 150 Days after planting.

Leaf spot

Leaf spot can be controlled by spraying Carbendazim 500 g/ha or Mancozeb 1 kg/ha or Copper oxychloride 1.25 kg/ha.

Leaf blotch

Leaf spot controlled by spraying Carbendazim 500 g/ ha or Mancozeb 1kg/ha or Copper oxy chloride 1.25 kg/ha. Mix sticker solution @ 5ml / 10 litre of spray solution.

Processing and curing:

Fresh rhizomes are not useful for marketing. Curing makes fresh rhizomes marketable. Curing involves boiling, drying and polishing.

A. Boiling: is done either by traditional or improved method.

I. Traditional method: Water is poured to cover rhizomes in the vessels of copper or galvanized iron or earthen material. Mother rhizomes and fingers should be boiled separately, since fingers take long time for boiling. Stop boiling when froth, fumes with typical odour comes. Rhizomes yield to finger pressure. Over cooking should be avoided as it spoils the colour, while under cooking renders the dried product brittle.

II. Improved method:

A. Boiling: 50 kg of cleaned rhizomes are taken in a perforated trough made of GI sheet. It is immersed in a pan. Alkaline solution 0.1% sodium carbonate/ sodium bicarbonate are poured in the trough. Boil till fingers become soft. Alkaline solution helps in imparting orange yellow colour to the core.

B. Drying: The boiled rhizomes are sun dried in 5.7 cm thick layers for 10 – 15 days. Rake

frequently for uniform drying. Dry until they become hard, brittle, break with a metallic sound. After drying they should possess only 8 – 10 % moisture.

C. Polishing: The dried rhizomes are smoothened by manual or mechanical rubbing. Manually they rubbed on hard surface or trampled under feet. Mechanically they are polished by mechanically operated polishing drums.

D. Colouring: They are coloured to improve the appearance. Rhizomes are artificially coloured in two way *i.e.* dry and wet colouring. Half polished fingers are coloured. In dry process– turmeric powder is added in the last 10 min to polishing drum. In wet process– turmeric powder is suspended in water and mixed by sprinkling. For brighter colour– boiled, dried and half polished fingers are taken in baskets and shaken continuously with an emulsion of

2 kg turmeric powder,
0.04 kg alum,
0.14 kg castor seed oil,
30 g of sodium bisulphate and
30 ml HCl.

Coloured rhizomes are again sun dried before sending to market.

Ginger (*Zingiber officinale* L.)
Zingiberaceae

Ginger, an indigenous plant as is an important spice crop of the world. It is herbaceous perennial with underground rhizomes. It is valued in medicinal as a carminative and stimulant of the gastro-intestinal tract. Dry ginger is used for the manufacture of oil, oleoresin, soft drink, non-alcoholic beverage and vitaminised effervescent soft drinks.

Varieties

Rio de Janeiro, Maran Nadan, Suruchi, Suprabha, Surari (X-ray induced mutant of local cultivar), Himagiri, IISR Varada, IISR Mahima and IISR Rejatha Athira and Karthika are the popular varieties.

Soil and climate

A friable well drained loamy soil rich in humus with warm and humid conditions with 150 cm of annual rainfall are preferable. This crop is cultivated in the tropics from sea level to an altitude of 1500 metres, both under rainfed and irrigated conditions. Dry weather with a temperature of 28 to 35^{o}C for about a month before harvesting is necessary.

Preparation of land

Preparation of land starts with receipt of early summer showers. The land is to be ploughed 4 to 5 times deeply. Weeds, stubbles, roots etc. are removed. Beds of about one meter width, 15cm height and of any convenient length are prepared. Planting is also done by forming ridges and furrows.

Spacing

Irrigated crop- 40-50 x 20 cm in ridges and furrows. Rainfed crop – Raised beds of 20 x 20 cm or 25x 25 cm

Planting time (Season)

May - June is highly suitable for cultivation.

Propagation

Ginger is always propagated by portions of the rhizomes, known as **seed rhizomes.** Carefully preserved seed rhizomes are cut into small pieces of 2.5-5.0cm length weighing 20-25g, each having one or two good buds. The seed rate 1500 - 1800 kg of rhizome/ha is required.

Seed treatment:

Treat the seed rhizomes with Mancozeb or Copper oxychloride 3 g/lit or 200 ppm Streptocycline for 30 minute.

Manures and Manuring

Basal: FYM 25-30 t + 30 tonnes green leaves as mulch in three splits : 15 tonnes- immediately after planting, 7.5 tonnes – 60 days and 120 days after planting**,** 50: 25 kg of P and K per ha**.**

Top dressing: 37.5: 12.5 kg of N and K per ha applied on 45th and 90th day after planting

Aftercultivation

Weeding is done before fertilizer application and mulching. Two to three weeding are required depending on the intensity of weed growth. Mulching is done at the time of planting with green leaves. After each top dressing, earth up the plants.

Harvesting

Harvesting is done from 6th month onwards for marketing the produce as green ginger. For preparing the dry ginger, the crop can be harvested after 8 - 9 months (between 245 to 260 days) when leaves start yellowing and drying.

Yield

About 15 - 25 t/ha

Plant protection

Pests

Shoot borer

Shoot borer can be controlled by spraying Dimethoate 30 EC 2 ml/lit or Phosphamidon 86 WSC 1 ml/lit.

Leaf roller

Leaf roller can be controlled by spraying Carbaryl 50 WP 2 g/ha or Quinalphos 25 EC 2 ml/lit.

Rhizome scale

Rhizome scale can be controlled by applying well rotten sheep manure @ 10 t/ha in two splits (once basally and other at earthing up) or Poultry manure in 2 splits followed by drenching Dimethoate 30 EC 2 ml/lit or Phosalone 35 EC 2 ml/lit.

Diseases

Soft rot (*Pythium* sp.)

- Provide adequate drainage facilities
- Select healthy and disease-free seed rhizomes
- Treat the seed rhizomes with Mancozeb or Copper oxychloride 3 g/lit or 200 ppm Streptocycline for 30 minutes.
- In the field, drench the beds with 2.5 g/lit of Copper oxychloride or 1% Bordeaux mixture or Metalaxyl - mancozeb 4 g/lit.

Rhizome rot

Rhizome treatment with *Pseudomonas fluorescens* @ 20g/kg rhizome + soil application, @ 10kg/ha immediately after planting and 45 days after planting followed by pre monsoon drenching with Metalaxyl 0.1%**.**

Leaf spot

Leaf spot can be controlled by spraying 1 % Bordeaux mixture or Copper oxychloride 0.25%.

Processing and curing:

I. Dry Ginger: Preparation of commercial dry zinger involves a series of steps. Fully developed rhizomes are harvested after 8 months of planting for preparation of Dry Ginger.

1. Soaking in water: The rhizomes are soaked overnight in cement tubs for easy removal of skin.
2. Trampling: The rhizomes are trampled under feet in the tub. Avoid damage to epidermal cells containing flavouring oil.
3. Peeling: The skin is peeled off, with sharp bamboo knives. Don’t rupture epidermal cells. This step hastens drying process.

4. Washing and Drying: The peeled rhizomes are washed and sun dried for 3-4 days on cement floors.
5. Polishing: After drying, the rhizomes are polished by rubbing with a coarse cloth to remove all bits of skin or dirt. These are called unbleached ginger. To get bleached Ginger, peeled rhizomes are soaked in 2% lime water for 6 hours, fumigated with sulphur for 12 hours. Yield of dry Ginger is 16 to 25% of the fresh Ginger.

II. Preserved Ginger: Ginger is harvested at 7 months after planted for preparing the preserved Ginger. It is preserved in syrup or brine.