Production Technology of Vegetables and Flowers
( VSF-231)
Part-I: Vegetable production

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**Course Outline**

Course title: Production Technology of Vegetables and Flowers  
Course No.: VSF-231  
Credit hours: 2+1=3  

Name and designation of the course instructors:  
1) Dr. Akhilesh Sharma (Assoc. Prof.)  
2) Dr. Desh Raj (Assoc. Prof.)

**Lecture schedule:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of the topic/practical</th>
<th>No. of lectures</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Theory</strong></td>
<td></td>
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</tr>
<tr>
<td>1</td>
<td>Importance of Olericulture, vegetable gardens, vegetable classification.</td>
<td>4</td>
<td>Dr. Akhilesh</td>
</tr>
<tr>
<td>2</td>
<td>Fruit vegetables- tomato, brinjal, capsicum, chilies and okra;</td>
<td>3</td>
<td>Dr. Akhilesh</td>
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<tr>
<td>3</td>
<td>Cucurbitaceous vegetables- cucumber, ridge gourd, ash gourd, snake gourd, bottle gourd, bitter gourd and melons;</td>
<td>2</td>
<td>Dr. Akhilesh</td>
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<td>4</td>
<td>Cole crops- cabbage, cauliflower, broccoli and knol-khol.</td>
<td>2</td>
<td>Dr. Akhilesh</td>
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<tr>
<td>5</td>
<td>Bulb crops- onion and garlic.</td>
<td>1</td>
<td>Dr. Akhilesh</td>
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<tr>
<td>6</td>
<td>Beans and peas- French beans, cluster beans, dolichos beans, garden pea and cow pea.</td>
<td>2</td>
<td>Dr. Akhilesh</td>
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<tr>
<td>7</td>
<td>Tuber crops- potato, sweet potato, tapioca, Colocasia, yams;</td>
<td>3</td>
<td>Dr. Akhilesh</td>
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<tr>
<td>8</td>
<td>Root crops- carrot, radish, turnip and beet root;</td>
<td>1</td>
<td>Dr. Akhilesh</td>
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<tr>
<td>9</td>
<td>Leafy vegetables- amaranthus, palak;</td>
<td>1</td>
<td>Dr. Akhilesh</td>
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<tr>
<td>10</td>
<td>Rare vegetables- asparagus, lettuce, parsley, celery.</td>
<td>1</td>
<td>Dr. Akhilesh</td>
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<tr>
<td>11</td>
<td>Perennial vegetables- drumstick, coccinia and curry leaf.</td>
<td>1</td>
<td>Dr. Akhilesh</td>
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<tr>
<td>12</td>
<td>Importance of ornamental gardens.</td>
<td>2</td>
<td>Dr. Desh Raj</td>
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<tr>
<td>13</td>
<td>Planning of ornamental gardens.</td>
<td>1</td>
<td>Dr. Desh Raj</td>
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<tr>
<td>14</td>
<td>Types and styles of ornamental gardens.</td>
<td>2</td>
<td>Dr. Desh Raj</td>
</tr>
<tr>
<td>15</td>
<td>Uses of trees, shrubs, climbers, house plants and seasonal flowers in the gardens.</td>
<td>5</td>
<td>Dr. Desh Raj</td>
</tr>
<tr>
<td>16</td>
<td>Package of practices for rose, chrysanthemum, marigold and tuberose.</td>
<td>4</td>
<td>Dr. Desh Raj</td>
</tr>
<tr>
<td>17</td>
<td>Cut flower crops- gladiolus, carnation, chrysanthemum and lilium.</td>
<td>3</td>
<td>Dr. Desh Raj</td>
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<tr>
<td><strong>Practical</strong></td>
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<tr>
<td>1</td>
<td>Planning and layout of kitchen garden</td>
<td>1</td>
<td>Dr. Akhilesh</td>
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<tr>
<td>2</td>
<td>Identification of important vegetable seeds and plants</td>
<td>2</td>
<td>Dr. Akhilesh</td>
</tr>
<tr>
<td>3</td>
<td>Raising of vegetable nurseries; transplanting of vegetable seedlings in main field</td>
<td>1</td>
<td>Dr. Akhilesh</td>
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<tr>
<td>4</td>
<td>Seed extraction in tomato and brinjal</td>
<td>1</td>
<td>Dr. Akhilesh</td>
</tr>
<tr>
<td>5</td>
<td>Intercultural operations in vegetable plots</td>
<td>1</td>
<td>Dr. Akhilesh</td>
</tr>
<tr>
<td>6</td>
<td>Seed production in vegetable crops;</td>
<td>1</td>
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<tr>
<td>7</td>
<td>Harvesting indices of different vegetable crops, Grading and packing of vegetables;</td>
<td>2</td>
<td>Dr. Akhilesh</td>
</tr>
<tr>
<td>8</td>
<td>Identification of ornamental plants (trees, shrubs, climbers, house plants, palms, etc.) and development of garden features;</td>
<td>3</td>
<td>Dr. Desh Raj</td>
</tr>
<tr>
<td>9</td>
<td>De-potting, re-potting and maintenance of house plants.</td>
<td>1</td>
<td>Dr. Desh Raj</td>
</tr>
<tr>
<td>10</td>
<td>Training and pruning of rose (standards, hybrid T roses, scented roses) and chrysanthemum (pinching and disbudding);</td>
<td>2</td>
<td>Dr. Desh Raj</td>
</tr>
<tr>
<td>11</td>
<td>Planning and layout of garden designs for public and private areas</td>
<td>1</td>
<td>Dr. Desh Raj</td>
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<tr>
<td>12</td>
<td>Layout of lawns and maintenance</td>
<td>1</td>
<td>Dr. Desh Raj</td>
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<tr>
<td>13</td>
<td>Prolonging shelf life of cut flowers</td>
<td>1</td>
<td>Dr. Desh Raj</td>
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</tbody>
</table>
| 14 | *Visit to commercial vegetable/Floriculture farms*  
  * Date to be fixed on holiday in consultation with Dean, COA | -- | |
IMPORTANCE OF VEGETABLES

India: second largest producer of vegetables in the world after China
- Area under vegetables: 8.98 million ha
- Total production: 156.3 million tonnes
- Productivity per ha: 17.4 t/ha
- Top five states (area wise): WB, UP, Bihar, AP, Orrisa, Guj
  • Highest productivity: Tamilnadu
  • India’s share in world production: 13-14%.

Himachal Pradesh
- Area under vegetables: 72,000 ha
- Production: 12,50,700 metric tonnes
- Productivity: 181 q/ha.

Important vegetables grown in different zones of Himachal Pradesh:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Range</th>
<th>Vegetables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone I</td>
<td>&lt;914 m, 60-100 cm rainfall</td>
<td>Tomato, frenchbean, okra, ginger, brinjal, cucumber, kharif onion, pea.</td>
</tr>
<tr>
<td>Zone II</td>
<td>915-1523 m, 90-100 cm</td>
<td>Tomato, French bean, capsicum, pea, garlic, potato, cabbage, cauliflower, cucumber.</td>
</tr>
<tr>
<td>Zone III</td>
<td>1524-2742 m, 100-200 cm</td>
<td>Pea, frenchbean, cabbage, potato, cauliflower, bean, carrot, turnip, radish and beet.</td>
</tr>
<tr>
<td>Zone IV</td>
<td>&gt; 2743 m, 25-40 cm</td>
<td>Pea, potato, cabbage, hops, temperate onion.</td>
</tr>
</tbody>
</table>

Olericulture: derived from two Greek holar/holas + cultra: The science of vegetable cultivation is termed as olericulture.
- 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.

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.

Definition 2: 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. Few exceptions are Jack fruit (Woody plant but used as raw), Lotus (Flower + vegetable), and Banana/Papaya (Fruit + vegetable).

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’.

Importance of Vegetables:
The country is now almost self-sufficient on food front. The researchers are now being directed for improvement in quality of agricultural produce. Self-sufficiency in true sense can be achieved only when each individual is assured of a balanced diet. Our dietary situation which is mostly cereal based is really alarming. Cereals chiefly supply carbohydrates which constitute only a part of the diet. Chief deficiencies in our diet are calories, proteins, vitamin A and riboflavin.
Dieticians advocate intake of 300g of vegetables every day to make our diet balanced along with other diets. 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.

- 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 beneficial in protecting against some degenerative diseases.
- Neutralizes the acids produced during digestion of proteinaceous and fatty foods.
- Provide valuable roughage which promotes digestion and helps in preventing constipation.

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

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Deficiency causes</th>
<th>Nutrient rich vegetables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrates</td>
<td>Serve as a chief source of energy in the food. It is found in vegetables mainly in the form of starch and cellulose.</td>
<td>Sweet potato, Potato, cassava, carrot, taro, pea, onion, elephant foot yam etc.</td>
</tr>
<tr>
<td>(400-500 g)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>• Retarded growth in children.</td>
<td>Pea, cowpea, broad bean, lime bean, fenugreek leaves, celery, drumstick</td>
</tr>
<tr>
<td>(60-70 g)</td>
<td>• 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.)</td>
<td></td>
</tr>
<tr>
<td>Fats</td>
<td>Vegetables contain very low fats (ranges between 0.1 and 0.2%)</td>
<td>Chilli, sweat pepper, brinjal, snake gourd,</td>
</tr>
</tbody>
</table>

*Values in parenthesis is the daily requirement of an adult

II. Protective foods:
  a) Vitamins:

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Deficiency causes</th>
<th>Nutrient rich vegetables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>• Night blindness, Xerophthalmia,</td>
<td>Carrot, Amaranthus, Palak, Spinach,</td>
</tr>
<tr>
<td>Vitamin</td>
<td>Deficiency</td>
<td>Foods Containing</td>
</tr>
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<tr>
<td><strong>(5000 IU)</strong></td>
<td>Frequent respiratory infection.</td>
<td>Fenugreen leaves, broccoli, kale, tomato</td>
</tr>
</tbody>
</table>
| Thiamin (B1) 1.2 mg | * beri-beri disease  
* Loss of appetite.  
* Dilation of heart. | Palak (0.56 mg), chilli (0.39 mg), sweat pepper, broccoli, lettuce, celery, Asparagus. |
| Riboflavin (B2) 1.7 mg | * Ulcers in the oral cavity.  
* Loss of hair & dry scaly skin.  
* Cracked lips. | Palak (3.3 mg), Aamaranth (1 mg), bitter gourd, chilli, radish, lettuce, carrot, pea. |
| Niacin (19 mg) | * Pellagra  
* Nervous break down.  
* Stomach and intestinal disorder.  
* Sore tongue. | Widely distributed in vegetables. |
| Pyridoxin (B6) | Ulceration of oral cavity, anaemia, skin diseases (acrodynia). | 
| 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 |

**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, osteomalacia 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.

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

**IV. 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 (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.
  - Vegetable seed: 142 crores.
  - Processed vegetables: Tomato, pea (140 crores).
  - Dehydrated: Ginger, garlic, turmeric, pea.

Diversification minimizes weather and pests risk involved. With the rapid industrialization, growing urbanization and higher employment opportunities and income level, purchasing capacity is multiplying and awareness for nutrition is increasing which creates more demand of vegetables. The emerging modern retail business and new innovations to minimize post harvest losses would create more opportunities for processing, value addition, export, seed business and other ancillary services.

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.
TYPES OF VEGETABLE FARMING

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

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:
1. Efficient and effective use of land for growing essential vegetables for use of family.
2. Saves some money as vegetables are quite costly in the market (fresh vegetables).
3. Play important part in vegetable production.
4. Constitute a very healthy hobby and the spare time of the family is well utilized.
5. Kitchen gardening should be aimed at giving a continuous supply of vegetables to a family throughout the year.
6. Pesticide residue free vegetables (health point of view).
7. Training/education of children and to develop a sense of co-operation.

Design 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: Peri-urban farming is known for its important role in providing self-employment besides enhancing the food security, helpful in poverty alleviation, waste management, community resource development and environmental sustainability.

- 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 focusing 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 prices are paid on contract basis on weight and quantity of the produce.
- 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 favourable 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 the 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, CO₂ 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 significantly increases.
- Year-round production

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 (120 m²) 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.
- Specialized knowledge is required to handle the seed crop i.e. curing, threshing, cleaning, grading, packing and storage.

Types of seeds:

(i) Nucleus/breeder seed is produced by the person or organization which gives out the variety.
(ii) Foundation seed is multiplied by government departments or by organization like NSC.
(iii) Certified/Registered seeds usually multiplied by grower.

- This is an expanding industry in India and has a good future.
- India has varied climatic conditions extending from the temperate Himalayas to tropical South where all the vegetable seeds can be profitably grown.
- There is an immense potential for exporting seeds to foreign countries.
- To expand foreign trades in this industry, the quality of seed produced must be raised.
- The seed act was enforced to maintain the quality of the seed.

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.
- This type of vegetable cultivation is a specialized technique and an art itself.

Organic Vegetable Gardening

In 1980, organic farming was defined by the USDA 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
- Marine, animal, and plant by-products
- Biorational, microbial, and botanical pesticides, and other natural pest control products

- The Organic Foods Production Act, a section of the 1990 Farm Bill, enabled the USDA to develop a national program of universal standards, certification accreditation, and food labeling.
In April 2001, the USDA released the Final Rule of the National Organic Program. This federal law stipulates, in considerable detail, exactly what a grower can and cannot do to produce and market a product as organic.

**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.
Classification of vegetable crops

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

2. Classification based on climatic zones
3. Classification based on the growing seasons.
4. Classification based on economic parts used as vegetables.
5. Classification based on method of cultivation

Botanical classification: Plants are divided into four great groups or sub-communities e.g.

a) Thallophyta: Thallophytes
b) Bryophyta: mosses
c) Pteridophyta: ferns
d) Spermatophyta: seed plants

Spermatophytes are further divided into two divisions Gymnospermae and Angiospermae. Gymnosperm produces naked ovule or ovules are not enclosed in the ovary. Angiosperms produce ovules enclosed in an ovary. All vegetable crops belong to division Angiospermae of sub-community spermatophyte. Angiospermae is further divided into two classes Monocotyledonae and Dicotyledonae.

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

<table>
<thead>
<tr>
<th>Common name</th>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Monocotyledonae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onion (Piyaj)</td>
<td>Alliaceae</td>
<td>Allium</td>
<td>cepa</td>
</tr>
<tr>
<td>Sweet corn (Makki)</td>
<td>Poaceae</td>
<td>Zea</td>
<td>mays</td>
</tr>
<tr>
<td>B. Dicotyledonae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomato (Tamatar)</td>
<td>Solanaceae</td>
<td>Solanum</td>
<td>lycopersicum</td>
</tr>
<tr>
<td>Brinjal (Baingan)</td>
<td></td>
<td></td>
<td>melongena</td>
</tr>
<tr>
<td>Bell Pepper (Shimla Mirch)</td>
<td>Solanaceae</td>
<td>Capsicum</td>
<td>annuum</td>
</tr>
<tr>
<td>Okra (Bhindi)</td>
<td>Malvaceae</td>
<td>Abelmoschus</td>
<td>esculentus</td>
</tr>
<tr>
<td>French bean (Frasbean)</td>
<td>Leguminosae</td>
<td>Phaseolus</td>
<td>vulgaris</td>
</tr>
<tr>
<td>Cucumber (Khira)</td>
<td>Cucurbitaceae</td>
<td>Cucumis</td>
<td>sativus</td>
</tr>
<tr>
<td>Bottle gourd (Ghiyya)</td>
<td></td>
<td>Lagenaria</td>
<td>siceraria</td>
</tr>
<tr>
<td>Bitter gourd (Karela)</td>
<td></td>
<td>Momordica</td>
<td>charantia</td>
</tr>
<tr>
<td>Musk melon (Kharbuja)</td>
<td></td>
<td>Cucumis</td>
<td>melo</td>
</tr>
<tr>
<td>Water melon (Tarbooj)</td>
<td></td>
<td>Citrullus</td>
<td>lunatus</td>
</tr>
</tbody>
</table>
Classification based on climatic zones:

i. **Tropical vegetables**: Tomato, brinjal cucumber, okra, French bean, cowpea, most of cucurbits, amaranthus, cluster bean.

ii. **Sub-tropical vegetables**: Okra, cucumber, brinjal, chilli, tomato, gourds (all), ginger, turmeric, cowpea.

iii. **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 classification 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, sweet potato, cassava, yam drumstick, elephant foot, yam. |

**Classification based on growing season**:

i. **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.

ii. **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) |

**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. |
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:

<table>
<thead>
<tr>
<th>Long day vegetables and shorter night (8-10 hours of dark)</th>
<th>Short day vegetables (10-14 hours dark)</th>
<th>Day neutral vegetables (Photo insensitive) not influenced by day length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onion, cabbage, cauliflower, potato, radish, lettuce, knolkhel, turnip, carrot</td>
<td>Sweet potato, lablab bean, winger bean, cluster bean</td>
<td>Tomato, brinjal, chilli, okra, frenchbean, cucumber, cowpea.</td>
</tr>
</tbody>
</table>

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:

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

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

Classification based on economic parts used as vegetables:

<table>
<thead>
<tr>
<th>Leaves</th>
<th>Flower</th>
<th>Fruits</th>
<th>Modified stem</th>
<th>Under ground (plant parts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage, palak, fenugreek, amaranthaus, lettuce, celery, parsley</td>
<td>Broccoli, Globe artichoke</td>
<td>Tomato, brinjal, chilli, beans, okra, and all cucurbits</td>
<td>Knolkhel, cauliflower, asparagus</td>
<td>Carrot, turnip, beet, radish, potato, sweet potato, taro, ginger, garlic, onion, elephant foot yam, cassava</td>
</tr>
</tbody>
</table>

From the above classifications, the vegetables categorized in a particular group have different method of their cultivation. This means that these groups are unable to avoid repetition with respect to their method of cultivation. Therefore, there is necessity to classify the vegetables in such groups where they have almost similar cultivation techniques.

Classification based on methods of culture: 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).
**Chapter 4**

**Production technology of important vegetable crops**

**Tomato**

Botanical name  
*Solanum lycopersicum*

Primary centre of origin  
Peru

Secondary centre of origin  
Mexico

Popularly known as  
Poor man’s Orange

**Importance and uses:**
- The fruits are eaten raw or cooked.
- Its large quantities is used to produce soup, juice, ketchup, puree, paste and powder.
- It supplies Vitamin A, C, B<sub>1</sub>, B<sub>2</sub> and dried tomato juice retains Vitamin C.
- It adds variety of colour and flavours to the food.

**Plant Growth Habit in tomato**

Tomato varieties are grouped into two broad categories based on their growth habit:
1. Determinate or dwarf or bush type
2. Indeterminate or tall type

<table>
<thead>
<tr>
<th>Determinate (Dwarf growth)</th>
<th>Indeterminate (Tall growth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflorescence occur more frequently on every internode until terminal ones are formed</td>
<td>Inflorescence cluster occurs at every third internode</td>
</tr>
<tr>
<td>Plant growth stops at terminal point with a flower cluster (self topping).</td>
<td>The main branch continues growing indefinitely with fruit formation until frost occurs.</td>
</tr>
<tr>
<td>Plants are compact and their fruits ripen more closely together</td>
<td>The fruits keep setting until frost</td>
</tr>
</tbody>
</table>

**Soil Requirement:** Well drained, fairly light fertile loam with a fair moisture holding capacity is the most ideal soil for tomato cultivation.

**Climate:** Tomato is a warm season crop which require long season to produce a profitable crop and highly susceptible to frost. High temperature and high humidity favours development of foliar diseases. Dry wind results in dropping of flowers. Seeds germinate at a temperature range of 15.5 to 30°C, optimum being 25°C. Night temperature is the critical factor in fruit setting, the optimum range is 15-20°C.

**Important Varieties for Plains**
- Indian Agricultural Research Institute, New Delhi: Pusa Rohini, Pusa Early Dwarf, Pusa 120, Pusa Ruby, Pusa Sadabahar, Pusa Uphar, Pusa Sheetal, Pusa Gaurav
- Indian Institute of Horticulture Research, Hasserghata (Bangaluru): Arka Abha, Arka Vikas, Arka Saurabh, Arka Alok, Arka Abhijit, Arka Shreshtha, Arka Vardan (Root knot nematode resistant), Arka Ananya (resistant to Tomato Leaf Curl Virus and bacterial wilt)
- Indian Institute of Vegetable Research, Varanasi: Kashi Amrit, Kashi Hemant, Kashi Sharad, Kashi Anupam, Kashi Vishesh (resistant to Tomato Leaf Curl Virus),

**Hybrids:** Kt-4, Pusa Hybrid 1, Pusa Hybrid 2, Pusa Hybrid 4, Arka Vardan, Arka Meghali, Arka Vishal, Arka Samrat, Kashi Hybrid 1, Kashi Hybrid 2

**CULTIVARS/HYBRIDS FOR PROCESSING:** Punjab Chhuhara, Roma, Pusa Gaurav, Pusa Uphar, Arka Saurabh, HS-110, S-152, Naveen (Hybrid), Arka Ahuti and A. Ashish
- **For long distance:** Punjab Chhuhara, Roma, Pusa Gaurav, Pusa Uphar
- **Low temperature resistant:** Pusa Sheetal, Sheetal Hybrid.
- **High temperature resistant:** Pusa Hybrid-1.
- **Both high and low temperature:** Pusa Sadabahar
- **Functional male sterile mutants:** Katrain Hybrid 1 and 2

**Cultivars recommended for cultivation in Himachal Pradesh:**

**OP varieties:** Solan Vajra, Solan Gola, Yashwant (A-2), Roma, Sioux, Marglobe, Best of All, Him Pragati, Palam Pink (BWR), Palam Pride (BWR)

Hybrids: MTH-15, Solan Shagun, Solan Sindhir, Solan Garima, Rupali, Naveen

**AGRONOMIC PRACTICES**

**Nursery sowing & transplanting time in India**

<table>
<thead>
<tr>
<th>Crop/Region</th>
<th>Spring-summer</th>
<th>Autumn crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Indian plains</td>
<td>Late Nov (mid Jan)</td>
<td>July-Aug (Aug-Sept)</td>
</tr>
<tr>
<td>Eastern India</td>
<td>Nov (Late Dec)</td>
<td>Aug-Sept (Sept-Oct)</td>
</tr>
</tbody>
</table>

*in parenthesis: Transplanting time is given*

**Himachal Pradesh**

<table>
<thead>
<tr>
<th>Region</th>
<th>Nursery sowing time</th>
<th>Transplanting time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Hill</td>
<td>1. Nov (Poly-house)</td>
<td>1. Jan end or Feb</td>
</tr>
<tr>
<td></td>
<td>2. February</td>
<td>2. February- March</td>
</tr>
<tr>
<td></td>
<td>3. June- July (rainfed areas)</td>
<td>3. June- August</td>
</tr>
<tr>
<td>Mid Hill</td>
<td>1. February-March</td>
<td>1. March- April</td>
</tr>
<tr>
<td></td>
<td>2. May-June (In-determinate)</td>
<td>2. June - July</td>
</tr>
<tr>
<td>High Hill</td>
<td>April</td>
<td>May end</td>
</tr>
</tbody>
</table>

**Nursery Raising:** For better survival in the field, it is advisable to harden the seedlings. Plants are allowed to nearly wilt for 2-3 days before watering and this practice can be repeated two- three times. Such seedlings can withstand better the extremes of temperature. Seedlings become ready for transplanting in 4-5 weeks time. Seedlings 5mm in diameter are better and about 15cm in length are the best for transplanting.

**Soil preparation and transplanting:** Tomato 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 leveling. Tomato is normally planted in raised beds of 60-75 cm width.

Transplanting should be done during late afternoon and the seedlings are placed on side of the beds. This provides ample moisture for the plants to survive.

**Seed Rate:** Open pollinated varieties: 400-500g

Hybrids: 150-200g

**Spacing:** Determinate varieties should be transplanted at a spacing of 60cm between rows and 45cm between plants to plant. On the other hand, indeterminate varieties should be planted at a spacing of 90cm between rows and 30cm with in rows.

**Manures and fertilizers:** Apply well rotten/decomposed farmyard manure (FYM) @ 200-250 quintals per ha at the time of field preparation. In addition, apply 75-100 kg N, 50-75 kg phosphorus (P₂O₅) and 50-60 kg potassium (K₂O) kg per hectare. Apply one third of nitrogen, full dose of phosphorus and half of potassium at the time of planting. Another one third of nitrogen is to be applied after one month of transplanting. Remaining half of potassium should be applied along with one third nitrogen after two months of transplanting.

**Table:** Recommended dose of N, P and K fertilizers and their time of application

<table>
<thead>
<tr>
<th>Recommended dose</th>
<th>Farmyard</th>
<th>Nitrogen</th>
<th>Phosphorus</th>
<th>Potassium</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Variety</th>
<th>Manure (q/ha)</th>
<th>(Kg/ha)</th>
<th>(Kg/ha)</th>
<th>(Kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open pollinated varieties</td>
<td>250</td>
<td>75-100</td>
<td>50-75</td>
<td>50-60</td>
</tr>
<tr>
<td>Hybrids</td>
<td>250</td>
<td>150-180</td>
<td>100-150</td>
<td>80-120</td>
</tr>
</tbody>
</table>

**Time of application and dose to be applied:**

<table>
<thead>
<tr>
<th>Time of Application</th>
<th>Application Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>At planting time</td>
<td>Full dose of Farm yard manure and phosphorus + one third of nitrogen and half of potassium is applied</td>
</tr>
<tr>
<td>After one month of transplanting</td>
<td>Another one third of nitrogen should be applied</td>
</tr>
<tr>
<td>After 2 months</td>
<td>Remaining one third of nitrogen and half of potassium is applied</td>
</tr>
</tbody>
</table>

During rainy season in tomato, foliar spray of urea @ 10% at an interval of 10 days is beneficial as it increases anther formation and more number of fruits per plant.

**Micronutrients:** Boron, Zinc and manganese deserve special attention in tomato. Boron deficiency causes reduction in root growth, swollen hypocotyls and cotyledons, brittle leaves and necrosis of shoot apex. It also leads to fruit cracking. Soil application of 20-30 kg of borax per hectare is beneficial. Zn deficiency occurs in high pH soils.

**Interculture and weed control:** Tomato is a widely space planted crop. Hence, scope of weeds is more in initial stages. The most critical period of crop for weed competition is between 30-50 days after transplanting. Therefore, herbicides can be used to control weeds in initial stages of plant growth while hand weeding can be practiced in later stages of plant growth along with fertilizer top dressings. Application of Alachlor (Lasso) @ 2kg a.i./ha (4 litres/ha in 750 litres of water) before transplanting is beneficial for controlling annual and broad leaved weeds. Pendimethalin (Stomp) @1.2 kg a.i./ha (4 litres/ha) or Fluchloralin (Basalin) @ 1.32 kg a.i./ha (2.5 litres/ha) can also be used before transplanting if there is problem of annual weeds only.

**Use of growth hormones:**
- Flower cluster and whole plant sprays with GA₃ at 50 and 100 ppm hastens fruit set and advanced harvesting by one week.
- Seedling treatment with NAA (0.1 ppm) gave better quality fruits. Seedling treatment by soaking them for 24 hours in dark in NAA at 0.1 ppm showed higher fruit set, early and increased total yield.

**Irrigation:** Careful irrigation is required for better growth of tomato crop which should be supplied at right time. Both over-watering and insufficient irrigation is harmful. Insufficient irrigation in tomato arrests flower development, dropping of flowers and cease fruit growth. Flowering and fruit development are the most critical stages of irrigation.

**Harvesting:** Tomato fruits are harvested at different maturity stages depending upon the purpose for which it is used and distance over which they are to be transported. Fully developed mature green fruits are harvested for long distance transportation. Such fruits ripen after reaching the market and develop good colour under favourable conditions. The following stages of maturity have been recognized in tomato:

1. **Immature green stage:** Fruits are green but have attained the normal size. The seeds are not fully developed and not covered with jelly like substances. The fruits do not give the actual colour. The fruits are harvested at this stage when they are to be transported over a long-long distance.

2. **Mature green stage:** the fully grown fruits with a brownish ring at stem scar, removal of calyx, light green colour at blossom end changes to yellowish green and seeds are surrounded by jelly like substances filling the seed cavity. Fruits develop good colour when ripen under favourable conditions. Harvested for long distance transportation and ripen after reaching the market.

3. **Turning stage (breaker stage):** 1/4th of the fruit especially at blossom end shows pink colour. These fruits are harvested for local market.
4. **Pink stage**: $\frac{3}{4}$th of the surface shows pink colour
5. **Hard ripe stage**: Nearly all red or pink with firm flesh
6. **Over ripe**: Fully coloured and soft. Suitable for processing and ensure desired quality and red colour in product.

Fruits at turning stage ($\frac{1}{4}$th of the fruit especially at blossom end shows pink colour), pink stage ($\frac{3}{4}$th of the surface shows pink colour) and hard ripe stage (nearly all red or pink with firm flesh) are harvested for local market. Over ripe fruits (Fully coloured and soft) are suitable for processing which ensure desired quality and red colour in processed products.

**Fruit Yield:**
- Open pollinated varieties: 250 – 300 quintals per hectare
- Hybrids: 500-800 quintals per hectare

**Post Harvest Handling:**

<table>
<thead>
<tr>
<th>Grading</th>
<th>Tomato fruits are categorized into four grades namely, Super A, Super, Fancy, Commercial. Different grades determine the prices in the market.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packing</td>
<td>Fruits are in general packed in bamboo or wooden baskets, Plastic boxes or plastic crates for marketing.</td>
</tr>
<tr>
<td>Storage</td>
<td>Mature green fruits can be stored for one month at 12-15°C temperature coupled with 85-90% relative humidity. Ripe fruits, on the other hand can be stored for 10 days at 4-5°C.</td>
</tr>
</tbody>
</table>

**Disease management**

1. **Damping off** (*Pythium aphanidermatum, Rhizoctonia solani)*: The fungus attack usually starts on the germinating seed, and further spread to the hypocotyl, basal stem, and developing tap-root.
   **Management:**
   - Drench the nursery bed with 5 litre formalin dissolved in 100 litres of water 15 days before sowing.
   - Before sowing, hot water treatment of seed at 52°C for 30 minutes should be done.
   - Spray mancozeb (2.5g /L), carbendazim (1g /L) on nursery seedlings.

2. **Buck eye rot** (*Phytophthora nicotianae)*: Symptoms appear on fruits as a brownish spot often at point of contact between fruit and soil.
   **Management:**
   - Grow resistant varieties.
   - Proper staking and drainage should be ensured.
   - Spray Ridomil MZ @ 2g per litre of water or mancozeb or zineb @ 2.5 g per litre of water at 5-7 days interval.

3. **Bacterial Wilt** (*Ralstonia solanacearum)*: Deadly disease of tomato which results in wilting of plant, stunting plant growth, and brown vascular system
   **Management:**
- Crop rotation with Cruciferous vegetables
- Grow recommended resistant varieties such as Palam Pink, Palam Pride etc.
- Transplant disease free seedlings.
- Spray with streptocycline @ 200ppm at 7 days interval.

4. **Early blight** (*Alternaria solani*): This disease appears on the foliage at any stage of plant growth. It occurs on the plants as small, black lesions mostly on the older foliage. In later stages, concentric rings also appear on the fruit.

Management:
- Seed treatment with Carbendazim @ 2.5 g per kg of seed.

5. **Late blight** (*Phytophthora infestans*): The symptoms are almost similar as that appear on potato crop. Spray Dithane-M-45 (0.25%) 

6. **Leaf curl virus**: Downward rolling and crinkling of the leaves. The newly emerging leaves exhibit slight yellow colouration and later they also show curling symptoms. The older leaves become leathery and brittle. There is drastic reduction in the size of nodes and internodes. The infected plants remain stunted in growth. It is transmitted by white fly.

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.
- Spray triazophos (0.04%) or lambda-cyhalothrin (0.004%).

Insect-pests

1. **Tomato fruit borer**: External symptoms appear in the form of a bored hole. Initially, the larvae feed on tender foliage but later on it moves on to flower buds, flowers and developing fruits. The caterpillars make holes into fruits by keeping half of their body inside the fruits and half outside and render them unfit for market.

Management:
- Crop transplanted late in summer (June) escapes the damage of fruit borer.
- Inundative release of egg parasitoid, *Trichogramma chilonis* and *T. brasssiliensis* @ 50,000-75,000 adults/ha
- Apply nuclear polyhedrosis virus (NPV) @ 250-500 LE/ha
- Application of *Bacillus thuringiensis* alone (1.0 litre/ ha) at flowering and fruit setting stage
- Foliar application of carbaryl (0.1%)/ deltamethrin (0.0028%) and acephate (0.05%) when one larva per five plants is observed. Observe a waiting period of 10 days before picking fruits.
- Use of African marigold as trap crop.

2. **Fruit fly**: The maggots (larvae) after hatching feed on pulp of the fruits and render them unfit for human consumption.

Management:
- Field sanitation *i.e.* removal and destruction of dropped fruits and infested fruits daily to minimize the pest intensity
- Use of pheromone traps (Palam trap @ 25/ha) for monitoring pest population
Application of malathion (0.05%) cover spray which kill the insects on contact or a bait spray that attracts and kill the adults. Bait spray is prepared by adding 50 g gur + 10 ml malathion in 10 L water.

Physiological disorders in tomato:

1. Blossom End Rot: A very common and destructive disorder. Rotting of fruits starts at blossom end of the fruit. Deficiency of Mg and Ca is the main cause. It can be managed by spraying calcium chloride @ 0.5% at fruit development stage. Also apply balanced irrigation and ensure proper staking.

2. Cracking of fruits: Cracking of fruits at stem end is common and often results in large losses. Cracks appear to develop at maturity or ripening stage than mature green or turning stage. Deficiency of boron and long dry spell followed by heavy watering are the main reason of cracking. Soil application of 20-30 kg of borax per hectare is beneficial. Application of proper irrigation at right stage is also very important.

3. Puffiness/ Hollowness: The outer wall continues to develop but the growth of remaining internal tissues is retarded. This results in light weight fruits which lack firmness and are partially filled. High or low temperature, low soil temperature and high soil moisture are predisposing factors. Single application of 4-CPA @ 20mg/litre or CPPU @ 20-25mg/litre results in reduction of this problem.

4. Sunscald: Exposed fruits either green or nearing ripeness scald readily during extreme heat. White or grey colour appears on green or yellowish red fruits. More sun intensity cause injury to fruits in May & June (11-3 pm) during peak heat period. Grow varieties having heavy foliage which provide greater protection to fruits from sun rays.

5. Cold Injury or Low temperature injury: Tomato is very sensitive to frost. At near freezing temperature, vines freeze, get withered and desiccated. Fruits show much severe symptoms as they become soft, water soaked and dull coloured. Cover the fruits with foliage to manage this problem. Planting should be adjusted in such a way that it does not coincide with frost.

6. Blotchy Ripening: Ripening of fruits is not uniform as certain portion develop colour while in others greenish-yellow or whitish patches can be seen on ripe fruits particularly in stem end portion. The possible reasons are imbalance of N and K nutrition especially when K is deficient. Even, more days or weeks of alternate sun and cloud during fruiting also lead to blotchy ripening. Balanced fertilization and proper irrigation help in managing this problem.
Methods of seed extraction in tomato

1. **Juice and seed extraction:***
   - The whole lot of tomato fruits of a particular variety is taken to some processing unit, where juice is removed for other processing purposes and seed is extracted separately.
   - This is the method being followed by National Seed Corporation and other seed companies as the seed cost is reduced in this way.

2. **Fermentation method:***
   - The selected ripe fruits are crushed by hand.
   - Keep entire mass for 24-72 hours depending upon the temperature conditions.
   - The pulp will float at the top and the seed will settle at the bottom.
   - Remove the fermented mass and clean the seeds with fresh water.
   - Dry the seeds.
   - Long fermentation period may damage the seed.
   - Seed cost is very high in this method and usually followed for nucleus seed or maintenance of seed stocks by the institutions.

3. **Acid treatment:**
   - Cut the selected fruits into two halves and scoop out the slimmy mass containing seed in a vessel.
   - Treat the mass with HCl @ 75-100ml/12 kg of material. Seed is separated in 15-30 minutes from the slimmy mass.
   - Wash the seeds and dry them.

4. **Alkali method:**
   - Cut the selected fruits into two halves and scoop out the slimmy mass containing seed in a vessel.
   - Treat the mass with equal volume of washing soda (300g dissolved in 4 litres of water).
   - The mixture is allowed to stand overnight.
   - Next day all the seeds will settle down at the bottom.
   - Seeds are washed thoroughly and dried.

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**Brinjal**

Botanical name: *Solanum melongena*  
Family: Solanaceae  
Origin: South East Asia-India.  

**Importance and uses**

- It is valued for its tender unripe fruits used as a cooked vegetable.
- White brinjal is said to be good for diabetic patients.
- It cures toothache if fruits are fried in sesamum oil.
- It acts as an excellent remedy for those suffering from liver complaints.
- It is rich in vitamin A and B.

**Soil:** It can be grown practically on all soils from light sandy to heavy clay. Silt loam and clay loam soils are generally preferred. The soil should be deep, fertile and well drained. pH 5.5-6.8.

**Climate:** It is a warm season crop and susceptible to severe frost. A long and warm growing season is desirable for its successful cultivation. It grows best at a temperature of 21-29 °C.

Brinjal is also known as “Poor man’s crop”. The other names of brinjal are “Aubergine”, “Guinea squash”, Egg plant. Bitterness in brinjal is due to Solasodine.
Temperature below optimum (21°C) affects yield and quality and result in deformed fruits. It can tolerate drought and excessive rainfall and remains vegetative under high temperature and humidity.

**Important varieties recommended for different regions of India:**
- **IARI:** Pusa Shymala, Pusa Purple Long, Pusa Purple Cluster, Pusa Kranti, Pusa Bhairav, Pusa Anmol (H), Pusa Hybrid 5 (long), Pusa Hybrid 6 & 9 (round),
- **IIHR:** Arka Sheel, Arka Shirish, Arka Kusumkar, Arka Navneet (Hybrid), Arka Nidhi, Arka Keshav, Arka Neelkanth
- **PAU:** Punjab Chamkila, Punjab Sadabahar, Punjab Barsati, Punjab Neelam, PH-4, Selection-4,
- **GBPUAT, Pantnagar:** Pant Samrat, Pant Rituraj, Pant Brinjal Hybrid-1
- **Others:** Hisar Jamuni, Hisar Shyamal Azad Kranti, T-3, Annamalai, Surya, Phule Hybrid 1, Aruna, Manjarigota

**Cultivars suitable for growing in Himachal Pradesh:** Pusa Purple Long, Pusa Purple Cluster, Pusa Kranti, Pusa Anupam, T-3, Arka Keshav, Arka Nidhi, Hisar Shyamal

**Agronomic practices**

**Nursery sowing and Planting time:**

<table>
<thead>
<tr>
<th>Crop/Region</th>
<th>Spring-summer</th>
<th>Rainy</th>
<th>Autumn crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>NI plains</td>
<td>Nov(mid Jan-Feb)</td>
<td>Mar-May(April-June)</td>
<td>June-July(July-Aug)</td>
</tr>
<tr>
<td>East and South Indian conditions: all the year round. Main season: July-August</td>
<td></td>
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</tbody>
</table>

- Shoot and fruit borer- serious problem in Spring-summer crop
- Little leaf and Phomopsis blight- Autumn winter and much more serious in rainy season crop

**Himachal Pradesh**

- **(Low Hills)**
  - 1.Oct- Nov(Poly-house) (Jan end or Feb)
  - 2. Feb- March (March- April)
  - 3. May- June (June- July)
- **Mid Hills**
  - March- May (April- June)
- **High hills**
  - April (May end)

**Soil preparation and transplanting:** Brinjal 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 leveling.

**Seed Rate:** 500-700g (OP), 350-400g (hybrids) 1g seed contains 250 seeds

**Spacing:** Dwarf varieties- 60 × 45 cm, Tall variety- 90 × 60 cm

**Manures and fertilizers:** FYM @200-250 quintals per ha should be applied at the time of field preparation. In addition, apply 75-100 kg N, 50-60 kg phosphorus (P₂O₅) and 50-60 kg potassium (K₂O) kg per hectare. Apply half of nitrogen and full dose of phosphorus and potassium at the time of sowing and remaining nitrogen after one month of sowing.

**Interculture and weed control:** Like tomato, brinjal is also a widely space planted crop. Hence, scope of weeds is more in initial stages. The most critical period of crop for weed competition is between 30-50 days after transplanting. Therefore, herbicides can be used to control weeds in initial stages of plant growth while hand weeding can be practiced in later stages of plant growth alongwith fertilizer top dressings. Application of Alachlor (Lasso) @ 2kg a.i./ha (4 litres/ha in 750 litres of water) before transplanting is beneficial for controlling
annual and broad leaved weeds. Pendimethalin (Stomp) @1.2 kg a.i./ha (4 litres/ha) or Fluchloralin (Basalin) @ 1.32 kg a.i./ha (2.5 litres/ha) can also be used before transplanting if there is problem of annual weeds only.

Irrigation: Same as tomato crop. Apply Irrigation at an interval of one week in summer season and 10-15 days during winter. In rainy season, it depends upon the frequency and intensity of rain. About 100-110 cm of irrigation water is required.

Use of growth hormones: Application of 2,4-D (2ppm) on pseudo short, short and medium styled flowers leads to higher fruit set. NAA (50ppm) after 30-35 days after transplanting, PCPA (20 ppm) and n-metatolylphthalmic acid (0.1, 0.5%) promoted fruit set.

Fruit set in brinjal is affected by flower type. Four types of flower are formed in brinjal based on style length such as
1. True short style: Ovary rudimentary, stigma is at the base of anthers- no fruit set.
2. Pseudo short style: Ovary is not well developed (rudimentary), stigma is half way up the anthers- no fruit set but can set if growth regulators are applied.
3. Medium styled: Ovary is well developed and pollination is normal. Stigma is near tip of anthers (30-40% fruit setting).
4. Long styled: Big size ovary, stigma proturate or exserted beyond the anther tip, more fruit set under natural conditions (50-60%).

Medium and long style flowers form fruit under natural conditions. Therefore, PGRs can be sprayed to enhance fruit set in brinjal e.g. NAA (50ppm) after 30-35 days of transplanting or PCPA (20 ppm).

Harvesting: Fruits should be harvested when they attain a good size, attractive colour and its surface should not lose its bright and glossy appearance. Timely harvesting of tender fruits increases the total growing period and number of pickings alongwith yield.

Yield: 300-500 q/ha (OP var.), Hybrids: 600-800 q/ha

Post harvest handling
i) Grade: Fruits of brinjal are categorized into three grades e.g. Super, Fancy and commercial
ii) Packaging: Fruits are packed in baskets or gunny bags

Disease management:
1. Phomopsis blight (Phomopsis vexans): Portion of fruit is bleached and gives burning appearance.
   Management:
   ● Treat the seed with thiram @3 gm per kg of seed.
   ● Spray the crop in the nursery with mancozeb.
   ● Grow resistant variety like Pusa Bhairav.

2. Bacterial wilt: Symptoms are similar as that appear in tomato crop. Grow resistant varieties Arka Nidhi, Arka Keshav, Hisar Shyamal.

3. Little Leaf: Caused by Mycoplasma transmitted by leaf hoppers. The affected plants remain shorter in structure. The leaves are malformed, narrow and remain short. Floral parts turn into leaf-like structures. No fruit bearing takes place.
   Management:
   ● Remove and destroy the affected plant at early stage.

Insect-pests:
**Shoot and fruit borer:** It is the most serious pest of brinjal crop. Initially, plant shoots wilt and dry. Later larvae bore below the calyx of fruits. Fruits are filled with frass. The holes are visible on the fruits when larvae come out.

**Management:**
- Grow the resistant/tolerant varieties like Pusa Purple Cluster, Arka Kusumkar.
- Avoid ratooning of brinjal crop, close spacing and continuous planting.
- Remove and destroy the infested shoots.
- Foliar application of carbaryl (0.1%)/fenvalerate (0.01%)/lambda-cyhalothrin (0.004%) is effective. Observe a waiting period of 10 days for harvesting of fruits after spray of these insecticides.

**Seed Production:**

**Isolation distance:** 50-100m.
Fully ripe fruits are harvested for seed extraction. The outer covering is peeled off and the flesh with the seed is cut into thin slices. These are then softened by soaking till the seed is separated from the pulp to which water is added gradually. Keep the material to stand overnight which make the separation of seed from the pulp easier. After separation, dip the seed into the water and reject those seeds which float on the water. Seeds should be dried in partial shade before storing.

**Seed Yield:** 100-120kg/ha

**Chilli and Bell pepper**

**Botanical Name:** Capsicum annuum var. hortense (chilli)  
Capsicum annuum var. grossum (Bell pepper)

**Family:** Solanaceae

**Origin:** New world (American) – Mexico and surroundings of central America

**Types of Capsicum**

a. **Hot pepper:** Pungent due to crystalline volatile alkaloid capsaicin, located mainly in the placenta of fruit, cultivated for vegetables, spices and pickles etc., potential foreign exchange earning crop, and rich source of vitamin A and C.

b. **Sweet Pepper (Shimla Mirch):** Bears bell shaped, non pungent/mild and thick pericarp/fleshed fruit, used as vegetable

c. **Paprika:** Mild in taste and slightly pungent than sweet pepper. Used as spice in European countries, gives colour and mild pungent taste to food stuff, used in pickles and sandwiches

**Importance and uses**

**Chillies**
- It is very important and indispensable items in every kitchen for its pungency, spicy taste and appealing colour which adds to the food.
• Its demand in the pharmaceutical industries is increasing day by day on account of its medicinal values since green chillies are rich in rutin.
• The fruits are rich in vitamins A and C.

**Bell pepper** or Shimla Mirch

- Sweet pepper green, or red or yellow, may be eaten cooked or raw, sliced in salads and pizzas.
- They are also used for pickling in brine, baking and stuffing.
- Sweet pepper imparts a novel flavour in stews.

**Soil:** Chilli can be grown practically on all type of soils except on saline soils provided the soil is well drained and well aerated. Sandy and sandy loam soils are generally preferred for an early crop or where season is short. The soil should be deep, fertile and well drained. It can be raised on the soil with a pH range of 5.8-6.5 for its better growth and development. It is not very sensitive to soil acidity.

**Climate:** Chilli requires a warm humid climate and can tolerate extreme of climate better than tomato and brinjal. It is highly sensitive to frost. The most ideal temperature for its better growth and development is 20-25°C. Temperature 16-32 °C is the most congenial for fruit set but maximum fruit set occurs at 16-21°C. It is mostly grown as a rainfed crop in areas having moderate rainfall with in the range of 60-120cm. Excessive rainfall results in poor fruit set, rotting of fruits and defoliation of plant.

**Varieties recommended for cultivation in India**

**Chilli:** G-3, Pusa Jwala, Pusa Sadabahar, Bhagya Lakshmi (G-4), HC-28, HC-44, Andhra Jyoti, Punjab Lal, Punjab Surkha, Punjab Guchhedar, NP-46A, Pant-C-1, Sindhur, Pant-C-2, X-235,

**Chilli hybrids:** CH-1, CH-3, Arka Meghana, Arka Harita, Arka Sweta, CCH-2, CCH-3

**Bell Pepper:** California Wonder, Yolo Wonder, Arka Mohini, Solan Hybrid 2, Arka Basant, Arka Gourav, Bharat (hybrid), Solan Bharpur, Pusa Deepti (hybrid)

**AGRONOMIC PRACTICES**

**Planting time under Indian conditions**

<table>
<thead>
<tr>
<th>Chilli</th>
<th>In frost free areas</th>
<th>South India</th>
<th>Northern Indian plains</th>
<th>Bell pepper</th>
<th>Nursery sowing &amp; transplanting time for H.P.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 crops</td>
<td>Mainly as Kharif season crop (June to October)</td>
<td>2 crops</td>
<td>Autumn-winter (sowing in Aug)</td>
<td>Nursery Sowing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>i. Autumn-winter (Oct-Nov)</td>
<td>i. December sowing (Feb)</td>
<td>Spring-summer (Nov)</td>
<td>1. November (Poly-house)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Spring-summer (Jan-Feb)</td>
<td>ii. May-June (June-July)</td>
<td></td>
<td>2. February</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii. Rainy season (June-July)</td>
<td></td>
<td></td>
<td>3. May- June (rainfed areas)</td>
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<td></td>
<td></td>
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**Nursery sowing & transplanting time for H.P.**

<table>
<thead>
<tr>
<th>Region</th>
<th>Nursery Sowing</th>
<th>Transplanting Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Hills</td>
<td>1. November (Poly-house)</td>
<td>1. Jan end or Feb</td>
</tr>
<tr>
<td></td>
<td>2. February</td>
<td>2. March</td>
</tr>
<tr>
<td></td>
<td>3. May- June (rainfed areas)</td>
<td>3. June- July</td>
</tr>
<tr>
<td>Mid Hills</td>
<td>March- May</td>
<td>April- June</td>
</tr>
<tr>
<td>High Hills</td>
<td>April</td>
<td>April- May</td>
</tr>
</tbody>
</table>
Seedlings are ready for transplanting when they attain a height of 15 cm with 4 leaves in 4-6 weeks. Plantation is done on flat or raised (rainfall prone areas) beds.

**Soil preparation and transplanting:** Soil should be thoroughly prepared by being ploughed 4 to 5 times before planting the seedlings. Farmyard manure or compost should be applied and incorporated well into the soil. Transplanting should be done during late afternoon.

**Seed Rate:**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Seed Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilli</td>
<td>1 kg/ha (2 or 3 kg/ha for direct seeded)</td>
</tr>
<tr>
<td>Hybrids</td>
<td>400-500 g/ha</td>
</tr>
<tr>
<td>Capsicum</td>
<td>1.25 kg/ha (seed size is bold)</td>
</tr>
<tr>
<td>Hybrids</td>
<td>700 g/ha</td>
</tr>
</tbody>
</table>

**Spacing:**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilli</td>
<td>45 × 45 cm or 60 × 45 cm</td>
</tr>
<tr>
<td>Capsicum</td>
<td>60 × 45 cm</td>
</tr>
</tbody>
</table>

**Manures and fertilizers:** Apply FYM @250q/ha, Nitrogen @75 kg/ha, Phosphorus @60-75 kg/ha and Potassium @50 kg/ha. Full dose of farmyard manure, phosphorus and potassium and half of N should be applied at the time of transplanting. Remaining part of N should be top dressed in two equal parts at an interval of one month each.

**Interculture and weed control:** These are space planted crops, hence scope of weeds is more in initial stages. Hand weedicings at 20 and 40 days after transplanting are essential. Among herbicides, application of Alachlor (Lasso) @ 2 kg a.i./ha (4 litres/ha in 750 litres of water) or Pendimethalin (Stomp) @1.2 kg a.i./ha (4 litres/ha) can be used 24-48 hours before transplanting. These herbicides can be used to control weeds in initial stages of plant growth while hand weeding should be done in the later stages of plant growth along with top dressing of fertilizers.

**Irrigation:** Chillies are grown mostly as rainfed crop though crop should be irrigated when there is insufficient rainfall. A light irrigation is given during the third day of transplanting and thereafter at weekly interval. Gap filling is done during second irrigation after 10 days of transplanting. The most critical stages for irrigation are blooming (flowering), fruit setting and development.

**Use of growth hormones:**

**Chilli:** Foliar application of NAA (50ppm) at full bloom stage can effectively control flower drop with an increase in yield. Treatment with NAA at 20 ppm at first flower opening followed by two sprays at an interval of 30 days is the most effective in increasing the yield, number of fruits per plant, fruit size and contents of capsaicin, ascorbic acid, carbohydrate, protein and fat of chilli. Planofix (10-20 ppm) as foliar spray at flowering stage can reduce flower and fruit drop in chilli.

**Bell Pepper:** Application of 5 ppm Mixtalol (triacontanol) gave the highest fruit yield. Foliar application of NAA at 10 ppm at the time of first flower appearance and 15 days later reduced the flower drop, improved fruit set and increased fruit size.

**Harvesting**

**Chilli:** The picking of fruits depends upon the type and purpose for which they are grown.

1. **Green fruits:** Fruits are harvested when they are still green but fully grown. It needs 5-6 pickings for harvesting the whole crop.
2. Pickles: The fruits are harvested either green or ripe
3. Drying: Red when fully ripe fruits are picked at an interval of 1-2 weeks and harvesting continues for a period of about three months. The ripe chillies are dried under sun for 8-15 days, while commercially it is dried at about 54.4 °C in 2-3 days.

Bell peppers: Fruits are usually harvested and sold when they are of suitable market size and are green, and are relatively firm and crisp. There is a limited demand for the mature red fruits. These are picked with an upward twist which leaves a piece of stem attached. Young, immature peppers are soft and yield readily to mild pressure of the fingers.

Yield:

- **Irrigated conditions:**
  - Green Chilli: 200-300 q/ha,
  - Dry: 15-25 q/ha
- **Rainfed:**
  - Green Chilli: 50-60 q/ha,
  - Dry: 5-10 q/ha
- **Capsicum**
  - OP Varieties: 125-150 q/ha
  - Hybrid: 250-300 q/ha

Post harvest management
As soon as peppers are harvested they should be hydro-cooled to remove field heat quickly. Due to the higher respiratory and metabolic rates of immature fruits, a shorter shelf life can be expected. Peppers should not be stored with ethylene releasing commodities. Waxing peppers before shipping is a very common practice to reduce moisture loss and resist bruising while in transit.

Disease Management:
1. **Anthracnose/Ripe fruit rot/die back:** Spots appear on the fruits which gradually turn brown to black.
   **Management:**
   - Use disease free seed.
   - Spray mancozeb or copper oxychloride (0.25%) or carbendazim (0.1%) and repeat at 8-10 days interval.
   - Go for seed treatment.
2. **Powdery Mildew:** White powdery growth on bottom side of the leaves. The diseased leaves drop off from the plant.
   **Management:**
   - Spray Sulphur based fungicide *i.e.* Sulfex(0.3%) or dinocap (0.05%) at an interval of 15 days interval.
3. **Cercospora leaf Spot:** There is formation of small circular and water soaked spots on the leaves, stems and petioles which are brown with white centre. On coalescence, there is yellowing of leaves and defoliation takes place.
   **Management:**
   - Remove severely affected plants and destroy them.
   - Go for seed treatment with carbendazim.
   - Spray Bavistin @ 0.1 % at 15 days interval.
4. **Bacterial Wilt:** Wilting of plant or stunting growth or yellowing of entire plant are the symptoms. **Management:**
   - Grow resistant varieties such Surjmukhi.
   - Crop rotation with Cruciferous vegetables is recommended.
   - Field sanitation and crop rotation reduces the disease incidence.
6. Chilli leaf curl virus: Leaves curl towards midrib and become deformed. The growth of plant is stunted due to shortened internodes and reduction in leaf size. There is flower drop. The virus is generally transmitted by whitefly. Management is similar as that in tomato leaf curl virus.

Insect-pests management

1. Fruit Borer: Adults lay eggs on the upper and lower side of leaf. Larva bore circular holes and usually thrust only head inside the fruit and may destroy many fruits.
   Management
   - Spray deltamethrin (0.0028%) or spray 5% neem seed kernel extract to kill early stage larvae.
   - Use other insecticides listed for Tomato Fruit Borer.

2. Aphids and Thrips: These insects suck cell sap as a result the plants lose their vigour.
   Management
   - Spray malathion (0.05%) and repeat the spray after 15 days if required.

Cucurbitaceous Crops

Importance
- Cucurbits form an important and a big group of vegetable crops cultivated extensively during summer season.
- This group consist as of wide range of vegetables which are used either as salad, pickling (cucumber) or for cooking (all squashes) or candied or preserved (ash gourd) or as desert fruits (musk melon and water melon).
- All cucurbits belong to the same family cucurbitaceae but genera may be different.
- The cultural requirements of all crops in this group are more or less similar.

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.

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.

Varieties:

<table>
<thead>
<tr>
<th>Crop/botanical name (Cucumis sativus)</th>
<th>Origin</th>
<th>Varieties for India</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cucumber</td>
<td>India</td>
<td>Japanese Long Green, Pusa Uday, Pusa Barkha, Pant Kheera-1, Pusa Sanyog (F₁ hybrid,)</td>
</tr>
<tr>
<td>(2n = 14)</td>
<td>Poinsette, Sheetal, Priya</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td><strong>Bottle Gourd</strong>&lt;br&gt;(<em>Lagenaria siceraria</em>)&lt;br&gt;(2n = 22)</td>
<td>Africa</td>
<td>Pusa Naveen, Pusa Samridhi, Pusa Sandesh, Pusa Santushti, Pusa Hybrid 3, Punjab Round, Punjab Komal, Punjab Long, Arka Bahar</td>
</tr>
<tr>
<td><strong>Bitter Gourd</strong>&lt;br&gt;(<em>Momordica charantia</em>)&lt;br&gt;(2n = 22)</td>
<td>Tropics of the old world</td>
<td>Arka Harit, Pusa Do Mausami, Pusa Vishesh, Pusa Hybrid-2, Coimbtore Long, Kalyanpur Baramasi, Solan Hara, Solan Safaid</td>
</tr>
<tr>
<td><strong>Summer squash</strong>&lt;br&gt;(<em>Cucurbita pepo</em>)&lt;br&gt;(2n = 40)</td>
<td>Central American and Mexican region</td>
<td>Pusa Alankar, Australian Green, Punjab Chappan Kaddu1, Early Yellow Prolific</td>
</tr>
<tr>
<td><strong>Sponge Gourd</strong>&lt;br&gt;(<em>Lufa cylindrica</em>)&lt;br&gt;(2n = 26)</td>
<td>India</td>
<td>Pusa Sneha, Pusa Supriya, Pusa Chikni</td>
</tr>
<tr>
<td><strong>Ridge Gourd</strong>&lt;br&gt;(<em>L. acutangula</em>)&lt;br&gt;(2n = 26)</td>
<td>India</td>
<td>Pusa Nutan, Pusa Nasdar, Arka Sumeet, Arka Sujat, <strong>Satputia</strong> (hermaphrodite flower)</td>
</tr>
<tr>
<td><strong>Ash Gourd</strong>&lt;br&gt;(<em>Benincasa hispida</em>)&lt;br&gt;(2n = 24)</td>
<td>Japan and Jawa</td>
<td>Pusa Ujjawal, Co-1, Co-2, S-1 (PAU), Karikumbala, Boodikumbala, APAU Shakti</td>
</tr>
<tr>
<td><strong>Snake Gourd</strong>&lt;br&gt;(<em>Trichosanthes anguina</em>)&lt;br&gt;(2n = 24)</td>
<td>India</td>
<td>Co-1, Co-4, TA-19, Chichinda</td>
</tr>
<tr>
<td><strong>Water melon</strong>&lt;br&gt;(<em>Citrullus lunatus</em>)&lt;br&gt;(2n = 22)</td>
<td>Africa</td>
<td>Arka Jyoti (F1), Arka Manik, Sugar Baby, Durgapur Meetha, Durgapur Kesar, Asahi Yamato</td>
</tr>
<tr>
<td><strong>Musk melon</strong>&lt;br&gt;(<em>Cucumis melo</em>)&lt;br&gt;(2n = 24)</td>
<td>North west India and hot valleys of Iran</td>
<td>Pusa Madhuras, Pusa Sharbati, Hara Madhu, Punjab Rasila, Punjab Sunheri, Punjab Hybrid, Arka Jeet, Arka Rajhans, Hisar Madhu, Durgapur Madhu, Kashi Madhu</td>
</tr>
</tbody>
</table>

**Agronomic practices**

**Sowing Times:**
- 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.
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.

1. **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.

2. **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.

3. **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.

4. **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.

**Seed rate, spacing and yield:**

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

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

**Manures and fertilizers:**

<table>
<thead>
<tr>
<th>Farmyard manure (q/ha)</th>
<th>Nitrogen (N)</th>
<th>Phosphorus (P₂O₅)</th>
<th>Potassium (K₂O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200-250</td>
<td>60-100</td>
<td>50-75</td>
<td>50-85</td>
</tr>
</tbody>
</table>

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 rotted 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 rotted of fruits

**Sex expression and sex ratio:** It is of great significance in most of the cucurbitaceous crops which have monoecious plants that means they 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 eteral, 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**

Cucurbits have following salient features which make them fit for river bed cultivation:

1. Long tap root system which makes use of subterranean moisture.
2. These are more space planted crops, less no. of plants per unit area are to be managed.
3. Hot & dry weather with maximum sunshine prevails right from March-June/July which is an essential requirement for melons.

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 °C) is provided probably from Saccharum spp. on north side of the pit. It serves following purposes:
  i. Checks the sand drifting on dug up trenches.
  ii. Provide protection against chilly winds.
  iii. This grass spread over the sand later on & vines spread over this grass.
  iv. Sand does not blow off in hot months.
- Fruits from river bed are available 30-50 days before then the normal field sown crop.

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

Disease management:
1. 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.
   Management:
   - Spray with dinocap or bitertanol or hexaconazole @ 0.05% at the first appearance of symptoms on the leaves have been reported effective.
2. 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.
   Management:
   - Spray the crop with zineb (0.25%) to control this disease.
3. 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.
   Management:
   - 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).
4. Fusarium wilt (*Fusarium oxysporum*): A fatal fungal disease that cause wilting of plants followed by dying. Symptoms may include white mold on the vines, stunted growth and discolored roots.
   Management:
   - Follow long term crop rotation.
Seed treatment and drenching of soil with blitox or bavistin (2.5 g/kg of seed) help in managing this disease.

5. Angular leaf spot (*Pseudomonas syringae* pv. *lachrymans*): Disease appear as small circular water soaked lesions which later become irregular and angular with yellow margins on the leaves. Warm, wet weather may cause stem and leaf spots in mid season.

**Management:**
- Use disease free seed. Follow crop rotation.
- Avoid over head irrigation and working when leaves are wet.

6. 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.

**Management:**
- Treat the seed with carbendazim or thiram or captan (2.5 g/kg of seed).
- Avoid flood irrigation.

7. 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**

1. 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.

**Management:**
- 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.

2. 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.

**Management:**
- 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.

3. 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.

**Management:**
- 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%).
4. **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.

**Management:**
- Spray cypermethrin (0.01%) or acetamiprid (0.01%) bifenthrin (0.01%) or malathion (0.05%).

5. **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.

**Management:**
- Spray acetamiprid (0.01%) or triazophos (0.04%) or bifenthrin (0.01%).

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**Okra**

**Botanical name:** *Abelmoschus esculentus* (L.) Moench

**Family:** Malvaceae

**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°C, optimum being 25-30°C. Optimum temperature for its better growth is 24-27°C and temperature above 42°C causes flower drop. A temperature range of 30-35°C is desirable for improved pollination and subsequent seed setting.

**Varieties recommended for cultivation in different parts of India**

- Pusa Sawani, Parbhani Kranti, Varsha Upchar and Pusa A-4 varieties find favour for export.

**Cultivars suitable for growing in Himachal Pradesh** Pusa Sawani, Prabhani Kranti, P-8, Arka Anamika and Palam Komal

**Agronomic practices**

**Sowing times**

<table>
<thead>
<tr>
<th>Region</th>
<th>Sowing Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indo-Gangetic plains</td>
<td>✓ Spring-summer crop: February-March&lt;br/&gt;✓ Autumn-winter crop: July- September</td>
</tr>
<tr>
<td>Eastern India</td>
<td>✓ January-February</td>
</tr>
<tr>
<td>Western &amp; South India</td>
<td>✓ November to March-April. and crop is over by February</td>
</tr>
<tr>
<td>Hilly regions</td>
<td>✓ April-June</td>
</tr>
<tr>
<td>Most parts of India</td>
<td>✓ Rainy season crop: June-July.</td>
</tr>
<tr>
<td><strong>Himachal Pradesh</strong></td>
<td></td>
</tr>
<tr>
<td>Low Hills</td>
<td>✓ Spring-summer crop: February-March</td>
</tr>
</tbody>
</table>
Problems associated with Okra cultivation

- The poor seed germination and erratic crop stand are the major problems in spring-summer crop due to low temperature in early spring, which can be overcome by selecting fresh and vigorous seed. Another problem is of shoot and fruit borer or spotted worm wall.
- Similarly, in rainy season crop, the major problems are incidence of Yellow Vein Mosaic disease which can be overcome by growing resistant varieties. Crop stand may be affected if proper drainage is not provided. Problem of shoot and fruit borer is more serious during September.

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 (P₂O₅) and 50-60 kg potassium (K₂O) 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 weedicings 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 @ 4 litres/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°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°C at 90% relative humidity.

Disease Management:
1. **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 spraying Sulfex (0.2%) or dinocap (0.05%) at 10 days interval.

2. **Cercospora Leaf Spot**: There is an appearance of spots in the leaf with grey centers and red borders. When the disease is severe, complete defoliation occurs.

**Management**
- Seed treatment with fungicides 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.

3. **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 Upahar, Arka Anamika, and Parbhani Kranti.

4. **Root rot** (**Fusarium solani**): Severely infected plants die as their roots turn dark brown.

**Management:**
- Seed treatment with carbendazim @ 3g/kg of seed
- Soil drenching with carbendazim @ 0.1%.
- Follow long crop rotation.

**Insect- pests:**
1. **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 Upaahr.
- Remove and destroy damaged shoots and fruits.
- Application of carbaryl (0.1%) and malathion (0.05%) is effective.

2. **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.

3. **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.
- Spray triazophos (0.04%) or lambda-cyhalothrin (0.004%).

Beans
There are at least 18 types of cultivated beans. They are the members of family *leguminosae*. They have the ability to fix atmospheric N through root nodules. They are used as green vegetables or green shelled seeds or dry seeds as pulse, according to the stage at which they are harvested. Frenchbean, cowpea, cluster bean and dolichos bean are of economic importance. All beans except broad bean are susceptible to frost and are grown as a summer crop.

<table>
<thead>
<tr>
<th>Bean type</th>
<th>Botanical name</th>
<th>Chr. no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>French bean</td>
<td><em>Phaseolus vulgaris</em></td>
<td>2n = 22</td>
</tr>
<tr>
<td>Cowpea</td>
<td><em>Vigna unguiculata</em></td>
<td>2n = 22</td>
</tr>
<tr>
<td>Asparagus bean or Yard long bean</td>
<td><em>Vigna unguiculata var. sesquipedalis</em></td>
<td>2n = 22</td>
</tr>
<tr>
<td>Lima bean</td>
<td><em>P. lunatus</em></td>
<td>2n = 22</td>
</tr>
<tr>
<td>Scarlet runner bean</td>
<td><em>P. coccineus</em></td>
<td>2n = 22</td>
</tr>
<tr>
<td>Tepary bean</td>
<td><em>P. acutifolius</em></td>
<td>2n = 22</td>
</tr>
<tr>
<td>Moong bean</td>
<td><em>V. radiata</em></td>
<td>2n = 22</td>
</tr>
<tr>
<td>Moth bean</td>
<td><em>V. aconitifolia</em></td>
<td>2n = 22</td>
</tr>
<tr>
<td>Cluster bean</td>
<td><em>Cyamopsis tetragonoloba</em></td>
<td>2n = 14</td>
</tr>
<tr>
<td>Hyacinth bean</td>
<td><em>Dolichos lablab</em></td>
<td>2n = 22</td>
</tr>
<tr>
<td>Winged bean</td>
<td><em>Psophocarpus tetragonolobus</em></td>
<td>2n = 18</td>
</tr>
<tr>
<td>Sword bean</td>
<td><em>Canavalia gladiata (tall)</em></td>
<td>2n = 22</td>
</tr>
<tr>
<td></td>
<td><em>C. ensiformis (dwarf/jack bean)</em></td>
<td></td>
</tr>
<tr>
<td>Broad bean</td>
<td><em>Vicia faba</em></td>
<td>2n = 12</td>
</tr>
</tbody>
</table>

Importance and uses: The beans are valuable source of protein, Ca, Fe and vitamins. Some of the important beans are as under:

Frenchbean
South and central America

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

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 23.9°C is the most ideal. The best pod setting is obtained at temperature range of 15-25°C for 4 hours after pollination.

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**

<table>
<thead>
<tr>
<th>Dwarf varieties</th>
<th>Pole type varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contender, VL Boni 1, Pusa Parvati, Arka Komal, Pant Anupama, Arka Suvidha, Arka Anoop, Phule Surekha, Kashi Param</td>
<td>Kentucky Wonder, SVM-1, Luxmi, KKL-1</td>
</tr>
</tbody>
</table>

**Cultivars suitable for growing in Himachal Pradesh:**

1. Dwarf varieties: Contender, VL Bauni 1, Pusa Parvati, Premier, Arka Komal, Palam Mridula, Solan Naina
2. Pole type varieties: Kentucky Wonder, SVM-1, Luxmi

**Agronomic practices**

**Sowing time**

<table>
<thead>
<tr>
<th>Region</th>
<th>Season</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Northern Indian plains</strong></td>
<td>Spring-summer</td>
<td>January-February</td>
</tr>
<tr>
<td></td>
<td>Autumn-winter</td>
<td>July-September</td>
</tr>
<tr>
<td><strong>South India</strong></td>
<td></td>
<td>September-October and crop is over by February</td>
</tr>
<tr>
<td><strong>Himachal Pradesh</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Hills</td>
<td>Spring-summer</td>
<td>February- March</td>
</tr>
<tr>
<td></td>
<td>Autumn-winter</td>
<td>August – September</td>
</tr>
<tr>
<td>Mid Hills</td>
<td></td>
<td>March-April</td>
</tr>
<tr>
<td></td>
<td>Rainy season</td>
<td>June (only tall varieties)</td>
</tr>
<tr>
<td>High Hills</td>
<td></td>
<td>April-June</td>
</tr>
</tbody>
</table>

**Problems associated with French bean crop:**

1) **Spring-summer crop**: The poor crop stand on account of low seed germination due to prevailing low temperature and incidence of dry root rots especially in the month of March due to dry weather and high temperature along with limited period of optimum temperature for pod set and development are the problems associated in spring summer crop.

2) **Autumn-winter crop**: Similarly, in autumn-winter crop, the major problems are poor crop stand due to root rot, more incidence of viral diseases and limited fruiting period on account of low temperatures from October onwards.

**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 (Bush type) and 30-40 (Pole type)

**Seed inoculation**: *Rhizobium* culture can be used to inoculate the seed before sowing. This seed inoculation helps in quick nodulation on the roots which turn 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 P₂O₅ and 30-60 kg K₂O/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 leaves.

**Management:**
- 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:**
- Follow crop rotation.
- 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:
1. **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.
2. **Jassids**: In severely infested crop, it produces typical ‘hopper burn’ symptoms. Follow same control measures as in aphid.
3. **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.
4. **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.
5. **Bean beetle**: Both larvae and adults feed on the leaves. Spray cypermethrin @ 0.01% to control the pest.
6. **Bean bug**: It is sucking pest and causes discolouration of leaves and pods. Spray cypermethrin @ 0.01% to control the pest.
7. **Hairy caterpillar**: 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.
8. **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.

### Cow pea (*Vigna unguiculata*)

<table>
<thead>
<tr>
<th><strong>Origin</strong></th>
<th>Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Climate</strong></td>
<td>A warm season crop, suitable to humid tropics and subtropical zones. Tolerates heat and dry conditions but intolerant to frost. Thrives best between 21 and 35 °C. It cannot withstand heavy rainfall and water logging.</td>
</tr>
<tr>
<td><strong>Soil</strong></td>
<td>It grows in all types of well drained soils with pH range of 5.5 to 6.5</td>
</tr>
<tr>
<td><strong>Cultivars</strong></td>
<td>Pusa Komal, Pusa Sukomal, Arka Samridhi, Arka Garima, Arka Suman, Bidhan Barbat-1, Bidhan Barbat-2, Kashi Kanchan, Kashi Gauri, Kashi Unnati. <strong>Photo insensitive varieties</strong> are Kashi Kanchan, Kashi Gauri, Kashi Unnati, Arka Garima and Arka Samridhi.</td>
</tr>
<tr>
<td><strong>Sowing time</strong></td>
<td>Spring-summer crop: February-March, Rainy season: June- July South India: December-January for spring-summer crop.</td>
</tr>
<tr>
<td><strong>Seed rate:</strong></td>
<td>12.5-20 kg / hectare.</td>
</tr>
<tr>
<td><strong>Spacing</strong></td>
<td>45-60 cm × 10-15 cm (bush type), 75 cm × 20-25 cm (indeterminate types)</td>
</tr>
<tr>
<td><strong>Nutrition Requirement</strong></td>
<td>50:80:80 kg NPK /ha, Band fertilizer 7-10 cm deep &amp; 5-7 cm away from the seed is good practice.</td>
</tr>
<tr>
<td><strong>Irrigation and inter culture:</strong> Same as that of bean</td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Harvesting</strong></td>
<td>At three different stages of maturity: green snaps, green mature and dry.</td>
</tr>
<tr>
<td><strong>Yield</strong></td>
<td>50-80 q</td>
</tr>
<tr>
<td><strong>Diseases</strong></td>
<td>Anthracnose, Die back, Ashy stem blight, Powdery mildew, Bacterial blight, Mosaic</td>
</tr>
<tr>
<td><strong>Insects</strong></td>
<td>Aphids, Jassids, Pod Borer, Bean Weevil</td>
</tr>
</tbody>
</table>

### Cluster bean or Guar (*Cyamopsis tetragonoloba*)

| **Importance** | The mucilagenous seed flour is valued as a guar gum (glactomannan) and used in textile, paper, cosmetic and oil industries. Also, useful absorbent for explosives. |
| **Origin** | Africa |
| **Climate** | A typical tropical crop prefer warm climate though grown in subtropics in summer. Long day conditions are required for growth and short day conditions for induction of flowering. Average Temp 30-40°C is congenial for growth and development. |
| **Soil** | It can tolerate saline and moderately alkaline soils with pH 7.5 and 8 and prefers well-drained sandy loam soils. |
| **Cultivars** | Pusa Navbahar |
| **Sowing time** | North India: June- August , South India: Through out year |
| **Seed rate:** | 15-40 kg / hectare. |
| **Spacing** | 45-60cm × 10-15 cm |
| **Nutrition** | 10-20: 50-70:50-70 kg NPK/ha, respectively. |
| **Irrigation and inter culture** | Flowering is the most critical stage for watering. To keep field weed free, 2-3 weedings are enough. Herbicides 2,4-D and DSMA (disodium methane arsenate) each @ 2 kg/ha to control *Parthenium* weeds. |
| **Harvesting** | It is ready for picking after 40 days of sowing and duration is 120 days. |
| **Yield** | 50-60 q/ha |

### Lablab bean or Dolichos bean or Hyacinth bean or Sem

| **Cultivars** | Pusa Early Prolific, Co-1, Co.2, Co.10, Hebbal Avare 3, Hebbal Avare 4, Deepaliwal , Arka Vijay (dual type). |
| **Sowing time** | NI: July- August , South India: Through out year |
| **Seed rate:** | 20-30 kg / hectare. |
| **Spacing** | 60×30cm (bush) and 100× 75 cm (tall) |
| **Nutrition Requirement,** | 10-20: 50-70:50-70 kg NPK/ha |
| **Rest practices are same as other beans** |
**Potato**

*Botanical Name:* *Solanum tuberosum* L.

*Family:* Solanaceae

*Origin:* Peru and Bolivia in South America

**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 (B₁, B₂, B₆ 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°C soil temperature for better germination. Young plant growth is good at 24°C but later growth is favoured by a temperature of 18°C. No tuberization takes place when the night temperature exceeds 23°C. Maximum tuberization occurs at 20°C. Tuber formation stops completely at about 29-30°C.

**Varieties:** The varieties of potato are categorized into three groups on the basis of their maturity. The important cultivars recommended for cultivation in different parts of India are as under:

**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

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.

Kufri Sindhuri and Kufri Lalima are red coloured main season varieties.

**Cultivars suitable for growing in Himachal Pradesh**

<table>
<thead>
<tr>
<th>No.</th>
<th>Cultivar</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Kufri Chandermukhi</td>
<td>An early maturing variety, gets ready for harvesting in 110-130 days, purple flowers, egg shaped large tubers, average yield 90-100q/ha</td>
</tr>
<tr>
<td>2.</td>
<td>Kufri Jyoti</td>
<td>Medium maturing variety, gets ready in 130-150 days, white flowers, resistant to late blight, average yield 150-175q/ha</td>
</tr>
<tr>
<td>3.</td>
<td>Kufri Giriraj</td>
<td>High yielding, late blight resistant</td>
</tr>
<tr>
<td>4.</td>
<td>Kufri Himsona</td>
<td>Good for chips making, highly resistant to late blight, suitable for cultivation in Kangra region in particular</td>
</tr>
</tbody>
</table>

**AGRONOMIC PRACTICES:**

**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**

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

**Planting time for H.P.**

- **Low Hill**
  - September- October
  - January

- **Mid Hill**
  - September
  - December-January

- **High Hill**
  - March- April
  - April- May

**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 1-1 1/2 hours and about 1 kg of thiourea is sufficient for 10 quintals of seed tuber. or
  - Tubers are kept in 5ppm solution of GA3 for 10 seconds. or
  - Treat the tuber with aqueous solution of thiourea for one hour followed by dipping in 2 ppm solution of GA for 10 seconds. Or
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 18-21°C 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: P₂O₅: K₂O /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:**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>200</td>
</tr>
<tr>
<td>Late</td>
<td>300</td>
</tr>
</tbody>
</table>

**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

**Marketing:** The factors which make marketing of potato a complicated process and result in high fluctuation of prices and often glut situation are:

- Transportation to long distances is problem as potatoes are semi-perishable and bulky.
- Often potatoes rot during transit because of high temperature at the time of transport.
- Problem is further compounded due to shortage of transporting wagons.
- Total cold storage capacity in the country is inadequate which can store only 35-40% of the total production of the country.
- Functioning of Cold Storage many a time is not up to the mark and is marked by various mal-practices.

**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**

**Potato**

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°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 within 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°C or below temperature. There is discoloration 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

<table>
<thead>
<tr>
<th>Disease</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Scab</td>
<td>Seed treatment with 0.5% Agalol-3 for 30 minutes. Grow scab resistant varieties.</td>
</tr>
<tr>
<td>Verticillium Wilt (Soil borne)</td>
<td>Use disease-free seeds. Follow long crop rotations.</td>
</tr>
<tr>
<td>Charcoal Rot</td>
<td>Surface disinfection with some fungicides.</td>
</tr>
<tr>
<td>Wart disease</td>
<td>Soil sterilization by steam, mercuric chloride, copper sulphate or 5% formalin. Grow resistant varieties–Kufri Jyoti, Kufri Sherpa and Kufri Kanchan</td>
</tr>
<tr>
<td>Black Leg and Soft Rot</td>
<td>Use disease-free seeds. Long crop rotations.</td>
</tr>
<tr>
<td>Bacterial Soft Rot</td>
<td>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</td>
</tr>
</tbody>
</table>

### Viral diseases

<table>
<thead>
<tr>
<th>Disease</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latent Mosaic</td>
<td>Virus is mechanically transmitted (PVX, PVS or PVM). Use disease free seeds. Local quarantine</td>
</tr>
<tr>
<td>Mild Mosaic</td>
<td>Use disease free seeds. Grow resistant varieties.</td>
</tr>
<tr>
<td>Rugose or Vein-banding Mosaic</td>
<td>Use disease free seeds. Grow resistant varieties.</td>
</tr>
<tr>
<td>Purple top leaf roll</td>
<td>It is transmitted by leaf hopper. Use of certified disease-free seed. Control insect vectors by spraying systemic pesticides</td>
</tr>
</tbody>
</table>

**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 field
- Plough 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, stem and 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

**Cole Crops**
This group of vegetables includes cauliflower, cabbage, brocoli, knolkhols, 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
- **Origin:** Mediterranean region
- **Cultivars:** Cauliflower cultivars grown in India can be classified in two broad groups:
  1. Indian Cauliflower/tropical/heat tolerant
  2. European types/ Early temperate type known as Snowball or late cauliflower

<table>
<thead>
<tr>
<th>Indian Type</th>
<th>European Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual and tolerant to heat</td>
<td>Biennial and not tolerant to heat</td>
</tr>
<tr>
<td>Curd formation at and above 20°C</td>
<td>Curd formation at 5-20°C</td>
</tr>
<tr>
<td>Yellow to creamish curds, loose with strong flavour</td>
<td>Snow white curds with very mild or no flavour (better quality curds)</td>
</tr>
<tr>
<td>Plants are short having long stalk and loosely arranged</td>
<td>Steady plants and long leaves giving protective</td>
</tr>
</tbody>
</table>
leaves.

**Early in maturity**
More variable (heterozygous)
More self-incompatible.
Small juvenile phase.
No need of vernalization but needs cold treatment at 10-13 °C.

**Late in maturity**
Less variable (homozygous)
Less self incompatible.
Long juvenile phase.
Needs vernalization at 7 °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 10-21°C 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 5°C to 28-30°C, depending upon the cultivar of a particular maturity group. Optimum temperature for growth of young plant is 23°C in initial stages while for growth in later stages, favourable temperature range is 17-20°C. Plants continue to grow vegetatively without any curd formation if temperature remains higher than optimum for curding. Late group cultivars require 15-20°C for optimum growth but the same temperature would cause curd formation in the early cultivars. Temperature should not fluctuate too much during curd initiation phase, otherwise curd quality deteriorates.

**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.

<table>
<thead>
<tr>
<th>Maturity group</th>
<th>Nursery sowing</th>
<th>Transplanting time</th>
<th>Opt. temp. range for curding</th>
<th>Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early I (A) Sept. maturity (mid Sept-mid Nov.)</td>
<td>Mid May</td>
<td>July beginning</td>
<td>20-25 °C</td>
<td>Early Kunwari, Pant Gobhi-3, Pusa Meghna, Pusa Kartik Sankar</td>
</tr>
<tr>
<td>Early I (B) Oct. maturity (Mid Oct-mid Nov)</td>
<td>May end to Mid June</td>
<td>Mid July</td>
<td>20-250C</td>
<td>Pusa Katki, Pusa Deepali, Pant Gobhi-2</td>
</tr>
<tr>
<td>Mid Early (II) Nov. maturity (Mid Nov-mid Dec)</td>
<td>July end</td>
<td>Sept beginning</td>
<td>16-20°C</td>
<td>Improved Japanese, Pusa Hybrid-2, Pusa Sharad, Pant Gobhi-4</td>
</tr>
<tr>
<td>Mid late (III) Dec maturity (mid Dec-mid Jan)</td>
<td>Aug end</td>
<td>Sept end</td>
<td>12-16 °C</td>
<td>Pusa Synthetic, Pusa Subhra, Palam Uphar, Pant Subhra, Pusa HimJyoti, Pb Giant 35, Pusa Paushja, Pusa Shukti</td>
</tr>
<tr>
<td>Late (IV) Snowball (Jan-March)</td>
<td>Sept end to mid Oct</td>
<td>Oct end-mid Nov</td>
<td>10-16 °C</td>
<td>Snowball 16, Pusa Snowball-I, Pusa Snowball K-1, Pusa Snowball KT-25, Dania, Ooty-1,</td>
</tr>
</tbody>
</table>
Cultivars suitable for growing in Himachal Pradesh

<table>
<thead>
<tr>
<th>Early</th>
<th>Mid</th>
<th>Late</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Kunwari, Pusa Deepali, Improved Japanese</td>
<td>Pusa Snowball K1, Pusa Snowball-1, Palam Uphar</td>
<td></td>
</tr>
</tbody>
</table>

Nursery sowing time in Himachal Pradesh

<table>
<thead>
<tr>
<th>Zone</th>
<th>Early group</th>
<th>Mid group</th>
<th>Late group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Hills</td>
<td>June-July</td>
<td>August-September</td>
<td>October-November</td>
</tr>
<tr>
<td>Mid Hills</td>
<td>April-May</td>
<td>July-August</td>
<td>September</td>
</tr>
<tr>
<td>High Hills</td>
<td>-</td>
<td>-</td>
<td>April-May</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Variety</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early varieties</td>
<td>600-750g</td>
</tr>
<tr>
<td>Mid-Early season varieties</td>
<td>500g</td>
</tr>
<tr>
<td>Mid-late varieties</td>
<td>400 g</td>
</tr>
<tr>
<td>Late varieties</td>
<td>300 g</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Variety</th>
<th>Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early varieties</td>
<td>45cm × 30cm</td>
</tr>
<tr>
<td>Mid and Late season varieties</td>
<td>60cm × 45cm</td>
</tr>
</tbody>
</table>

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. Remaining part of N should be top dressed at an interval of one month each while half of potassium is to be applied alongwith N during second top dressing.

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

Pre and post harvest handling: Harvesting should be done preferably in the late evening or early morning so that the product remains turgid and fresh. The freshly harvested plants should be put in the truck or cart in such a way that the bruising of the curd is minimum. The bruised portions of the curd become blackish and unattractive for the fresh market.

Packing and Packaging Material: Generally packaging material is not used for transportation or storage of cauliflower in India. Freshly harvested plants with most of the leaves intact are loaded in cart/truck keeping the curd downward. By doing this, the curds are not exposed to the sun and the leaves protect the curd from bruising and impact damage. This practice is for the market situated nearby. They are sent in gunny bag packings or in crates to distant market.

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 riceyness 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.

5. **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.

6. **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.

7. **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 and hence is known as red or brown rot. Application of borax @20kg/ha can manage this disorder.

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**Cabbage**

**Botanical name:** *Brassica oleracea* var. *capitata*

**Family:** Brassicaceae

**Origin:** Mediterranean region

**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 cultivars 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

**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°C soil temperature. The optimum temperature for growth and head formation is 15-20°C whereas, the growth is checked above 25°C.

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

In Himachal Pradesh

<table>
<thead>
<tr>
<th>Zone</th>
<th>Time of nursery sowing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Hills</td>
<td>August – September</td>
</tr>
<tr>
<td>Mid Hills</td>
<td>August – September, February – March</td>
</tr>
<tr>
<td>High Hills</td>
<td>April - May</td>
</tr>
</tbody>
</table>
Seed Rate: For raising nursery for one hectare area, early 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 a.i. /ha or Oxyfluorfen (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, Late season varieties: 400-500

Pre and post harvest handling: Harvesting should be done preferably in the late evening or early morning so that the product remains turgid and fresh. Trim diseased, damaged, rotten and discoloured leaves. Avoid direct contact of heads with the soil and exposure to direct sunlight. Proper packing is to be done to avoid bruising.

Physiological disorder:
- Cracking: Possible Reasons: Excess nitrogen fertilizer. Hot, dry weather.
- Management: Do not let soil dry out. Fertilize properly.
**Broccoli (Brassica oleracea var. italic L.)**

Morphologically, broccoli resembles cauliflower. The plant forms a head consisting of green buds and thick fleshy flower stalks. The terminal head is rather loose, green in colour and the flower stalks are longer than cauliflower. Besides, the main head in the sprouting broccoli, long slender small heads (called spears or sprouts) are developed in the axil of the leaves. These become ready for harvest after removal of main head. Both terminal head and the sprouts with bud clusters are consumed as salad or cooked vegetable.

**Different Types of Broccoli**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purple sprouting broccoli</td>
<td>Biennials, branched, purple spears, variable</td>
</tr>
<tr>
<td>Purple cape broccoli</td>
<td>Biennials, single purple heads, variable</td>
</tr>
<tr>
<td>White sprouting broccoli</td>
<td>Biennials, branched, white spears.</td>
</tr>
<tr>
<td>Purple Sicilian broccoli</td>
<td>Single heading pale-purple heads also known in horticulture as purple cauliflower.</td>
</tr>
<tr>
<td>Couve broccolo</td>
<td>‘Roxo de Cabeça’ Tall purple heading, sprouting type from Portugal</td>
</tr>
<tr>
<td>Calabrese</td>
<td>Green sprouting broccoli from Calabrian region. Now a world wide crop and virtually single heading.</td>
</tr>
<tr>
<td>Black broccoli</td>
<td>Highly branched annual with dark green spears and sickle shaped leaves, from Rome area.</td>
</tr>
</tbody>
</table>

Broccoli needs fertile soil with good moisture holding capacity for its cultivation. It is mainly grown as a winter crop in most parts of the country, however in high hills it may be grown as a spring summer crop. It is sensitive to temperature as bud clusters grow loose quickly and give rise to bracts under warm weather conditions. Light frost causes considerable damage to the buds, though vegetative growth is not affected to that extent. An optimum temperature of 12-18°C is suitable for proper head development. The important varieties recommended for cultivation in India are Palam Samridhi, Palam Haritika, Palam Kanchan, Palam Vichitra, Pusa Broccoli Kt Selection-I and Punjab Broccoli-I.

The crop is planted during mid August to mid September in north Indian plains. Seed rate of 400-500g/ha is required to raise a crop of broccoli in one hectare area. The seedlings are transplanted at 45 cm between the rows and also with in a row. The field preparation, nutrient management, intercultural and weed management operations, and irrigation practices are similar to those followed in cauliflower. It is important to harvest the broccoli heads at correct time i.e. before the buds open and when the bud clusters are compact. The heads are cut along with stalk (around 15cm) in case of sprouting broccoli. After cutting, part of the foliage is removed from the harvested shoots. Average yield of broccoli is around 150-200q/ha.

**Knol Khol (Brassica oleraceae var. gongylodes)**

Knolkhol 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.

In India, mainly two cultivars are commonly cultivated. The most common cultivars of knolkhol are White Vienna, Purple Vienna and Palam Tender Knob. It can be grown on all types of soil. However, good soil condition and fertility favour growth in a uniform manner. It is mainly grown as a winter vegetable crop and thrives well in relatively cool moist climatic conditions. Seeds germinate well at 15-30°C. Optimum temperature requirement for its growth is between 15-25°C depending upon cultivars. The cultivation of knolkhol or Kohlrabi in India is not very popular except in Kashmir, West Bengal and some parts of the south.
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. 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. 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:

1. **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.

1. **Downy mildew** (*Peronospora parasitica*): It causes serious damage at all stages of plant growth. Discolouration occurs in the young seedlings and in severe cases whole plant perishes. In adult plants, purplish leaf spots or yellow brown spots on the upper surface of the leaf appear, while fluffy downy fungus growth is found on the lower surface. During bolting stage, the seed stalk show blackish patches and in severe cases whole curd is spoiled.

   **Management:**
   - Spray Ridomil MZ 72 @ 2.0 g/litre of water at 10-15 days intervals or with mancozeb @ 2.0 g/litre of water.
   - Chinese cabbage and kale are resistant to downy mildew while other cole crops are susceptible.

3. **Rhizoctonia** (*Rhizoctonia solani*): causes damping off, wire stem, bottom rot, head rot or crown rot

   **Management:**
   - Grow resistant varieties and soil application of Brassicol @ 20-30 kg/ha.
   - Foliar sprays of Dithane-M-45, Difolatan 80 or Daconil @ 1.5 – 2.0 g / L at an interval of 15 days for 2-4 times.

4. **Black spot** (*Alternaria spp.*): Light brown spots with concentric ring appear on leaves. The infected leaves become yellow and fall down when mature.

   **Management:**
   - Treat the seeds with Thiram @2.5 g/kg seed or spray at 15 days interval as needed.

5. **Watery soft rot** or *Sclerotinia* rot: Disease first appears as wet soft lesions on cauliflower head and leaf. Later lesion enlarges into a watery rotten mass of tissues that is covered by white silvery appearance.
Management:
Spray carbendazim (1g/L) or mancozeb (2g/liter of water) after appearance of disease or at an interval of 15 days if required.

3) **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.
- Hot water seed treatment at 50°C for half an hour.
- Spray Streptocycline @ 5g and Blitox @ 10g per 10 litre of water after transplantation.

7. **Bacterial soft rot** (*Erwinia carotovora*): A weak parasite which penetrates the plants through damaged tissue e.g. lesions caused by other pathogens as a result of mechanical injury to nearly mature cabbage head. High humidity favours development of disease. The affected plants show a soft, slimy, bad smelling rot that under favourable conditions rapidly spreads throughout the plant.

Management:
- Control of other diseases and avoid damage to cabbage head can check the development of disease.
- Spray 100-200 ppm streptocycline or plantomycin combined with copper oxychloride (0.3%) at 15 days interval.

**Insect-pests:**

**Diamondback 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.
- Spray of malathion (0.05%), deltamethrin (0.028%), cypermethrin (0.01%) and lambda-cyhalothrin (0.004%) can be used for effective suppression of the pest.

2. **Cutworms:** They damage the seedlings of the newly planted crop. Stems are chewed near the soil level during night.

Management:
- Use of well-decomposed manure helps in reducing the incidence.
- Collect and destroy the larvae after flooding of fields/beds.
- Soil drenching with chlorpyriphos (0.04%) or spray of cypermethrin (0.01%) on foliage and soil surface reduces the incidence.

3. **Aphids:** As a result of sucking cell sap, the seed setting stage is seriously affected.

Management:
- Foliar application of malathion (0.05%) with the appearance of the pest and repeating every 15 days. Stop spraying atleast 7 days before harvesting.
- In seed crop, apply phorate granules @ 1.5 kg a.i./ha as side dressing during mid February to early March or spray oxydemeton methyl (0.025%) or dimethoate (0.03%) or phosphamidon (0.03%) as soon as aphid population is above 50 aphids per plant.

4. **Cabbage butterfly** (*Pieris brassicae*): Damage is caused by caterpillars. The white winged butterflies deposit yellow coloured eggs in clusters on the undersurface of leaves.

Management:
Cultivars suitable for growing in Himachal Pradesh

- Collect and destroy yellow egg masses and early stage larvae of cabbage butterfly.
- Use *Cotesia glomeratus* which parasitizes the larvae.
- Spray of malathion (0.05%)/ deltamethrin (0.0028%)/ cypermethrin (0.01%) and dichlorovos (0.05%) can be effective.

5. **Snails and slugs:** They damage the growing tips of plant and also the surface of curd in cauliflower. They are problematic under humid conditions or when crop is irrigated with sewerage water.

**Management:**
- Baiting with metaldehyde and bran (1: 25 in 12 litres of water) is effective for their control. As a repellent, alum may be sprayed @ 2% solution.

### Garden Pea

**Botanical Name:** *Pisum sativum L.*

**Family:** Fabaceae

**Origin:** Central Asia, the near East, Abyssinia and the Mediterranean

**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.

**Cultivars are grouped on the basis of various characters:**

a) According to seed: 1.Round or smooth seeded cultivars 2.Wrinkled seeded cultivars.


c) According to maturity period: 1.Early (65-80 days), 2.Medium (90-100 days), 3.Main season (110-120 days).


**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.

### Cultivars suitable for growing in Himachal Pradesh

- **Early Varieties:** Arkel, Matar Ageta 6, VL Ageti Matar 7 (VL-7), Palam Triloki

- **Main season:** Bonneville, Lincoln, Azad P-1, Pb-89, Palam Priya, VL-3, Solan Nirog, Kinnauri, Palam Sumool
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°C and that for better growth and yield is 13-19°C. High temperature reduces the pod quality as sugars in the seeds changes to hemicellulose and starch. Temperature above 27°C shortens the growing period and adversely affects pollination.

**AGRONOMIC PRACTICES**

**Sowing time**

<table>
<thead>
<tr>
<th>Area</th>
<th>Early varieties</th>
<th>Main season varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>North India</td>
<td>September</td>
<td>First fortnight of October – end November</td>
</tr>
<tr>
<td>Peninsular India</td>
<td>June - July</td>
<td>Adverse effect when sown after November</td>
</tr>
</tbody>
</table>

**Himachal Pradesh**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Early varieties</th>
<th>Main season varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Hills</td>
<td>September - October</td>
<td>November</td>
</tr>
<tr>
<td>Mid Hills</td>
<td>September (first fortnight)</td>
<td>Late October- November</td>
</tr>
<tr>
<td>High Hills</td>
<td>March - June</td>
<td>October- November, March - June</td>
</tr>
</tbody>
</table>

**Seed Rate (kg/ha):** Early varieties: 120-130, Main season varieties: 75-100

**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.

There is another kind of pea which is consumed whole just like french bean, known as edible poded/snap/snow pea. Pods of these are very crisp, sweet and tender that can be eaten raw as well as cooked.
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 Main season varieties: 100-150

Disease management:
1. 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.
2. Fusarium wilt (*Fusarium oxysporum* f.sp. *pisí*): Near wilt attacks young plants. The affected plants show yellow-orange internal discolouration in the lower internodes.
3. Root rot (*Fusarium solani*): The vascular tissue shows red discolouration extending upward 1-3 nodes above soil surface. Diseased plants appear unthrifty, variously dwarfed depending upon the severity of infection, and may wilt and die.
   - The other soil borne organisms like *Rhizoctonia* and *Pythium* also cause seed decay, damping off and root rot.
   Management: Fusarium wilt and root rot can be controlled by using following treatments:
   - Seed treatment with Bavistin @ 3g/kg of seed
   - Soil drenching with Bavistin @ 0.01% or Captan or Brassicol reduces the disease.
   - Follow long crop rotation
4. 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.
5. 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:
1. 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
2. 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%
3. 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%
4. **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. Fumigation of dry peas with methyl bromide

**Sugar snap peas**
- A type of edible poded pea or snow pea developed from a cross of a standard pea with a mutant.
- These are very crisp, sweet, tender pod pea that can be eaten raw as well as coked.
- Sugar snaps are characterized by slow development of seeds and pod fibre.
- It tastes like sweet young peas and like tender, sweet edible poded peas.
- These are more difficult to grow than standard peas because
  - Sensitive to adverse environment conditions
  - Very susceptible to powdery mildew
  - Sensitive to over ripeness, losing market quality rapidly and must be harvested with in 12-24 hours of maturity
- The crop is harvested before the seed enlarges and the pod become fibrous.

**Onion**

**Botanical Name:** *Allium cepa* L.
**Family:** Amaryllidaceae
**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 relieve 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.

**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.
1. **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

2. **Kharif Onion:** Arka Kalyan, Arka Pragati, N-53, Arka Niketan

3. **White skinned varieties:** Pusa White Flat, Pusa White Round, Punjab-48, Udaipur-102

4. **Yellow skinned varieties:** Brown Spanish (Long day variety, suitable for growing in hills), Early Grano (Good for salad, suitable for green onions).

5. **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.

6. **Small Onion:** Agrifound Rose (pickling type, suitable for export), Arka Bindu

**Cultivars suitable for growing in Himachal Pradesh:**

1. **Rabi season varieties:** Palam Lohit, Patna Red, Agrifound Dark Red, Palam Lohit

2. **N-53 (Kharif onion variety),

3. **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°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°C temperature for vegetative growth before bulb initiation and 16-25°C for bulb development and 25-30°C for bulb maturation.

**AGRONOMIC PRACTICES:**

<table>
<thead>
<tr>
<th>Season</th>
<th>Time of sowing</th>
<th>Time of transplanting</th>
<th>Harvesting time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Northern India</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainy (Kharif)</td>
<td>May–June (July)</td>
<td>July-Aug (Mid Aug)</td>
<td>Nov-Dec</td>
</tr>
<tr>
<td>Winter (rabi)</td>
<td>Oct-Nov (Nov)</td>
<td>Dec-Jan (Jan-early Feb)</td>
<td>May-June</td>
</tr>
</tbody>
</table>

| 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              |
| Rainy (kharif)                        | May-June               |
| Winter (rabi)                         | Sept-Oct               |

**Nursery sowing & transplanting time in Himachal Pradesh**
Nursery Sowing | Transplanting Time
--- | ---
Low Hills | 1. Mid November  
2. Jan- Feb (Kharif onion)
Mid Hills | Mid October – Mid November  
High Hills | April

1. December- January  
2. July –August (for sets)

December

May - June

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:** 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.

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 0.25-0.5 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.

**Possible 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°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**

1. **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.

2. 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%.

3. 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).

4. Stemphylium blight: It appears on onion leaf as well as on leaf stalk. Infection appears as small yellow to pale orange spots or streaks in the middle of leaves/flower stalks on one side.

Management: Spray crop with mancozeb (0.25%) alongwith sticker triton can control the disease.

**Insect- pests**

1. 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.

2. 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 is beneficial.

3. 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.)

Pungency in garlic is due to the compound diallyl-disulphide.

**Cultivars suitable for growing in Himachal Pradesh:** 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°C) during growth and relatively dry weather (20-25°C) during bulbing and 25-30°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

### Himachal Pradesh

<table>
<thead>
<tr>
<th>Region</th>
<th>Sowing time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Hills</td>
<td>October- November</td>
</tr>
<tr>
<td>Mid Hills</td>
<td>September- October</td>
</tr>
<tr>
<td>High Hills</td>
<td>April</td>
</tr>
</tbody>
</table>

**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.

**Curing:** same as onion

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.

**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

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**Root Crops**

Root vegetables include carrots, radish, turnip, beets, parsnips, rutabagas, horse radish and Jerusalem artichoke. These crops are grown for their enlarged fleshy roots which actually consist of both root and stem tissues. These vegetables are short duration and have high productivity. Hence, these can be grown in sequential cropping, intercropping and relay cropping which enables maximum use of arable land. Botanically they belong to different families but their cultural practices are almost similar.

**Carrot**

Botanical Name: **Daucus carota** L.  
Family: Umbelliferae  
Origin : South western Asia (Afghanistan)
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.
- Carrot seeds are aromatic, stimulant and carminative and its oil is used for flavouring different food items.

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 namely, Asiatic type and European type:

<table>
<thead>
<tr>
<th>Asiatic or tropical type</th>
<th>European Type or Temperate Type Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. It produces seed in plains.</td>
<td>1. It produces seed in hills</td>
</tr>
<tr>
<td>2. It does not require low temperature treatment for flowering.</td>
<td>2. It requires chilling (4.8-10 C) for flowering.</td>
</tr>
<tr>
<td>3. Roots are long and red in colour with white or creamy core.</td>
<td>3. Roots are medium in size and orange in colour with centre core.</td>
</tr>
</tbody>
</table>

Varieties

| Pusa Kesar, Pusa Meghali, Pusa Vrishi, 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) |

Cultivars suitable for growing in Himachal Pradesh:
European or temperate type varieties: Nantes, Chantney, Pusa Yamdagini, Solan Rachna
Asiatic or tropical type: Pusa Kesar

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°C is suitable for seed germination and 18.3 to 23.9°C for better root growth. The optimum temperature for better colour development of roots is 15.6-21.1°C.

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

Himachal Pradesh:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Time of nursery sowing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Hills</td>
<td>August-September</td>
</tr>
<tr>
<td>Mid Hills</td>
<td>July – September</td>
</tr>
<tr>
<td>High Hills</td>
<td>March- July</td>
</tr>
</tbody>
</table>
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 50-90N: 40-80P₂O₅: 40-80 K₂O
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 carrots 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

Post harvest handling: Roots should be washed thoroughly, graded and tied in bunches of 6 or 12 roots after harvesting. Fresh carrots can be stored for more than 3-4 days under ordinary conditions. At temperature 0-4.4 ºC with 93-98 % RH roots can be stored for 3-4 months. Mature topped carrots can be stored upto 7-9 months while immature ones can be not be stored for more than 2-3 weeks under cold storage at 32 ºF with high humidity (98-100%).

Physiological disorders:
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
   ➢ Early cultivars tend to split more readily than late ones.
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.

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**Radish**

Botanical Name: *Raphanus sativus* L.

Family: *Brassicaceae*

Origin: Western Asia

Uses: The leafy tops are very rich in vitamin A, B, C and minerals particularly Ca and Fe. The roots and leaves are consumed both as salad and as cooked vegetable. The roots are good appetizer, effective in curing liver, gall bladder and urinary disorders, piles and gastrodynia.

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## Two types of radishes

<table>
<thead>
<tr>
<th>Spring radishes</th>
<th>Winter radishes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very common, rapid growing and quick maturing (20-30 days)</td>
<td>Slow growing and late maturing (50-90 days)</td>
</tr>
<tr>
<td>Relatively small roots</td>
<td>Large roots</td>
</tr>
<tr>
<td>Root quality deteriorate quickly and mildly pungent</td>
<td>Stored better and have characteristic strong flavour</td>
</tr>
</tbody>
</table>

### Varieties

<table>
<thead>
<tr>
<th>Asiatic/tropical/subtropical type</th>
<th>European/temperate Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>These produce seeds in plains</td>
<td>Seed production is limited to high hills.</td>
</tr>
</tbody>
</table>

### Cultivars suitable for growing in Himachal Pradesh:

**European or temperate type varieties:** Palam Hriday, White Icicle, Pusa Himani

**Asiatic or tropical type** Japanese White, Chinese Pink, Pusa Chetki

**Soil:** Light, friable loamy soil containing high amount of humus are suitable for radish cultivation. Usually, the heavy soils produce rough ill shaped roots with small fibrous laterals. The optimum soil pH is 5.5-7.0.

**Climate:** It is predominantly a cool season crop and best adapted to cool or moderate climate. Indian types with greater temperature adaptation can resist heat better than the European types. The optimum temperature for best flavour, texture, root growth and development is 10-15°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. 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

**Himachal Pradesh**

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

**Schedule of growing radish throughout the year in the plains**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Sowing time</th>
<th>Harvesting time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pusa Chetki</td>
<td>Early April-Mid August</td>
<td>Early May- September</td>
</tr>
<tr>
<td>Pusa Desi</td>
<td>Mid August- Mid October</td>
<td>Last week of September-Early December</td>
</tr>
<tr>
<td>Pusa Reshmi</td>
<td>Mid September- Mid November</td>
<td>Last October- early January</td>
</tr>
<tr>
<td>Japanese White</td>
<td>Mid October- Mid December</td>
<td>Mid December- Early March</td>
</tr>
<tr>
<td>Pusa Himani</td>
<td>Mid October- Mid February</td>
<td>Mid February- Mid April</td>
</tr>
<tr>
<td>White Icicle</td>
<td>Last October-end February</td>
<td>Late November- Early March</td>
</tr>
</tbody>
</table>

**Seed Rate:** 9-12 kg/ha (1 g seed contains 80-125 seeds)
- Asian type – 10 kg  
- European type – 12-14 kg

**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:**

<table>
<thead>
<tr>
<th>Farmyard manure (q/ha)</th>
<th>N (Kg/ha)</th>
<th>P₂O₅ (Kg/ha)</th>
<th>K₂O (Kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>50-90</td>
<td>50-80</td>
<td>40-80</td>
</tr>
</tbody>
</table>

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.*Cchetki* type 30-40 days and mid maturity group 40-60 days.

**Yield:**

<table>
<thead>
<tr>
<th>Type</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>European type</td>
<td>50-80q/ha</td>
</tr>
<tr>
<td>Asiatic type</td>
<td>200 –500 q/ha</td>
</tr>
</tbody>
</table>

**Post harvest handling:** Immediately after harvesting, roots are hydrocooled is effective in this regard. At 32°F temperature and 95-100% relative humidity, topped radishes can be stored for 3-4 weeks while bunched roots can be generally stored only for 1-2 weeks. Roots can be stored for 2 months at 0°C and 90-95% relative humidity.

**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:**

<table>
<thead>
<tr>
<th>Problem</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damping off</td>
<td>Seed treatment with bavistin/thiram/captan</td>
</tr>
<tr>
<td>Alternaria blight</td>
<td>Seed treatment with bavistin/thiram/captan</td>
</tr>
<tr>
<td>White Rust</td>
<td>Arka Nishant is reported to be resistant</td>
</tr>
<tr>
<td>Aphids</td>
<td>Use systemic pesticides</td>
</tr>
</tbody>
</table>

**Turnip (Brassica rapa L.)**

**Origin:**

i. Mediterranean (European type varieties)  
ii. Eastern Afghanistan (Asiatic type varieties)  

**Uses:** It is grown for elongated roots as well as for its foliage. Fresh roots are consumed salad or cooked as a vegetable or used in pickles. The turnip greens are rich in vitamin A and C and contain appreciable amount of vitamin B, and are also good source of Ca, P and Fe.

**Varieties**

<table>
<thead>
<tr>
<th>Asiatic/tropical/subtropical type</th>
<th>European/Temperate Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early and more tolerant to heat. More pungent and better for pickles.</td>
<td>Sweeter and more palatable.</td>
</tr>
<tr>
<td>Pusa Kanchan, Pusa Sweti, Punjab Safed 4</td>
<td>Purple Top White Globe, Golden Ball, Snowball, Early Milan Red Top, Pusa Chandrima, Pusa Swarnima.</td>
</tr>
</tbody>
</table>

**Varieties Cultivars suitable for growing in Himachal Pradesh:**

**European or temperate type varieties:** Purple Top White Globe (PTWG), Snowball, Pusa Chandrima, Pusa Swarnima  
**Asiatic or tropical type:** Pusa Sweti
Turnip is best adapted to a cool or moderate climate. It is a hard crop, can tolerate frost and mild freezing temperatures. Asiatic varieties require warmer conditions are sown earlier than European types. It can be grown on all types of soil but good soil conditions and fertility favour uniform growth. In India, Purple Top White Globe (PTVWG) is the most common variety.

**Sowing time:**

<table>
<thead>
<tr>
<th>Region</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Indian plains</td>
<td>September-December</td>
</tr>
<tr>
<td>Himachal Pradesh</td>
<td></td>
</tr>
<tr>
<td>Low Hills</td>
<td>September- November</td>
</tr>
<tr>
<td>Mid Hills</td>
<td>August- October</td>
</tr>
<tr>
<td>High Hills</td>
<td>April- July</td>
</tr>
</tbody>
</table>

Seed rate is 4-4.5 kg/ha. The plants are retained at a spacing 30-45 cm between the rows and at 7.5-15 cm with in rows. 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. Mix 200-250q/ha farmyard manure thoroughly at the time of field preparation. Application of nitrogen, phosphorus and potash 50-90: 50-80: 50-80 kg per hectare respectively is required to raise a healthy crop of turnip. 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. It should be harvested as soon as the roots attain appreciable size because quality of roots deteriorates at a faster pace. Large roots have poor texture and bitter taste. A light irrigation may be given before harvesting to facilitate lifting. After harvesting, roots are cleaned, tops are cut and roots are graded according to size and tenderness. Yield may vary from 25-30 t/ha under Indian conditions.

**Beet Root**

- **Botanical Name:** Beta vulgaris sp vulgaris.
- **Origin:** Europe, North Africa & West Asia
- **Variety:** 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 betacyanin and yellow pigmentation is due to betararitin. 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°C. Beets are very sensitive to low temperature and if exposed to 4.5°C – 10°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, interculture and weed management operations are more or less similar to that of radish and turnip. The soil should be kept sufficiently moist until emergence of seedlings. Three irrigations are sufficient when there are winter rains. 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. Internal black spot, a physiological disorder is associated with boron deficiency. Plant usually remains dwarf or stunted. Apply 10-15 kg of Borax/ha.
Leafy Vegetables

These vegetables include beet leaf, spinach, amaranth, and fenugreek etc. These crops are grown for their leaves. They are highly nutritious and rich sources of vitamin A and C and minerals like iron, calcium and phosphorus.

Types of spinach: There are two types of spinach
1. Desi or common palak (spinach beet or beet leaf).
2. Vilayati palak (spinach)

Difference between beet leaf and spinach

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

Beet leaf (Beta vulgaris var. bengalensis L.)

Varieties: Pusa Bharti, All Green

Cultivars suitable for growing in Himachal Pradesh: Pusa Harit and Banerjee’s Giant

The general tips which are to be followed for raising beet leaf crop

- It can be grown on any type of soil having sufficient fertility and proper drainage system but does not grow well in sandy loam soil.
- High yields of better quality greens are produced in neutral soils having a pH 7.0.
- It is highly tolerant to saline conditions and can be successfully grown in saline sodic soils.
- It is predominantly a cool season crop but can be grown throughout the year under mild temperature conditions.

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.

Himachal Pradesh

<table>
<thead>
<tr>
<th>Low Hills</th>
<th>Mid Hills</th>
<th>High Hills</th>
</tr>
</thead>
<tbody>
<tr>
<td>July-November, February-March</td>
<td>July-October, February-April</td>
<td>March-June</td>
</tr>
</tbody>
</table>

- 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

**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;

1. **On the basis of seed:** Further in 2 groups :a) Prickly seeded  b) Round seeded
2. **On the basis of leaf:** a) Smooth leaved eg Early Smooth Leaf  b) Savoy leaved: Virginia Savoy

**Cultivars suitable for growing in Himachal Pradesh:** 1. Virginia Savoy  2. Long Standing

**Soil:** same as beet leaf. 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°F. Withstands hard frost and temperature as low as 20°F, but the growth is depressed below 35°F. The plant is very intolerant of warm temperature above 77°F which in combination with long days causes plants to bolt. Seed germination at 10-15.5°C (50-60°F) and decreases at higher temperature

**Sowing time:** North Indian Plains September-October  
Himachal Pradesh

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>October-November</td>
<td>September-October</td>
<td>March- July</td>
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**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)

**Soil preparation, Manures and fertilizers, Interculture and weed control, Irrigation:** same as beet leaf

**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

**FENUGREEK**

There are two types of fenugreek which are of economic importance:

(i) *Trigonella foenum-graecum*, common methi
(ii) *Trigonella corniculata*, Kasuri or Champa methi or Marwari methi.

**Kasuri Methi** is slow growing and remains in rosette condition during most of the vegetative growth period. It bears dark green coloured leaves, yellow coloured flowers and sickle shaped pods. The seeds are very small in size. Their cultivation is mostly confined to North India.

**Common methi** has light-green leaves, white or light violet coloured flowers and long slender pods with a prominent beak. It is quick growing upright crop. The pods are straight and seeds are bold.

The climate, soil and cultural practices for the cultivation of fenugreek are as under:

- The common cultivars are Lam Selection 1, Pusa Early Bunching, Kasuri Selection, CO-I Fenugreek, Rajendra Kranti, RMT-1, Methi No. 47, Methi No. 14, and Palam Soumya

- **Varieties for For Himachal Pradesh:** IC-74, Palam Soumya, Kasuri Methi, Pusa Kasuri

- Clay loam soil is the ideal for its cultivation though can be grown in all types of soils.

- Being a cool season crop, it is fairly tolerant to frost and freezing weather. It can also be grown as a hot weather crop.

- Sowing time for common methi is Mid September -Mid March. When it is grown as a leafy vegetable, the duration of the crop is only 30-40 days and thus can be successfully adopted in the multiple cropping systems.

- For Himachal Pradesh, sowing time for **Low hills** is Oct-Nov., **Mid hills**: Aug.-Oct **High hills**: April-July.

- Seed rate for common methi is 25 kg/ha and that for Kasuri type is 20 kg/ha

- Spacing is 20-30 cm × 5-7 cm.

- The field is ploughed to bring it to a fine tilth. Farmyard manure or compost is applied at the last ploughing.

- Manures and fertilizers requirement is FYM @ 10-25 t/ha, 30:40:45 kg N:P₂O₅:K₂O/ha, respectively.

- Frequent irrigation is necessary to obtain quick growth of the crop. Irrigation during early vegetative and grain formation stages is more critical than later stages.

- Excess irrigation is likely to make the crop susceptible to root rot disease.

- Weeding is necessary at the early stage of the crop. The crop growth is slow at the initial stage and becomes vigorous after 4-5 weeks which then does not allow weeds to compete with it.

- The young shoots are nipped off in about 3 weeks of sowing. More number of cuttings may be taken from the Kasuri types.

- The first cutting is ready in about 25-30 days after sowing and the subsequent cuttings may be taken after an interval of 12-15 days.

- Yield of common methi is 80-100 q/ha while kasuri type produces 90-100 q/ha

- The common diseases are powdery mildew, downy mildew, root rot, damping off, leaf spot, rust, mosaic and wilt.

- The important pest is aphid.
**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

1. *Amaranthus blitum: chhoti chaulai*
2. *Amaranthus tricolor: Badi chaulai*

The general requirements and agronomic practices followed for its cultivation are as under:

- 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
- 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.
- 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
- 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.
- Two to three weedings or hoeings are sufficient to keep the weeds under control and to ensure good aeration.
- 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.
- Average yield is 60-80 q/ha.
- Common pests are aphids and leaf eating catterpillar while white rust is the serious disease.
Perennial vegetables

Moringa (Moringa oleifera Lam)

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
1. Perennial: Jaffna (yazhpanam), Chavakacheri murungai, Chemmurmungai, Palmurungai and Puna murungai
2. 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°C. It is highly susceptible to frost and high temperature exceeding 40°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 45x45x45 cm at a spacing of 2.5x2.5 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 (80-90 fruit/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°C.
- It produces fruits throughout 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 at least 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.
Salad Crops
Lettuce (Lactuca sativa)

- Most important salad crop
- Occupy maximum area under salad vegetables.
- Temperate vegetable but also grown in tropical and subtropical climate of the world
- Tender leaves and heads are consumed as salad after chopping
- Rich in vit A, Ca and Fe.

Four important botanical varieties of cultivated lettuce:
1. Head type (L. sativa var. capitata): it is of two types:
   a) Butter head type: produce relatively small & loose heads. The outer leaves are green in colour where as, inner leaves are creamy or yellow which is oily, crumpled & soft texture. They do not withstand shipping and handling e.g. White Boston Dark green
   b) Crisp head type: It is popular in North America & European countries. Brittle textured, a tightly folded large heads (upto 1 kg). Excellent shipping & handling abilities. Leaves are wrinkled, non-wrapped and round. The outer leaves are green and inner leaves are very thin, crisp & soft. eg Green lakes Imperial 859
2. Leafy or bunching type (L. sativa var. crispa): Non-heading type cultivar. Colour of leaves varies from light green to red. eg Slobolt Chinese Yellow
3. Cos or romain type (L. sativa var. longifolia): Plants are straight growing and about 25 cm in height which produce elongated leaves to form a loaf shaped head. The outer leaves are slimy & light green coloured but inner leaves are finer & light in colour. It produces coarse leaves but have good eating quality.
4. Asparagus or stem type (L. sativa var. asparaginina): Also known as celery lettuce. It produces thick stems, which are consumed either raw or cooked as vegetable after peeling. The leaves are also edible but inferior in quality than other types. eg Lettuce

Varieties for H.P.
- Alamo 1: Head type.
- Simpson Black Seeded: Leafy type.
- Eves Wonder: Heading type.
- Ruby: Leafy & purple coloured.

Climate: A cool season vegetable. It requires a monthly average temperature of 12-15°C. Seeds become dormant & fall to germinate when the soil temperature is above 22-30 °C. Temperature above 22 °C promotes bolting causing bitterness in leaves & accelerates the development of tip burn and rot. Hot, rainy or humid weather is also not favourable as it causes rotting of head lettuce.

Soil: Thrives best on well-drained sandy loam soil rich in organic matter. It is sensitive to high acidity. Optimum pH is 5.8-6.6. About 2-3 ploughings followed by planking is essential to get the soil friable and leveled.

Seed rate: 400-500 g/ha. Leafy type is sown directly in the field.

Spacing: 45 x 30 cm.

Manures & Fertilizers: FYM 10 t/ha, 60:40:40 kg. N:P:K /ha (H.P.)

Planting time: Sept-Oct is the time of nursery raising in North Indian plains.

Irrigation: Immediately after transplanting and subsequently at an interval of 8-12 days.

Interculture & weed control: Shallow hoeing & weeding are essential to keep the field free from weeds & to maintain proper aeration. About 3-4 hand weedings at 15-21 days interval are sufficient. Pre-transplant application of Fluchloralin @ 1.0-1.5 kg/ha effectively controls most of the weed.
**Harvesting:** The leafy var. become ready for harvesting within 50-60 days of sowing & harvested when the leaves attain full size but remain tender. Head type var. takes 60-70 days to harvest. Heads are harvested when they attain a good size & become solid.

**Yield:** Head type: 100-140 q/ha

**Physiological disorder:**

**Tip burn:** Tip burning of the lateral margins of the inner leaves of mature heads: the possible reasons are:
- High temperature, light intensity & long duration
- Excess N
- Ca & B deficiencies.
- High Mn content.
  
  Spray the crop with CaCl$_2$ @ 0.5%

**Diseases:** Damping off, Root rot, Downy mildew, Bacterial rot, Lettuce mosaic, Big vein (soil borne viruses, fungus *Olpidium*)

**Insects:** Aphids

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**Parsley (*Petroselinum crispum*)**

**Family:** Apiaceae  
**Origin:** Mediterranean - possibly Sardinia

- It is a bright green biennial herb, often used as spice or garnish.
- It grows to about 30cm and produces long stalks of tiny greenish yellow flowers which should be cut off when they appear.
- Parsley is used for its leaf in much the same way as coriander (which is also known as *Chinese parsley* or *cilantro*), although parsley has a milder flavor.
- Finely chopped leaves are used for flavouring sauces, soups, stuffing and minces etc and also sprinkled over vegetable and salads.
- A good source of Vitamin A and C, Ca and protein. Besides, K, Fe, Na and P also available.

**Two forms of parsley are used as herbs:**

1. Curly leaf: is often used as a garnish.
2. Italian or Flat leaf (*P. neapolitanum*).
   
   One of the compounds of the essential oil is apiol.

**Root parsley :**

- Grown as a root vegetable (*Petroselinum crispum* var. *tuberosum*).
- This type of parsley produces much thicker roots than types cultivated for their leaves.
- Root parsley is very common in Central and Eastern European cuisine,
- Used in soups and stews.

**General tips for cultivation:**

- Parsley prefers an open, sunny and well-drained position.
- It requires an ordinary, good and well worked soil but a moist and partially shaded position is the best.
- Parsley grows best between 22 to 30°C, optimum being 21°C.
- Low temperature causes severe damage.
- Common varieties are Curled Leaf, Double Curled and Mass curled Champion.
- Sowing of nursery: Low hills: October, Mid hills:August-September, High hills:March- April.
- Seed rate 250 g/ha.
- Seed germination is difficult and inconsistent and may require 3-6 weeks.
- Furanocoumarins in seed coat may be responsible. Soaking seeds overnight before sowing shortens the germination period.
✓ FYM 150q/ha, 60:40:30 kg NPK/ha. Apply full P, K and half N at planting and resy N in 2 equal splits at one month interval each.
✓ Spacing 45 cm X 10 cm
✓ Parsley leaves are ready for use about 3 months after seeding.
✓ Average yield is 100-125 q/ha

**Celery**

- A salad crop grown for long fleshy leaf stalks.
- Ranks second in importance among salad crops.
- Leaf stalk and petioles are eaten raw or used for preparation of sauces, vegetable juices, stews, soups etc.
- Eaten primarily for its unique texture and crispness.
- Seeds are used as condiment in European countries and spice in India
- Good for rheumatism.

**Cultivars:** Three types are found:
1. Celery (*Apium graveolens* var. dulce): only central parts of plant are used.
2. Leaf celery or French or Chinese celery ( var. *secalinum*): grown for its pretty fragrant leaves.
3. Celeriac (var *rapacerum*): cultivar of celery.

**Common varieties:** Utah, Pascal, Golden Deteroit, Golden Self Blanch

**Soil and climate:**
- Peat and high sandy loam soils are better for growing.
- High temperature during early stages results in higher yield.

**Sowing time:**
- Low hills: September-October
- Mid hills: August-September
- High hills: April- May

✓ Seed rate is 125 g/ha. Pre-soaking of seeds overnight in water facilitate germination.
✓ Spacing: 40 cm X 15 cm, 60 cm X 20-30 cm for H.P.
✓ FYM 100 q/ha + 100:50:30 kg NPK/ha. Application method same as Parsley.
✓ Blanching by covering the petioles with soil or non-transparent paper is important to get white or non-green petioles.
✓ Harvesting is done when stalk length reaches to a height of 35-40 cm.
✓ Early harvesting before the plant reaches full size produce stalks with high market quality.
✓ Plant is cut 2.5cm below the crown and coarse outer leaves are trimmed.
✓ Yield 400-500q/ha
✓ Pithiness is a major disorder.
✓ Black Heart is caused due to Ca deficiency and preharvest water stress.
Other tuber crops
Sweet Potato (*Ipomoea batatas*)

It is an 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.

**Origin**: Tropical America

**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 °C. The optimum soil temperature is 20-30 °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**
   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 m². 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 m². 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)
- In Nilgiri hills – April-May.

**Manures and Fertilizers**: Farmyard manure -100-150 q/ha. 90: 60: 90 kg N: P₂O₅ and K₂O 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°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.

Storage: The red skinned tubers generally store better tan white skinned. The optimum temperature is 15 oC & 85-90% RH for prolonged storage.

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
2. Leaf eating caterpillar: Spray Endosulfan (0.05%).

**Yams (Dioscorea spp.)**

Yams (Dioscorea spp.) are under utilized tuber crops in the tropics. It is grown in southern and eastern parts of India. The tubers are rich source of protein and aminoacids. The tuber is consumed after roasting, boiling or with other vegetables. It is also used as chips, flakes and flours. Many species of yam contain small amounts of sapogenins and alkaloids for various uses. The main sapogenins present is diosgenin, which is a starting, point in several corticosteroid drugs.

The ancestral Dioscoreaceae may have originated in Southeast Asia. In India, D. alata and D. esculenta are extensively cultivated in different regions as a subsidiary food crop. Dioscorea are deciduous perennial plants. It bears dioecious flowers.

Climate: The optimum temperature range is between 25 and 30°C and cannot tolerate frost. Growth is affected at a temperature below 20°C. Shorter days favour tuber formation and development while longer days (>12 hours) influences vine growth. Evenly distributed rainfall of 120-200 cm throughout the growing season is ideal.

Soil: Well drained, loose friable soil containing good amount of organic matter is preferred for its cultivation. It can be grown in a wide range of soil pH between 5 and 7.

Varieties: D.alata - Sree Keerthi, Sri Roopa, DA 173, DA 11, DA 199, DA60, DA 80 and Da122.
D. esculenta - “Sree Latha” and Sree Kala.

**Propagation:** Yams are mainly propagated vegetatively and the commonly used material for planting is tuber piece or small whole tuber. Among the portions of tuber (head, middle and tail), heads are the best, which sprout readily followed by tails and middles. A seed tuber weighing 200-250 g is ideal for optimum production in D. alata and 100-125 g in D. esculenta, although large sized seed tubers give higher yield.

**Planting method and spacing:** Yams are planted in flat or raised beds or on mounds formed over pits. The seed tubers are planted at a depth of 10-15 cm in the soil from March-May before the onset of monsoon. A spacing of 75 x 75 cm for D.esculenta and 90 X 90 cm for D.alata may be followed for the optimum yield of tubers.

**Manures and fertilizers:** Application of NPK @ 80:60:80 kg/ha is recommended.

**Intercultural operations:** Normally 2-3 interculture operations would be sufficient to check the growth of weeds. The first interculturing sufficiently deep should be done one week after sprouting of 50% tubers and the second and third ones at an interval of 15 days to one month depending on the weed growth. Mulching after planting of tubers is very useful for increasing the yield. It provides protection from excessive temperature, conserves soil moisture, ensure quick and uniform sprouting of the tubers and suppresses weeds.

**Training:** Trailing of vines is an important operation to expose the leaves to sunlight. Staking to provide support to the vine has been found essential for better growth, development and yield of yams. The emerging shoots should be immediately provided with supports to avoid any injury to the tender shoots. The species D. alata requires trailing to a greater height as compared to D. esculenta due to its bushy growth. Trailing is done with in 15 days of sprouting by coir rope attached to artificial supports or trees in a growing area. The most effective method is Pandal system which gives higher yield about 50% higher over that of without trailing.

**Harvesting:** When the leaves turn yellow and the vines completely dry up, the crop is ready for lifting, which will be achieved in about 8-9 months after planting. D.esculenta matures early as compared to other species. There is a practice of double harvesting i.e. remove mother tubers after two months of growth and allowing subsequent production of side tubers. However, double harvesting is not economical as compared to single harvesting. Care should be taken while harvesting that tubers are not cut or damaged which causes rottig of tubers.

**Yield:** D.esculenta is 10-30 t/ha, D.alata is 20-40 t/ha.

**Post Harvest handling:** Among the tuber crops, yam possesses an excellent quality of post harvest storage. Tubers after harvest develop few layers of cork cells around it and protect the tuber from the loss of water. Yams are stored in tropical countries at a temperature of 30°C.

**Pests:** Two major diseases, the blight and die back caused by Cercospora spp. and Colletotrichum spp. are found. Among the insects, scale, white grubs, termites, chrysomelids and hairy caterpillar are important.

**Elephant foot yam (Amorphophallus paeoniifolius)**

**Family: Araceae**

Elephant foot yam is a tropical tuber crop. It is basically a crop from south east Asian origin. In India, it is commonly known as "Suran" or "Jimmikand". It is used for making vegetables, pickles and indigenous Ayurvedic preparations for various ailments. The tubers of wild plants are highly acid and cause irritation in throat and mouth due to excessive amount of calcium oxalate present in the tubers.

**Climate and soil:** Elephant foot yam grows well in hot climate at 25-35°C. Humid climate help in the initial stages of the crop growth whereas dry climate facilitates tuber bulking. Well-distributed rainfall of 1000-1500 mm is helpful in good crop growth and tuber yield.
Well-drained, fertile, sandy loam soil is ideal for elephant foot yam cultivation. Water stagnation at any stage adversely affects crop growth, tuberisation and tuber quality.

**Varieties:** Gajendra, Sreepadma, Palam Zimikand 1

**Cropping season:** Under irrigated conditions: mid-March and harvested during mid-November.

**Under rain-fed condition:** last week of June just before the onset of monsoon.

- February-March is the best time for planting in Kerala and northeastern India
- Depending on the market demand, the harvesting can be started after 5-6 months. The crop planted in March, obviously gives better yield as compared to June planting. The plant height is 1-1.5m.

**Planting method:** Planting should be done in pits (40cm x 40 cm x 40 cm) filled with Farm Yard Manure, good soil and fine sand in the ratio of 1:1:1. For seed materials ranging from 400-500g, a distance of 90cm x 90 cm is recommended. If the seed materials are smaller in size, a spacing of 60 cm x 60 cm should be provided. The tubers are planted 4-6” below the soil surface. It is very important to provide earthing-up after weeding and fertilizer application at 30-35 and 60-65 days after planting.

**Manures and fertilizers:** farmyard manure @ 20-25 t/ha, 100:80:100 kg/ha of Nitrogen, Phosphorus and Potash has been found to be optimum. Full dose of phosphorus and one-third quantity of Nitrogen and potash is applied at the time of planting. The remaining dose of Nitrogen and Potash is applied in two split doses at 30 and 60 days after planting, immediately after weeding and followed by earthing-up.

**Irrigation:** If the planting is done in mid-March, a light irrigation should be provided immediately after planting. Depending on the soil moisture availability, irrigation should be given at regular intervals till the arrival of monsoon. Care should be taken to prevent water stagnation at every stage of crop growth.

**Plant Protection:** Elephant foot yam is affected by three major diseases namely,

1. Collar rot caused by *Sclerotium rolfsii*,
2. Leaf blight caused by *Phytophthora colocasiae*
3. Mosaic caused by virus.

Use of mosaic virus free tubers + mulching after planting and two foliar sprays with Mancozeb (0.2%) and Monocrotophos (0.05%) at 60 and 90 days after planting has proved very effective in reducing the incidence of major diseases and pests of Elephant foot yam.

**Harvesting:** Yellowing of the leaves and drying up of the plants indicate that the crop is ready for harvest. Tubers are harvested by digging using crowbars or spades. While harvesting, care should be taken to avoid injury to the tubers. After harvesting, soil and roots should be removed from the tubers. Damaged tubers should be immediately disposed-off for local sale as vegetable. The tubers should be graded and dried in shade for 4-5 days before marketing.

**Yield:** 50-60 t/ha.

**CASSAVA (Manihot esculenta)**

It is also known as yucca, tapioca, manioc or indioca. It is a perennial shrub cultivated in the tropics for its starchy tuberous roots.

**Origin:** New world crop with origin in the low land tropics.

**Cultivars:** M-4, Kalikalan; Kuruthakaliyan; H-97; H-165; H-226; Sree Visakham (hybrid); Sree Sahya(Hybrid); Sree Prakash; Sree Jaya; Sree Harsha

**Climate:** Its cultivation is limited to the hottest areas of tropics and sub-tropics and grown up to an area of 2300m near the equator. The ideal temperature for the crop is 25-30°C and well...
adapted to annual rainfall ranging between 1000 and 3000 mm. It is highly tolerant to drought.

**Propagation and planting material:** It can be propagated either from the true seed or vegetatively from stem cuttings called stakes or sets. All commercial plantings are from cuttings of mature stem.

**Land preparation and planting:** Deep ploughing and cultivation before planting increases yields. The most common plant population for cassava is about 10,000 plants per hectare.

**Spacing:** 90 X 90 cm for branching types and 75 X 75 cm for non-branching types

**Planting season:** Generally, planting coincides with the beginning of rainy season. The best time of planting is April-May with the onset of south-west monsoon.

**Manures and fertilizers:** though reputed for its ability to perform well even in poor soils, requires higher levels of fertilizer for better yields. FYM-12.5 t/ha 100:50:60 kg NPK/ha is recommended for high yielding cultivars whereas for local cultivars, 50:50:50 kg NPK/ha + 12.5 t FYM/ha. Apply N and K in two splits i.e half as basal and other half one or two months after planting while P should be applied as basal.

**Irrigation:** It is usually raised as a rainfed crop. On the day of planting, one irrigation is given followed by two irrigations at an interval of 3-5 days till the plants established. Further irrigations are scheduled depending upon the distribution of rainfall.

**Interculture and weed control:** Interculture to suppress weeds in the initial stages of crop growth and to encourage tuber development is essential requirement in cassava production. Light raking of soil followed by earthing twice at one and two months after planting, had significant beneficial effects on cassava yield.

**Harvesting:** Most of the cultivars are ready for harvest at 8-10 months after planting. Some of the short duration types can be harvested at 7th months, while the long duration types may be retained in the field up to 18 months. For human consumption and starch production, the ideal time for harvesting is 8-10 months.

**Yield:** Average yield in India is 19t/ha while the high yielding cultivars are capable of producing 25-30 t fresh tubers/ha

**Storage:** Cassava tubers once harvested are highly perishable due to physiological and microbiological changes. The harvested tubers should be used within a day or two in the absence of long term storage methods. Farmers overcome this problem to some extent either by delaying the harvest or by slicing the tubers and sun-drying as dry chips.

**Diseases:**

- **Brown leaf spot:** spray 0.1% benlate or 0.2% cercobin.
- **Cassava bacterial blight:** disease is transmitted through infected planting material, careful selection of stems for planting will check the disease.
- **Cassava mosaic disease:** transmitted by white fly.
- **Insects:** Spider mites; Termite; White Grubs; White Scale (Aonidomytellus albus)

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