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Vegetables comprise of a large number of plants, mostly annuals, of which different parts like root, stem, leaf, flower bud, flower, fruit etc. are consumed either raw as salad or cooked. They are essential items of balanced diet and are rich in nutrients. Therefore, these are very rightly called as protected food as their consumption can prevent several diseases. Many vegetables can play a major role in the economic development of a nation. This 'e-course' is a valuable addition to the upcoming of literature for undergraduate students. The main objective of this 'e-course' is to acquaint the students with the facts and principles on which successful production and handling of vegetables are based. They will learn how to grow temperate vegetables, their agronomy, and protection and seed production aspects besides varieties, nutritive value, origin and economic importance. Every effort has been made to make the language simple and student friendly. In addition, a glossary has been cited at the end to make students understand new and tough terms. I hope this course will serve a sort of text as well as help book to the beginners.

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SYLLABUS

Course	Title:	Temperate	Vegetables	2(1+1)
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Theory: Importance of cool season vegetable crops in nutrition and national economy. Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, seed production, post-harvest technology and marketing of cabbage, cauliflower, knol-khol, sprouting broccoli, Brussels' sprout, lettuce, palak, Chinese cabbage, spinach, garlic, onion, leek, radish, carrot, turnip, beet root, peas, broad beans, rhubarb, asparagus, globe artichoke and potato.

Practical: Identification and description of varieties/hybrids; propagation methods, nursery management; preparation of field, sowing/transplanting; identification of physiological and nutritional disorders and their corrections; post-harvest handling; cost of cultivation and field visits to commercial farms.

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BASIC STATISTICS

BASIC STATISTICS: Source: National Horticulture Board, 2011.

India is the second largest producer of vegetables in the world after China.

- Area under vegetables 8.495million ha
- Total production 146.554 million tonnes
- Productivity per ha 17.3 t/ha
- Top five states (area wise) West Bengal, Uttar Pradesh, Bihar, Orrisa, Maharashtra.
- Highest productivity Tamil Nadu (28.92 t/ha)
- India's share in world production: 14%.
- According to an estimate, by the end of 2030, nearly 151-193 million tones of vegetables are to be produced to meet the requirement (NHB, 2010).

DEFINITIONS OF VEGETABLES:

- **Definition 1:** These are the products of herbaceous plants which are annuals, biennial or perennials (mostly annual) whose plant parts such as fruits, leaves roots, stems, petioles flowers etc. are used for culinary purpose 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)

IMPORTANCE OF VEGETABLES:

The country is now almost self-sufficient on food front. The researches 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.

- 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 food-carbohydrates) but also promise supply of vital protective nutrients like minerals and vitamins.
- Consumption in sufficient quantities provides taste, palatability, 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.
- According to Indian Council of Medical Research (ICMR), intake of 300g of vegetables every day 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 recommendation for average women is more or less same with exception in roots and tubers which should be at least 75g per day.
- The average intake of vegetables of the country is about 230 g/head/day.
- Low availability per capita per day is due to high population and heavy post harvest losses (approx 35%).

- The importance of vegetables is further increased as majority of the Indian population is vegetarian.

1. Productive Foods (energy-rich food) are Carbohydrates, Proteins, and Roughages.

Nutrient	Deficiency causes	Nutrient rich temperate vegetables
Carbohydrates (400-500 g)	Serve as a chief source of energy in the food. It is found in vegetables mainly in the form of starch and cellulose.	Carrot, Pea, Onion, Parsley, Potato etc.
Protein (60-70 g)	Retarded growth in children. Discolouration of skin and hair. (Vegetables contain less proteins compared to the product of animal origin. However, protein quality (composition of amino acids) is quite good although sulfo-amino acids (methionine, cystine) are most of the time limited in vegetable protein.)	Pea, broad bean, celery etc.

- Consumption of 100g of leafy vegetables in a day can supply 15 % or more of the total protein intake

Protective Foods Vitamins and Minerals

II. a) Vitamins

Protective

Foods:

Nutrient	Deficiency causes	Nutrient rich temperate vegetables
Vitamin A (5000 IU)	Night blindness, Xerophthalmia, Frequent respiratory infection.	Turnip Green, carrot, Palak, Spinach, broccoli, kale
Thiamin (B ₁) 1.2 mg	<ul style="list-style-type: none"> • Beri-beri disease • Loss of appetite. • Dilation of heart 	Turnip green (0.31 mg), Palak (0.26mg), Pea(0.25 mg), leek
Riboflavin (B ₂) 1.7mg	<ul style="list-style-type: none"> • Ulcers in the oral cavity. • Loss of hair & dry scaly skin. • Cracked lips. 	Turnip green (0.57 mg), Palak (0.56 mg) , broccoli, lettuce, celery, Asparagus
Niacin (19 mg)	<ul style="list-style-type: none"> • Pellagra • Nervous break down. • Stomach and intestinal 	Turnip green (5.4 mg), Palak (3.3mg), radish, lettuce, carrot, pea.

	disorder. • Sore tongue.	
Pyridoxin (B ₆)	Ulceration of oral cavity, anaemia, skin diseases (acrodynia)	Widely distributed in vegetables
Vit C (70 mg)	• Scurvy (oedema, anaemia, bleeding gums and mucus membrane). • Reduced resistance to diseases.	>100 mg: Turnip green, cabbage, broccoli, kale, parsley 70-100 mg: cauliflower
Vit K (0.15 mg)	Delayed and faulty coagulation of blood in cut wounds. Hindrance in normal secretion of bile	Green leafy vegetables

- Only 30 g of leafy vegetables will be sufficient to meet the requirements of vitamin A and C.

b) Minerals:

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

Nutrient	Deficiency causes	Nutrient rich temperate vegetables
Ca	Bones & teeth, blood clotting, osteomalacia in women after repeated pregnancies	Turnip green, palak, sprouting broccoli, kale, parsley, onion
Fe	Important component of haemoglobin, Anaemia – pale smooth tongue, pale lips, eyes & skin: spoon shaped nails, frequent exhaustion	Green leafy vegetables are rich in sources e.g. palak, spinach, lettuce
P	Component of DNA (deoxyribonucleic acid) – basis of life	Vegetables are quite rich in P e.g. Pea, sprouting broccoli, cauliflower, globe artichoke

- It has been estimated that 100g of leafy vegetables can provide 60-140 mg of ascorbic acid (vitamin C), 100 mg folic acid, 4-7 mg iron and 200-400 mg of calcium.

C) Roughages/Dietary Fibres:

- Dietary fibres or non starch polysaccharides are the complex polysaccharide such as cellulose, hemicelluloses, lignin, pectin and mucin.
- Dietary fibres possess ability to imbibe water and swell, thus contributing bulk to the diet.
- Help in digestion & prevent constipation
- Leafy vegetables such as spinach, Indian palak and lettuce and root crops like radish, turnip and beet root provide the dietary fibre essential for bowel movement and possibility for prevention of diseases such as appendicitis, colon cancer, diabetes, diverticulosis, gall stones and obesity.
- Foods containing dietary fibre require chewing hence it limits food intake and acts as natural appetite suppressant.

D) Other Medicinal Properties:

- Vegetables also contain a number of flavour compounds such as sugars, amino acids, and organic acids; volatiles such as aromatic hydrocarbons, aldehydes, acetals, ketones, alcohol, esters and sulphur compounds.
- Antioxidants and bioflavonoid and several other compounds present in these crops protect human body from various ailments like cancer and heart diseases.
- Quercetin, a bioflavonoid present in onion and garlic provide protection against cancer and heart diseases.
- Compounds like allicin, alliin, garlicin, diallyl disulphide (garlic) and allyl propyl disulphide (onion) are sulphur containing compounds which reduces chances of heart attack and strokes.
- Indoles and isothiocyanates prevent cancers of colon, rectum and breast and are present in cole crops.
- Diphenylamine found in onion is effective against diabetes.
- Leguminous vegetables reduce blood cholesterol thus prevents heart attack.
- Celery contains 3-n butyl aldehyde, which is effective against hypertension.

COMMERCIAL AND ECONOMIC IMPORTANCE

I. Vegetable crops give higher yield per unit area as compared to other crops and produce 4-5 times more food per unit area compared to cereals; as a result they play an important role in reducing levels of malnutrition.

- Tomato 400-500 q/ha and Garden pea: 100q/ha
- Wheat 25-30 q/ha.
- Pulses 10-15 q/ha.
- Presently, yield per unit area of most of the vegetables in India is very low e.g. in cabbage, the productivity is 22.0 MT/ha which is far less than the world's best i.e. Korea Republic having figure as 67.3 MT/ha.
- There exists lot of scope for increasing yield in most of the vegetables by growing

high yielding varieties/hybrids and adopting improved production technology.

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 . 25,000/ha
- Off-season: Tomato 1 lakh/ha
- Peas 50,000/ha.

III. Vegetable Production Assures More Farm Employment

- Labour intensive, 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, potato. etc.

V. Potao-onion-french bean-okra: 400%

- Radish-pea-french bean-okra: 400%

V Industrial Development:

- Supports many other industries like processing, seed industry, fertilizer, pesticide, weedicides and farm machinery.

VI. Foreign Exchange Earner:

- Vegetables are becoming increasingly important as cash crop for urban and export markets.
- Export as per APEDA 2007-08 (Agricultural and Processed Food Products Export Development Authority) of different vegetable based commodities is as under:
- Fresh produce: onion, okra, pea, cole crops, cucurbits, bean (Rs1, 525 crores).
- Vegetable seed: 142 crores.
- Processed vegetables: Tomato, pea (140 crores).
- Dehydrated: Ginger, garlic, turmeric, pea.

VII. High Aesthetic Value:

- growing vegetables in kitchen/ large scale – one gets internal satisfaction by observing the growth of crop (right from germination to harvesting).

VIII. Vegetable consumption therefore, is considered an important economic factor in a society because it improves health as well as working capacity.

PROBLEMS OF 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.

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NUTRIENT COMPOSITION

Nutrient composition of important temperate vegetables per 100 g of edible portion:

- Potato is the richest source of energy (97kcal) followed by Pea (84kcal), Leek (77kcal), Turnip greens (67kcal) and Kale (53kcal),
- Pea and Garlic are the richest sources of proteins (6.3g) followed by Kale (6.0g), Brussel's sprout (4.9g) and Fenugreek leaves (4.4g).
- Turnip green is the richest source of fats (1.5g), followed by Fenugreek leaves (0.9g), Kale and Spinach beet (0.8g) and Brussel's sprout and Pea (0.4g).
- Garlic is the richest source of carbohydrates (29.8g) followed by Potato (22.6g), Leek (17.2g), Pea (14.4g), and Carrot (9.7g).
- Turnip green is the richest source of vitamin A (15691 IU) followed by Carrot (11000 IU), Kale (10000 IU), Spinach (8100 IU), and Spinach beet (5862 IU).
- Pea is the richest source of thiamine (0.35mg) followed by Turnip green (0.31mg), Spinach beet (0.26mg), Kale (0.16mg) and Cauliflower (0.11mg).
- Turnip green is the richest source of riboflavin (0.57mg) followed by Spinach beet (0.56mg), Fenugreek leaves (0.31mg), Kale (0.26mg), Sprouting broccoli and Garlic (0.23mg).
- Turnip green is the richest source of niacin (5.4mg) followed by Spinach beet (3.3mg), Pea (2.9mg), Kale (2.1mg) and potato (1.2mg).
- Kale is the richest source of ascorbic acid (186mg) followed by Turnip green (180mg), Sprouting broccoli (113mg), Brussel's sprout (102mg), and Parsley (90mg).
- Turnip green is the richest source of calcium (710mg) followed by Fenugreek leaves (395mg), Spinach (380mg), and Kale (249mg).
- Garlic is the richest source of the phosphorus (310mg) followed by Pea (116mg), Kale (93mg), Brussel's sprout (80mg), and Sprouting broccoli (78mg).
- Turnip green is the richest source of iron (28.4mg) followed by Fenugreek leaves (16.5mg), Spinach beet (16.2mg), Onion stalk (7.9mg) and Spinach (3.1mg).

Table 1. : Nutrient composition of vegetables per 100 g of edible portion

Crop	Macronutrients					Vitamins					Minerals		
	Energy (kcal)	Moisture (g)	Protein (g)	Fat (g)	CHO (R)	A (IU)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)	Ascorbic acid (mg)	Ca (mg)	P (mg)	Fe (mg)
Broad bean	48	85.4	4.5	0.1	7.2	15	0.08	-	0.8	12	50	64	1.4
Brussel's sprout	45	85.2	4.9	0.4	8.3	550	0.10	0.16	0.9	102	36	80	1.5
Cabbage	24	92.4	1.3	0.2	5.4	130	0.05	0.05	0.3	47	49	29	0.4
Carrot	42	82.2	1.1	0.2	9.7	11000	0.06	0.05	0.6	8	37	36	0.7
Cauliflower	27	91.0	2.7	0.2	5.2	60	0.11	0.10	0.7	78	25	56	1.1
Celery	17	94.1	0.9	0.1	3.9	240	0.03	0.03	0.3	9	39	28	0.3
Chinese cabbage	14	95.0	1.2	0.1	3.0	150	0.05	0.04	0.6	25	43	40	0.6

Crop	Macronutrients	Vitamins	Minerals
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	Energy (kcal)	Moisture (g)	Protein (g)	Fat (g)	CHO (R)	A (IU)	Thiamine(mg)	Riboflavin (mg)	Niacin (mg)	Ascorbic acid (mg)	Ca (mg)	P (mg)	Fe (mg)
Fenugreek leaves	49	86.1	4.4	0.9	6.0	3861	0.04	0.31	0.8	52	395	51	16.5
Garden beet	43	87.7	1.7	0.1	8.8	0	0.04	0.09	0.4	10	18	55	1.0
Garlic	30	62.0	6.3	0.1	29.8	Trace	0.06	0.23	0.4	13	30	310	1.3
Kale	53	82.7	6.0	0.8	9.0	10000	0.16	0.26	2.1	186	249	93	2.9
Knol-khol	29	90.3	2.0	0.1	6.6	20	0.06	0.04	0.3	66	41	51	0.5
Leek	77	78.9	1.8	0.1	17.2	30	0.23	-	.	11	50	70	2:3
Lettuce	14	95.1	1.2	0.2	2.5	900	0.06	0.06	0.3	8	35	26	2.0
Onion	50	86.6	1.2	0.1	11.1	Trace	0.08	0.01	0.4	11	47	50	0.7
Onion stalk	41	87.6	0.9	0.2	8.9	993	0.05	0.03	0.3	17	50	50	7.4
Parsley	16	90.0	2.2	0.3	1.3	5200	0.08	0.11	0.7	90	125	40	2.0
Pea	84	78.0	6.3	0.4	14.4	640	0.35	0.14	2.9	27	26	116	1.9
Potato	97	74.7	1.6	0.1	22.6	40	0.10	0.01	1.2	17	10	40	0.7

Crop	Macronutrients					Vitamins					Minerals		
	Energy (kcal)	Moisture (g)	Protein (g)	Fat (g)	CHO (R)	A (IU)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Ascorbic acid (mg)	Ca (mg)	P (mg)	Fe (mg)
Radish	17	94.4	0.7	0.1	3.4	5	0.06	0.02	0.5	15	35	22	0.4
Spinach	26	90.7	3.2	0.3	4.3	8100	0.10	0.20	0.6	51	93	51	3.1
Spinach beet	46	86.4	3.4	0.8	6.5	5862	0.26	0.56	3.3	70	380	30	16.2
Sprouting broccoli	32	89.1	3.6	0.3	5.9	2500	0.10	0.23	0.9	113	103	78	1.1
Swiss chard	16	92.0	1.8	0.2	1.5	3300	0.04	0.09	0.4	30	51	46	1.8
Turnip root	29	91.6	0.5	0.2	6.2	0	0.04	0.04	0.5	43	30	40	0.4
Turnip green	67	81.9	4.0	1.5	9.4	15691	0.31	0.57	5.4	180	710	60	28.4
Water spinach	28	90.3	2.9	0.4	3.1	3267	0.05	0.13	0.6	37	110	46	3.9

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CABBAGE

BOTANICAL NAME : *Brassica oleracea* var. *capitata* Linn.

COMMON NAME : Bund Gobhi

FAMILY : Cruciferae

CHROMOSOME NUMBER : 2n=2x=18

USES (common for all cole crops)

- These are eaten in the raw state as well as cooked.
- These are known for their rich source of vitamin A and C. Also, contains minerals including P, K, Ca, Na and Fe.
- There may be some protective properties against human bowel cancer in these vegetables.
- They are used against ailments such as gout, diarrhea, coeliac trouble, stomach trouble, deafness and headache.
- The leaves are used to cover wounds and ulcers and also recommended against hangover.
- Cabbage juice is said to be a remedy against poisonous mushrooms and also used as a gargle against hoarseness.

ORIGIN AND HISTORY

- Cabbage was originated from a wild non-heading type plant *Brassica oleracea* var. *sylvestris* Syn. (*Brassica sylvestris*) commonly known as wild cliff cabbage or cole worts.
- It is native to the Mediterranean region.
- The real headed cabbage was evolved in Germany.
- The savoy cabbage originated in Italy and spread to France and Germany in the sixteenth and seventeenth centuries.
- At present, cabbage is grown in Caribbean countries, Indonesia, Malaysia, Central East and West America.

The nutritive value of cabbage per 100 g of edible portion is given here under:

NUTRITIVE VALUE AND USES

Energy (k cal)	24	Riboflavin (mg)	0.05
Moisture (g)	92.4	Niacin (mg)	0.3
Protein (g)	1.3	Ascorbic acid (mg)	47
Fat (g)	0.2	Ca (mg)	49
CHO (g)	5.4	P (mg)	29
Vitamin A (IU)	130	Fe (mg)	0.4
Thiamin (mg)	0.05		

- Cabbage leaves are low in calories (24 per cent), fat (0.2 per cent) and carbohydrates (5.4 per cent).
- It is a good source of protein (1.3 per cent).
- Cabbage is an excellent source of minerals such as calcium, iron, magnesium, sodium, potassium, and phosphorus.
- It contains good amount of ascorbic acid.
- Cabbage is used mainly as a vegetable and nice pickle (sauerkraut) is prepared from it.

- It is also used for salad purposes.
- Cabbage is well known for its medicinal properties. It is widely used for cough, fever, peptic ulcers and skin diseases.

AREA AND PRODUCTION

- India is the third largest producer of cabbage in the world.
- It is mainly grown in states like Uttar Pradesh, Orissa, Bihar, Assam, West Bengal, Maharashtra and Karnataka.
- Apart from India, the other major cabbage producers in the world are China, Russian Federations, Japan, Korea Republic, Poland, USA, Indonesia and Ukraine.
- The area under this crop in India is 369 thousand ha having a production 7949 thousand tonnes with a productivity of 21.5MT/ha (NHB, 2011).

VARIETIES/HYBRIDS

The cabbages are classified into three broad groups:

- **White Cabbage:** Most common shapes for cultivated cabbages are pointed, round and flat or drumhead.
- **Red Cabbage :** Leaves have distinct coat of wax and tolerant to diamond back moth.
- **Savoy Cabbage:** Blistered leaves and the shape is pointed round and flat.

A. White Cabbage: cultivars are divided into 3 groups on the basis of maturity of heads after transplanting

Early Group (Takes 55-70 days to maturity)	Mid season Group (Cultivars fall between early and late) 80-90 days	Late Group (Takes 85-130 days)
Golden Acre, Pride of India, Copenhagen Market, Pusa Ageti, Pusa Mukta, Pusa Sambandh (Synthetic var.) Pusa Synthetic	Wisconsin All Green, All Heads early, Glory of Enkhuizen, September, Pusa Drum Head	Pusa Drum Head, Danish Ball Head, Indian Edips, Late Flat Dutch, Late K-1, Late Large Drum Head

B. Red Cabbage: 1. Red Acre 2. Red Mammoth

C. Savoy Cabbage:

Perfection

(Syn.

Chieftain)

The varieties can also be grouped as open pollinated and hybrid varieties

Open Pollinated Varieties

Open a)	Early	Pollinated and	mid	Varieties season
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Copenhagen Market:

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

Early Drum Head:

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

Golden Acre:

- This is an earliest variety evolved by selection from the Copenhagen Market and recommended by IARI for cultivation in India.
- It takes about 60-65 days from transplanting to head formation.
- The heads are solid, short core and weighing about 1.0-1.5 kg.
- The heads should be harvested immediately after head formation otherwise, cracking may take place.

Jersey Wakefield:

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

Pride of India:

- It is an introduction, early in maturity and good in taste.
- The plant type of this variety is similar to 'Golden Acre' but it is about a week later in maturity. It has bigger sized heads, weighing about 1.5 to 2.0kg per head.

Pusa Synthetic:

- This variety has been developed from IARI, Regional Station, Kartain, Kullu Valley, HP.
- It is an early synthetic variety.

- The yield potential of this variety is 350-460 q/ha.

Pusa Mukta (Sel.8):

- This is a new variety developed by Indian Agricultural Research Institute, Regional Station, Katrain by hybridization between EC 24855 x EC 10109.
- The light green foliage with wavy margins is a distinguishing character of the variety.
- The heads are compact, slightly flattish round with loose wrapper leaves at the top.
- Average head weight is 1.5-2.0 kg.
- It is resistant to black rot

Pusa Drum Head:

- It is an important selection released by IARI, Regional Station, Katrain (Kullu Valley, HP).
- Heads are solid and flat weighing about 3 to 4kg.
- It takes about 80-90 days from transplanting to harvesting.
- It also possesses field resistant to black leg.

**b) Late group:
September:**

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

Late Drum head:

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

Red Cabbage:

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

Hybrids:

a) Early and mid season:

H-113:

- This is a self-incompatible based hybrid between Sel-8 and 83-6 line, developed at IARI Regional Station, Katrain.
- Plants bear roundish, compact head (13.5 x16 cm), blush green and waxy leaves.
- It gives average yield of 473q/ha in 60-68 days of crop duration.

Suhda (BSS-115):

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

Bajrang (BSS-50):

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

Kranti:

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

Mitra:

- It is an early hybrid with excellent head to plant ratio.

- Heads are fresh green, uniform, compact, ball shaped and weights around 0.8 to 1.2kg each.
- It has good field retention ability.

Pusa Ageti:

- It has been developed from TKCBS -28 (F₁ Hybrid) procured from Tiwan.
- It takes about 70-90days from transplanting to harvesting.
- Head weight varies from 600 to 1,200g.
- This hybrid is resistant to *Fusarium* wilt.

Quisto:

- It is a high yielder hybrid and has ability to stand over severe hot condition.
- Head can stand in the field condition up to 70days.
- Heads are solid with dark blackish colour. It is good for tropical climate.

BSS-44:

- The hybrid has been developed by Beejo Sheetal Seeds Pvt, Ltd., Jalna.
- The head is roundish, average weight 2.5 kg and mature in 75 days after transplanting.
- Its head can also stand for 20 days in field after maturity.
- This hybrid can grow well both in cold and hot weather conditions.

b)

Late

group:

Harirani Gole:

- It is a good hybrid for medium late maturity.
- It produces medium sized ball shaped dark green, solid head with good wrapper leaves. Average head weight is 1.5-2.0kg.
- It can be harvested 95-100days after transplanting.

Sri Ganesh Gol:

- This hybrid has been developed by Maharashtra Hybrid Seeds Co. Ltd., Jalna and recommended for cultivation in Andhra Pradesh.
- Heads are round, compact, attractive, bluish green and become ready for harvest in 90 to 95days.
- Average yield is 500 to 750q/ha.

Suvarna (BSS-32):

- The hybrid has been developed by Beejo Sheetal Seeds Pvt. Ltd., Jalna.
- Heads are round and average head weight is 3kg.

- This hybrid has strong smooth outer leave. It matures in 110days.

CLIMATIC REQUIREMENTS

- Cabbage can be grown under a wide range of environmental conditions but cool moist climate is most suitable.
- The optimum soil temperature for seed germination is between 21.2 to 26.2°C
- The optimum temperature for growth and heading is between 15-20°C.
- Minimum temperature for growth of cabbage is just above 0°C.

SOIL

- Cabbage can be grown in a wide range of sandy to heavy soils.
- Early cultivars grow well in light soils, whereas, late maturing ones perform better on heavy soils.
- The optimum pH of soil for cabbage cultivation is between 6.0-6.5.
- Most of the cabbage varieties are tolerant to salts. In saline soils, the plants are more prone to diseases.

SOWING TIME

- In high hills, seeds are sown in May-June for summer/autumn crop.
- In the hilly areas which receive heavy rains, the summer and autumn crop is rather limited and sowing is done in autumn to harvest them in late spring or early summer by over watering them.
- In the plains of Northern India, sowing in situ or in seed beds starts from August and in Eastern India, it starts from mid to late September.

SEED RATE

- Early season 600-800g/ha.
- Main season 200-50g/ha
- One gram seed give rise to about 100seedlings

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NURSERY MANAGEMENT

NURSERY MANAGEMENT

- Cabbage is basically a transplanted crop.
- The seeds are sown in seed bed.

- In the plains, the seed beds for early crop require cover (mulching) to save the small seedlings from rains, while in the high hills, it may be better to grow them under glass flames or poly tunnels.
- The seedlings of mid-season or late cultivars may be raised in the open.
- The soil of nursery should be well prepared and free from diseases.
- Well rotted farmyard manure should be added @ 2-3kg/m²
- The optimum spacing between rows in the nursery beds is 10cm and the depth of sowing is 1.5-2.5cm.
- For planting one hectare, about ten nursery beds of 300 x 100 x 15 cm dimension are required.
- After sowing, the seeds are properly covered with a thin layer of mixture of fine manure and soil.
- Regular and optimum moisture supply is needed. Then cover the nursery beds with dry grass.
- Generally, 4-6weeks old seedlings are ready for transplanting but seedlings up to 8weeks age can also be transplanted.
- The time of transplanting varies in different climatic conditions.
- In plains of India, it can be done from August to December and in hills from April to August.

SPACING

- The planting distance may be varying according to cultivars, planting season and soil.
- Early maturing cultivars: 45 cm x 45 cm or 60 cm x 30 cm,
- Mid season: 60 cm x 45 cm
- Late maturing: 60 cm x 60 cm
- The planting is done in the flat bed or ridges and furrows depending on soil and climate.

NUTRIENT MANAGEMENT

- Manures and fertilizer requirements in cabbage depend upon fertility of soil.
- Accordingly, add 200-250q/ha farmyard manure and it should be mixed thoroughly at the time of field preparation.
- Application of nitrogen, phosphorus and potash varies with soil type, varieties and place.
- The requirement of N: P: K is 120-180:75-80:60-75kg /hectare.
- 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 30-45days of transplanting.

INTERCULTURAL OPERATIONS

- Cabbage is a shallow rooted crop, so 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.
- Crust formation in medium heavy and clay soils hinder water and air penetration in root system and should be broken otherwise adversely affect 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 @ 0.5kg/ha or Fluchloralin @ 0.5kg/ha before transplanting is beneficial for controlling annual and broad leaved weeds.
- Pendimethalin (Stomp @ 1.2kg a.i. /ha or Oxyflurofen (Goal) @ 600ml/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 will result in splitting of heads.

HARVESTING AND YIELD

- The harvesting of cabbage is done when the heads attain marketable size.
- The early cultivars grown under comparatively warmer conditions develop loose head at the initial stage, but later become compact.
- In some cultivars, the heads start cracking soon after the maturity.
- In such cases, the quality of heads deteriorates fast, if harvesting is delayed.
- Harvesting should be done at right stage for getting good quality head.
- 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.
- The early cultivars take about 60-80 days, medium 80-100 days and late 100-130 days for harvesting after transplanting.
- Owing to higher prices and small family requirements, the demand of market is for small to medium sized heads weighing around 0.5-1.0kg.
- Average yield of cabbage varieties from 20t/ha in OP varieties and that of hybrids between 50-70t/ha.

POST HARVEST HANDLING AND STORAGE

- Avoid direct contact of heads with the soil and exposure to direct sunlight. Proper packing is to be done to avoid bruising.
- Grading of cabbage should be done on the basis of size and firmness of head.

- The early varieties can be stored for 4-6weeks at 0°C-1.7°C and RH between 92-95% while the late ones for 12weeks due to firmness of heads.

PACKAGING

- Cabbage heads are sent to the market in loose condition in trucks or in sacks.
- For transportation of early cultivars, either loose or in sacks, there is damage of the heads due to their succulence and looseness.
- Heads are packed according to their size.
- Crates are popularly used for packing.

VALUE ADDED PRODUCTS

- Sauerkraut
- Drying
- Pickling
- Canning
- Cole slaw

SEED PRODUCTION AND SEED CERTIFICATION STANDARDS

Seed Production

Climatic requirements

- Cabbage thrives well in a cool, moist climate with moderate rainfall.
- It can withstand frost in the head stage.
- It requires a dormant period of cool temperature (Chilling/vernalization) to bolt and initiate seed stalks and flower.
- After the cold treatment at 4 to 7°C for 4-6weeks, the plant bolt sooner and flower more abundantly but the plants must have passed juvenile phase (pencil thickness of stem).
- Intensity of flowering depends upon age of plants and 3-5months old plants are capable of transformation (early vernalized) since they pass the juvenile phase.

Land requirements:

Land should be free from volunteer plants and crop debris.

Methods of seed production

- Being a biennial, cabbage requires two seasons to produce seed.
- For seed production, sowing time should be adjusted in such a way that heads get ready by the onset of winters.
- In the first season, the heads are produced and in the following season formation of seed stalks begin and the process of seed production follows.

- The seed crop can be left *in situ* or replanted during autumn.
- The *in-situ* method is usually followed for certified seed production and the *ex-situ* for nucleus seed production.
- In *in-situ* method, the crop is allowed to over winter and produce seed in their original position, i.e. where they are first planted in the seedling stage.
- In higher hills where heavy snowfall is experienced during winters, heads are uprooted and stored in trenches to avoid snow injury to the heads.
- In replanting method, the mature heads/plants are uprooted.
- After removing whorls (non wrapper leaves), the plants are immediately reset in a well prepared new field, in such a way that the whole stem below the head is set in the soil with the head resting just above their surface.

Ex-situ/replanting method of producing seed of cabbage:

This method is further divided into three methods to produce seed of cabbage:

i) Stump method:

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

Advantages:

- This method gives extra income by way of sale of heads.
- The crop matures 12-15days earlier than the head intact method and seed yield is slightly higher.

Disadvantages:

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

ii) Stump with central core method:

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

- This is an improvement over stump method in that the shoots arising from the main stem are not decumbent.
- During the last week of March, and until 15th April, when the heads start bursting, two vertical cross-cuts are given on the heads (Kalpa valley of HP).
- Taking care that the central growing point is not injured.
- In the absence of such cuts, the heads burst out irregularly and sometimes the growing tip is broken.
- The operation is completed by going around the field twice or thrice during this period.

Advantages:

- Shoots arising from the main stem are not decumbent, hence very heavy staking is not required and seed yield is increased.

Disadvantage:

- The chopped head can not be marketed.

iii) Head intact method:

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

Advantage:

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

Disadvantage:

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

Brief Cultural Practices(*In-situ* method)

Time of sowing and transplanting

- The sowing time of different varieties should be adjusted according to complete head formation by the end of October or first week of November in high hills before snowfall.
- When the mean temperature falls to 10°C or below the heads stand best for over wintering.
- Early varieties are sown from 10th July to 25th July and transplanted when the seedlings are three to four weeks old.

- The late crop, planted during September does not form heads and bolts directly during spring.
- Late varieties takes about 2 to 3 months to produce mature heads and should be sown during the second and first fortnight of June, respectively and transplanting finished by the first week of August.
- The mean temperatures viz., 22.5°C, 20°C and 14°C of August, September and October, respectively, afford optimum requirements for growth and head development.
- The transplanted crop starts head formation during spring and continues up to June and usually does not produce seed stalks.

Preparation of land for replanting

- Prepare the land to a fine tilth by repeated ploughings and harrowings followed by leveling.

Nutrient management

- Cabbage grows well only when the supply of organic matter is liberal.
- In addition to head crop, apply 100 quintals of farmyard manure per hectare at the time of land preparation for good seed crop.
- Also apply about 100 kg nitrogen, 100 kg phosphorus and 55 kg potash per hectare before replanting of heads.
- Another dose of 50 kg/ha nitrogen will be applied at the time of seed stalk emergence during March –April.
- Extra application of nitrogen may be given as and when there is a need before flowering starts, depending upon the condition of the crop.

Spacing

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

Irrigation

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

Hoeing and Weeding

- At least three weeding and hoeing till the end of October are essential.
- One weeding and earthing up during June the second during August is required which control weeds and also help in proper drainage during winter and thereafter.

Handling the Mature Head

- Before the onset of winters, fully developed heads are uprooted and selected on the basis of varietal characteristics for seed production.
- Handling of plants can be done by any one of the methods described earlier.

Roguing

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

Staking

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

Harvesting and Threshing

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

Seed Yield

- 700 kg per hectare.

SEED CERTIFICATION STANDARDS

I. Field inspection

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

II. Field standards

A. General requirements

Isolation:

- Seed fields should be isolated from the contaminants shown below:

Contaminants	Minimum distance (Meters)	
	Foundation	Certified
Fields of other varieties	1600	1000
Fields of the same variety not conforming to varietal purity	1600	1000

B. Specific requirements

Factors	Maximum Permitted (Per cent)	
	Foundation	Certified
Off types	0.10	0.20
Plants affected by seed borne diseases	0.10	0.50

C. Seed Standards

Factors	Standards for each class	
	Foundation	Certified
Pure seed (minimum) %	98	98
Inert matter (maximum) %	2	2
Other crop seeds (maximum) Number/kg	5	10
Weed seeds (maximum) Number/kg	5	10
Germination (minimum) %	65	65
Moisture (maximum) %	7	7

CHINESE CABBAGE

AIM: Chinese cabbage is an important crop of temperate region. It is an important leafy cum salad vegetable of South East Asian countries. Its cultivation is possible only under moderate to cool countries (15-20°C). All cultural operations Chinese cabbage are same as those for cabbage except that the seeds of Chinese cabbage can also be produced under North Indian plains. The study of present chapter will make the students understand regarding its importance, production technology, seed production techniques and plant protection measures.

BOTANICAL NAME:

- *Brassica campestris* var. *pekinensis* (Heading type)
- *Brassica campestris* var. *chinensis* (Non-heading type)

FAMILY : Cruciferae

CHROMOSOME NUMBER : 2n=18

ORIGIN :

- It is native of China
- Originated from hybridization of “Pak choi” (non-heading Chinese cabbage) and “turnip” when they were grown together in the city of Young-chou.
- It is not a member of cole group but regarded as very closely allied crop due to
 - Similarity in breeding systems,
 - Cultivation practices,
 - Season of growing and other features besides being a member of *Brassica* vegetables.

NUTRITIVE VALUE (per 100 g of edible portion)

Water	95 %	Ca	43 mg
Calories	14 k cal	P	40 mg
Carbohydrates	3.0 g	K	235 mg
Proteins	1.2 g	Na	44 mg
Fat	0.1 g	Mg	13 mg
Fiber	0.57 g	Fe	0.6 mg
Vitamin C	25 mg	Carotene	625 IU
Niacin	0.6mg		

SOIL AND CLIMATE

- Fertile soil with sufficient moisture supply and good physical condition of soil is required
- Soil pH 6.8-7.8.
- Because of its sensitivity to high temperature, chinese cabbage cultivation in low land areas is confined to winter months.
- During summer, this crop is grown in high altitudes on a limited scale.
- It thrives best at temperature ranging from 15-21⁰C, below which seed stalk may emerge before the production of heads.

TYPES AND VARIETIES

There are two more or less distinct spp. of Chinese cabbage, *Pe-tsai* (*B pekinensis*) and *Pak choi* (*B chinensis*).

- Under *Pe-tsai*, two varieties exist.
 1. Chihili (tall, elongated, cylindrical, types about 4x18 inches heads): Jade Pagoda, Mounmeny, Michihli and Statue.
 2. Napa or Wong Bok (short, blunt, barrel shaped about 5x12 inches, chunky heads): All autumn, China flash and China Pride.
- In Pakchoi, the plants produce non heading types. It produces dark rather smooth leaves with fleshy white petioles.

Chinese cabbage can also be broadly classified into four types:

1. **Loose leaved variety (var. *dissoluta*):** Terminal bud under developed, forming no leaf bud; rosette leaves oblanceolate, spreading or erect & usually grown in spring and summer in all parts of China.
2. **Semi heading variety (var. *imfareta*):** Terminal bud with its outer layer of leaves fairly well developed, forming head with a hollow centre; plants large & tall. Usually grown in autumn.
3. **Fluffy topped heading variety (var. *laxa*):** Terminal bud well developed forming rather a solid head with its leaf tips curling upwards & forming a fluffy top; plants small, rosette leaves obovate and spreading. Usually grown in late summer & autumn and
4. **Heading variety (var. *cephalata*):** Terminal bud well developed forming a solid head with leaf tips close to over lapping on the top; grown usually either as an early crop for autumn or a late crop for winter. This variety is further classified into three types (i) ovate type (*f. ovata* Li), (ii) flat topped type (*f. depressa* Li) and (iii) cylindrical (*f. cylindrical* Li).

CULTIVARS

Palampur Green:

- Leaves green, tender, stem creamy and late flowering type.
- Provides 5 -6cuttings, first after 23-30 days and subsequent after 15 days.

Pusa Sag:

- A cross from Wongbok (Suttons) x Turnip.
- Tastes like local sag.

Solan Band Sarson:

- A heading variety, heads long and solid, head weight 700-1100gram and 6-9outer leaves.
- Ready in 120days, leaves light, core light golden in colour.
- Suitable for long distance transportation, used for salad and cooking.
- Average yield 400q/ha.

Solan Selection:

- Leaves tender, well filled light green petioles.
- Average yield 150-190q/ha.

Chinese Sarson No. 1:

- It is a non heading type with light-green, broad leaves and semi-erect plant habit.
- Its mid rib is white, succulent and tender.
- It takes about 30days for the first cutting after transplanting.
- It is quiet rejuvenating, giving 6-8 cuttings.
- Its average yield is 40q/ha.
- It poses field resistance to *Alternaria* leaf spot.

Other cultivars fall in the following groups.

- Chiffu Group
- Hotoren Group
- Kaga Group
- Aichi Group
- Kenshin Group

SOWING TIME

- In plains, sowing is done in mid September to end of November while in mid hills; it is done in April to July.

SEED RATE

- For direct sown crop, seed rate is 2-2.5kg/ha but if transplanted then the seed rate will be 500-750g/ha.

SPACING

- 30-40 x 30-40cm - Early maturing variety
- 70 cm x 55cm - Late maturing variety

NUTRIENT MANAGEMENT

- Manures and fertilizer requirements in Chinese cabbage depend upon fertility of soil.
- Accordingly, add 200 -250q/ha farmyard manure and it should be mixed thoroughly at the time of field preparation.
- The application of nitrogen, phosphorus and potash varies with soil type, varieties and place.
- The requirement of N: P: K is 250-300:150-200:250-300kg /hectare. Apply 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 30days after transplanting.

IRRIGATION

- First irrigation should be given immediately after transplanting.

WATER MANAGEMENT

- Chinese 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 10-15days interval according to the season and soil but optimum soil moisture should be maintained regularly.
- Usually, the crop is irrigated by furrow method of irrigation.
- Heavy irrigation is avoided at the time of maturity of heads.

BINDING

- For harvesting in winter, heads which are nearing maturity, are covered with outer leaves and bound with rice straw to protect them from cold damage.

HARVESTING

1. Heading Type

- Harvesting begins when compact heads (1-2 kg) have formed.
- Heads are cut off with a kitchen knife.
- Fully developed heads are cut from the stalk and loose outer leaves removed before marketing.

2. Non-Heading Type:

- Harvest the fully developed leaves from near the base without injuring the central growing point.

YIELD

- Yield varies from 250-500q/ha

STORAGE

- Storage life is shorter at higher temperatures.
- Shelf life is 30 days at 5°C, 60days at 2.5°C and 90 – 120days at 0°C.
- Can be stored for several weeks at 0°C and 95%RH under controlled atmospheric conditions.
- Low O₂ (2%) in combination with low CO₂ (2%) improves shelf life.

SEED PRODUCTION

- For the production of market seed, seed to seed method is used.
- For stock/breeder's seed, it is better to use head to seed method.
- The stump method gives the lower seed yield.
- For both, foundation and certified seed use seed to seed method.

Three important methods are

- Seed to seed method
- Head to seed method
- Stump method

Details similar to that of cabbage

- Cultural practices for seed production namely, nutrient management, hoeing and weeding, irrigation and harvesting and threshing are similar to that of cabbage.

SEED CERTIFICATION STANDARDS

I. Field Inspection

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

II. Field Standards

A. General requirements

Isolation Distance

Contaminants	Minimum distance (m)	
	Foundation	Certified
Fields of other varieties	1600	1000
Fields of same variety not confirming to varietal purity	1600	1000

B. Specific requirements

Factor	Maximum permitted percentage	
	Foundation	Certified
Off-type	0.10	0.20
Plants affected by seed borne diseases	0.10	0.20

III. Seed Standards

Factors	Standards for each class	
	Foundation	Certified
Pure seed (minimum) %	98	98
Inert matter (maximum) %	2	2
Other crop seeds (maximum) Number/kg	5	10
Weed seeds (maximum) Number/kg	5	10
Germination (minimum) %	65	65
Moisture (maximum) %	7	7

CAULIFLOWER

BOTANICAL NAME : *Brassica oleracea var. botrytis L.*

COMMON NAME : Phool Gobhi

CHROMOSOME NUMBER : 2n=18

FAMILY : Cruciferae

NUTRITIVE VALUE (Per 100 g of edible portion)

Energy (kcal)	27	Vitamin A (IU)	60	Ca (mg)	25
Moisture (%)	91	Thiamin (mg)	0.11	P (mg)	56
Protein (g)	2.7	Riboflavin (mg)	0.1	Fe (mg)	1.1
Fat (g)	0.2	Niacin (mg)	0.7	Carbohydrates (g)	5.2
Ascorbic acid (mg)	78				

ORIGIN:

- The name cauliflower has originated from the Latin word “Cauli” meaning cabbage, “floris” meaning flower and ‘botrytis’ meaning budding.
- It is said that the cauliflower has originated around the Mediterranean Sea from the wild cliff cabbage, *Brassica oleracea var. sylvestris* a native of coastal region of Europe and Africa.
- It was introduced in India during the Mughal period.
- Cauliflower is one of the most important vegetable crops of India.
- It is grown in winter season for its white tender curds formed by the pre floral fleshy apical meristem.
- It is used as vegetable in curries, soups and for pickling.
- The area under this crop in India was 369 thousand ha having a production 6745 thousand tonnes with a productivity of 18.93MT/ha (NHB, 2011).

AREA AND PRODUCTION

- The area under this crop in India is 369 thousand ha having a production 6745 thousand tonnes with a productivity of 18.3MT/ha (NHB, 2011).

CLIMATIC REQUIREMENTS

- Climatic factors play important role during transformation from vegetative to curding and curd development stages.
- Temperature 10-21°C is good for germination.

- It is thermo-sensitive i.e. temperature influences growth stages from vegetative to reproductive.
- Transformation from vegetative to curding take place from 5°C to nearly 28-30°C, depending on the cultivar of a particular maturity group.
- Certain amount of vegetative growth is necessary to pass over juvenile phase of plant.
- Four weeks in mid-late group and 5-6weeks in late group would be sufficient for transformation from vegetative to curding phase.
- Optimum temperature for growth of young plant is 23°C in initial stages while growth in later stages is more favourable at 17-20°C.
- The tropical cultivars can grow even at 35°C or more.
- Plant will go on putting vegetative growth without forming any curd 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.
- Therefore, when tropical cultivars are grown at lower temperature, they form button and show severe riceyness to typical green bud formation.
- Temperature should not fluctuate too much during curd initiation phase, otherwise curd quality deteriorates.
- Temperature higher or lower than optimum for curding results in physiological disorders like riceyness, leafyness, blindness, loose and yellow curd.

VARIETIES

Varieties have been divided into four different maturity groups (I-IV) for north Indian plains

Maturity group	Nursery sowing	Transplanting time	Optimum temp. range for curding	Varieties
Extra Early: May maturity (May-June)	End of February	March	24°C-30°C	Pusa Meghna, DC 23, Pusa Kartik Sankar
Early I (A) Sept. maturity (mid Sept-mid Nov.)	Mid May	July beginning	20-25°C	Early Kunwari, Pusa Early Synthetic, Pant Gobhi-3, Pusa Meghna, Pusa Kartik Sankar
I (B) Oct. maturity (Mid Oct-mid Nov)	May end to Mid June	Mid July	20-25°C	Pusa Katki, Pusa Deepali, Pant Gobhi-2

Mid Early (II) Nov. maturity (Mid Nov-mid Dec)	July end	Sept beginning	16-20°C	Improved Japanese, 12-C, Pusa hybrid-2, Pusa Sharad, Pant Gobhi-4
Mid late (III) Dec maturity (mid Dec- mid Jan)	Aug end	Sept end	12-16°C	Pusa Synthetic, Pusa Subhra, Palam Uphar, KT- 25, Pant Subhra, Pusa HimJyoti, Pb Giant 35, Pusa Paushja, Pusa Shukti
Late (IV) Snowball (Jan-March)	Sept end to mid Oct	Oct end-mid Nov	10-16°C	Snowball 16, Pusa Snowball-I, Pusa Snowball K-1, Dania, Ooty-1,

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

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

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

The varieties can be grouped as early, mid early, mid late and late season varieties on the basis of maturity groups.

Early Varieties:

- Early Kunwari
- Pusa Early Synthetic
- Pant Gobhi 3
- Pusa Deepali
- Pant Gobhi 2.

Mid Early Varieties:

- Improved Japanese
- Pusa Hybrid- 2
- Pusa Sharad
- Pant Gobhi- 4

Mid Late Varieties:

- Pusa Synthetic
- Pant Shubhra
- Pusa Shubhra
- Pusa Himjyoti
- Punjab Giant 35

Late Varieties:

- Pusa snowball-1
- Pusa snowball K-1
- Ooty-1

Description

Dania:

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

Early Kunwari:

- It is an early variety suitable for growing in Punjab, Haryana, Himachal Pradesh and Delhi.
- It is released by Punjab Agricultural University, Ludhiana.
- The leaves are bluish green.
- Curds are semi-spherical with even surface and ready for harvesting from mid September to mid October.

Pant Gobhi-2:

- It is a composite variety released by GB Pant University of Agriculture and Technology, Pantnagar.
- Curds become ready for harvesting from October onwards.

Pusa Deepali:

- This has been developed at IARI, New Delhi.
- Plants are medium tall.
- Curds are compact, self blanching, white and medium in size.
- Riceyness is almost absent.
- Curds are ready in late October when the average temperature is around 20-25°C.

Pusa Himjyoti:

- It is released from IARI, Regional Research Station, Katrain (HP).
- Plants are straight.
- Curd is quietly white, solid and round.
- It is early in maturity, having curds of 500-600g in weight.
- Yield of this variety is 160-180q/ha.
- The only variety which can be grown from April - July in the hills.

Pusa Hybrid-2:

- First public sector hybrid of cauliflower developed by crossing a self-incompatible line and selection 1-3-18-19.
- It is recommended from IARI, New Delhi.
- Plants are erect and medium tall with bluish green upright leaves.

- Curd is creamy-white and highly compact.
- The yield potential of this variety is 230-250q/ha.
- It is resistant to downy mildew.

Pusa Snowball:

- It is derivative of the cross between EC-12013 x EC-12012 and released from IARI, Regional Station, Katrain (Kullu Valley).
- It is a late variety and suitable for cool season.
- Curds are very compact, medium in size and snow white in colour.

Pusa Snowball K-1:

- This is also developed at IARI, Regional Station, Katrain (Kullu Valley) and is tolerant to black rot.
- Amongst the snowball types, it has the best quality of snow white curds.

Swarna:

- It can be grown from September-December.
- Curds are white, compact and ready for harvesting within 80-85 days after transplanting.
- On an average, it yields 1.0-2.5kg curd weight.

SOIL

- The mid season and late crop will 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.
- The deficiency symptoms of Mg may quickly appear in acidic soils while pH higher than 7 reduced the availability of boron causing browning

SOWING TIME

Maturity Group	Sowing time	Transplanting Time
Extra Early	End of February	March
Early I (A)	Mid May	July beginning
Early I (B)	May end-June end	Mid July
Mid early	July end	Sept. beginning
Mid late	Aug. end	Sept. end

Late	Sept. end – mid Oct.	Oct. end –mid Nov.
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SEED RATE

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

SPACING

- Early crop : 45 x 30 cm
- Mid and Late crop : 60 x 45 cm

NUTRITIONAL REQUIREMENT

- Apply FYM @250-300q/ha, Nitrogen @100-150kg/ha, Phosphorus @ 60-80kg/ha and Potassium @ 80kg/ha.
- Half quantity of N and entire quantity of P and K are applied to the soil at the time of field preparation.
- The remaining half quantity of N is top dressed four weeks after transplanting.

USE OF PLANT GROWTH REGULATORS

PGR	Method of application	Attributes affected
IBA@ 10ppm	Seedling treatment	Increase in yield
GA@ 100ppm +NAA@ 120ppm+Mo@ 2%	Foliar spray	Increase in yield
GA@ 50ppm +Urea @1%	Foliar spray	Increase in yield
GA ₃ @50ppm	Foliar spray	Increase in yield
NAA 10ppm	Seedlings treatment	Plant stand in the field and vegetative growth.
GA4 + GA7 @ 80 mg/l	Foliar spray	Shortens the period from transplanting to the harvest

INTERCULTURAL OPERATION

INTERCULTURAL OPERATION

- Cauliflower is a shallow rooted crop, so 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.
- Crust formation in medium heavy and clay soils hinder water and air penetration in root system and should be broken otherwise adversely affect 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 before transplanting is beneficial for controlling annual and broad leaved weeds.
- Pendimethalin (Stomp) @1.2kg a.i. /ha or Oxyflurofen (Goal) @ 600ml/ha can also be used before transplanting if there is problem of annual weeds only.

IRRIGATION

- First irrigation should be given immediately after transplanting.
- Being shallow rooted crop, it requires frequent and light irrigation.
- Early season crop require irrigation at an interval of 5-7 days while mid and late sown crop require irrigation at an interval of 8-12 days.
- Curd development is the critical stage.
- Heavy irrigation is avoided at the time of maturity of heads.
- Optimum moisture level at the time of curd formation is very essential.

BLANCHING

- An important operation to protect the curds from yellowing due to direct exposure to sun.
- The curds may also lose some of their flavour because of this exposure.
- This problem generally occurs in varieties of early and mid maturity group, which have spreading and open plant type.
- In Snowball group and some of hybrids of early and mid maturity groups, curds remain naturally protected and surrounded by inner whorls of leaves.
- This may be done by drawing and tying of leaves when curds are fully developed. Sometimes, a leaf of cauliflower is kept over the curd 4-5 days prior to harvesting.

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 flower stalk and loose, over matured curds, deterioration of quality and turns into loose, leafy, ricey and fuzzy. Such curds should be eliminated from the consignment to be sending 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 up to 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.
- These bruised portions of the curd become blackish and unattractive for the fresh market.

STORAGE

- Most of cauliflower grown in India is harvested and used for fresh consumption.
- In general, it is not stored in the cold storage because of lack of capital to erect and run the cold storage by farmers.
- Snowball cauliflower can be stored for 7days at 0°C-1.7°C and RH between 85-95%.
- Cauliflower with intact leaves and head size 25-30cm diameter are the most suitable for long-term storage.

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 so that they 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 markets.
- Cling wraps may be used for packing in which only the curd portion is kept.

VALUE ADDED PRODUCTS

- In India, cauliflower is mainly dried or processed into mixed vegetable pickles.
- In the glut season, cauliflower can also be preserved in chemical solution containing 3% salt + 0.3% potassium metabisulphate + 0.8% glacial acetic acid in glass jars for 6-8months for culinary purpose and for pickling.
- **Frozen cauliflower:** The curds are washed, cut into pieces, blanched, packed in poly bags of the desired size and then marketed in the lean period.

- **Dehydrated Cauliflower:** Cauliflower buttons are separated and cut into small pieces. These pieces are blanched for 4-5 minutes in boiling water, steeped in 0.5% SO₂ solution for about an hour, then drained and washed. These are then dried at 60°C for about 10-12 hours. The dry matter content is 7 and 8-10% in snowball and tropical cauliflower, respectively.
- **Canning:** Canning is also done on limited scale in India. Compact curds are cut into small pieces of suitable size. These are then blanched for 5-6 minutes in boiling solution of 0.1% citric acid or tartaric acid and subsequently cooled in 2% brine to prevent discoloration. Blanched material is filled in plain cans containing 2% brine, then they are sealed and sterilized. Pink coloration in the canned product is a problem.

SEED PRODUCTION

- Periods of low temperature (chilling) is not essential, but cool conditions are required for seed production.
- Seed production of late varieties can only be taken up in hilly regions of the country.
- Himachal Pradesh has emerged as the major producer of quality cauliflower seed of late varieties.

Methods of Seed Production

- There are two methods of seed production:
- In-situ method (Seed-to-Seed method)
- Replanting method (Head-to-Seed method)
- For seed production, seed to seed method is recommended, since the head to seed method in India has not been very successful.
- In seed to seed method, crop is allowed to over winter and produce seed in the original position, where they were first planted in the seedling stage.

Cultural	practices/production	technology
Time of sowing and transplanting		

- For seed production purpose, the sowing time of cauliflowers should be so adjusted in such a way that the plants put up the maximum leafy growth by the second week of December, when the temperature goes down and the plants become almost dormant.
- The first week of September is the optimum time of sowing for the seeds in the nursery beds.
- Transplanting of seedlings should be completed by the end of September.
- The mean temperature of 6.5-11°C during February to March is very conducive to curd formation.
- Early sowing done in June to July, results in curd formation during October to November.
- The curds, being very susceptible to cold injury, rot during winter and hence fail to flower the following summer.
- If sown late, the crop starts curd formation late in the spring and consequently flowering is delayed.

Method of seed sowing

- Method of seed sowing and raising of healthy nursery is same as that of cabbage.

Preparation of land for transplanting

- The field should be prepared well to fine tilth by one deep ploughing followed by 3 to 4 harrowing and plankings/levelings.

Nutrient management

- The cauliflower seed crop requires heavy manuring as it removes large quantities of major nutrients from the soil.
- For good seed yield, 20-30 tonnes of farmyard manure are applied per hectare.
- Apply 50 kg/ha nitrogen, 60kg/ha phosphorous and 60kg/ha potassium per hectare before transplanting.

Transplanting

- Transplant the seedlings when 12 to 15cm long, preferably in the evening time, and irrigate immediately after transplanting..

Spacing

- Row to row : 60-90cm
- Plant to plant : 45-60cm.

Irrigation

- Irrigate the crop according to the soil type and climatic conditions.
- A crop after transplanting may need irrigation twice a week and later once in a week.
- Adequate moisture supplies during flowering and seed formation are necessary to obtain high yields.

Interculture

- Frequent shallow cultivation should be given to the soil to kill weeds and provide soil mulch.
- Four to five weeks after transplanting, earthing up of plants is highly desirable.

Early Varieties (Seed Production in Plains):

- Most of the cultural practices for seed production of early varieties in the plains are same, except for the time of sowing (June to August) as it varies with the varieties and a little closer spacing (60 x 45cm) is adopted and scooping of curds is normally not required.

Isolation distance

- The seed field must be separated from fields of other varieties, fields of the same variety not confirming to varietal purity requirements of certification, and from all other kinds of cole crops at least 1600 meters for foundation and by 1000 meters for certified seed.

Pollination

- It is a highly cross-pollinated crop.
- Honey bees are the usual pollinating agents, though bumble bees and house flies may also be responsible for pollination.
- It has been found that stigma of *Brassica* spp. is receptive even 5days before and 4days after anthesis.
- The period from pollination to fertilization generally takes about 24-48hours, depending on temperature.
- The ideal temperature has been found to be 12 to 18⁰C for seed production in hills.
- The seeds are globular, smooth and dark brown in colour.
- The fruit is often called as siliqua and popularly as pod.

Roguing

- Selection of curds is done when the curds are well developed.
- Off type plants and those not confirming to varietal characteristics should be removed at this stage.
- Subsequently roguing for off types, diseased plants and infected with phyllody should be done from time to time.

Harvesting and threshing

- Harvesting is done when majority of pods turn brown.
- Overripe pods dehisce, hence harvesting may be done in lots.
- Generally, the early plants are harvested first when about 60-70per cent of the pods turns brown and rest of the crop changes to yellowish brown.
- After harvesting, it is piled up for curing.
- After 4-5days, it is turned upside down and allowed to cure for another 4-5days in the same way.
- Threshed is done with sticks and sifted with hand sifters.
- After thorough drying of seed in the sun (up to 7 % moisture content) it is cleaned and stored.

Seed Yield

- Average seed yield varies from 400-500 kg per hectare

SEED

CERTIFICATION

STANDARDS

A.

Fields

Standards

a. General requirements

Isolation distance

- Seed fields should be isolated from the contaminants as shown in the table given below:

Contaminants	Minimum distance (meter)	
	Foundation	Certified
Fields of the other varieties	1600	1000
Fields of the same variety not conforming to varietal purity	1600	1000

b. Specific requirements

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

B. Seed Standards

Factors	Standards for each class	
	Foundation	Certified
Pure Seed (minimum) %	98	98
Inert matter (maximum) %	2.0	2.0
Other Crop seeds (maximum) number/kg	5	10
Weed seeds (maximum) number/kg	5	10
Germination (minimum) %	65	65
Moisture (maximum) %	7.0	7.0
For vapour-proof containers (maximum) %	5.0	5.0

SPROUTING BROCCOLI

AIM: Broccoli is an important cool season vegetable crop in which the terminal heads are edible. Besides this, slender and smaller heads which appear in the axil of leaves are also harvested. It is a highly nutritious crop and grows well in temperate climate. The present chapter will make the students understand regarding its production technology, importance, seed production techniques and plant protection measures.

BOTANICAL NAME : *Brassica oleracea var. italica*

COMMON NAME : Broccoli

FAMILY : Cruciferae

CHROMOSOME NUMBER : $2n=18$

ORIGIN : East Mediterranean and Italy (Main center of diversification)

- The word broccoli is derived from the Latin word Brachium meaning an arm or branch. Broccoli contains 3.3 per cent protein, high content of vitamin A and C and appreciable quantities of thiamine, riboflavin, niacin, calcium and iron.
- Broccoli refers to green buds and thick fleshy floral stalks arising from the main stem.
- In Italy, these have been used as a vegetable from early times but their economic importance become appreciable only since thirties of last century when this vegetable became popular in the U.S.A.
- A larger part of the produce in the U.S.A. goes to the freezing industry.
- It is also becoming popular in other parts of the country very rapidly.
- Sprouting broccoli is sometimes briefly called as broccoli though this name is also used for broccoli rape (the sprouts which develop on turnips) and for winter cauliflower (winter broccoli or heading broccoli).
- In U.S.A., it is also known as Italian broccoli pointing to its Italian origin.
- Morphologically, sprouting broccoli resembles cauliflower.
- The plant forms a kind of head, consisting of green buds and thick fleshy flower stalks.
- A main head is produced terminally and comparatively smaller heads in the shoots arise from axils of leaves laterally.
- The terminal head is rather loose, green in colour and the flower stalks are longer than cauliflower.
- The sprouts in the axils of leaves develop strongly, especially after the removal of terminal bud or head.
- Both terminal head and the sprouts with bud clusters are consumed as human food.

NUTRITIVE VALUE (per 100 g of edible portion)

Moisture (%)	89.1	Vitamin-C (mg)	113
Energy (K cal)	32	Niacin (mg)	0.9
Carbohydrates	5.9	Ca (mg)	103

(g)			
Proteins (g)	3.6	P (mg)	78
Fat (g)	0.3	Fe (mg)	1.1

CLIMATE

- Broccoli is a cool season crop.
- Seed germination takes place at 12-16°C and optimum temperature for growth is 16-20°C.
- Hot weather results in development of small and thin leaves in the head. Generally, the plants of broccoli are hardy, can withstand fairly heavy frosts.
- It is generally biennial, while the annual cultivars are slightly sensitive to frost.

SOIL

- The requirement of broccoli is not that specific as in other cole crops though the soil should be sufficiently fertile and rich in organic matter for the development of seedlings after transplanting.
- Broccoli is slightly tolerant to acidic soils (pH 5.5-6.5).
- Soil should be well cultivated so that it becomes friable and suitable for planting.

CULTIVARS

Different Types of Broccoli

Purple sprouting broccoli	Biennials, branched, purple spears, variable
Purple cape broccoli	Biennials, single purple heads, variable
White sprouting broccoli	Biennials, branched, white spears
Purple Sicilian broccoli	Single heading pale-purple heads also known in horticulture as purple cauliflower
Couve broccoli	'Roxo de Cabeça' Tall purple heading, sprouting type from Portugal
Calabrese	Green sprouting broccoli from Calabrian region. Now a world wide crop and virtually single heading
Black broccoli	Highly branched annual with dark green spears and sickle shaped leaves, from Rome area

- In Broccoli, purple and green variants occurs though in U.S.A, only the green types are grown.
- The purple types are fairly hardy and can be harvested during winter.
- The green sprouting broccoli is classified in accordance to their maturity i.e. early, medium and late cultivars.
- Though a very sharp distinction is not possible but the cultivars may differ in the size of plant, size of clusters and buds, firmness of heads, colour of heads and foliage.
- The demand is more for a firm head with small dark green buds while demand for the side shoots have decreased in recent years possibly due to difficulty in harvesting.
- Cultivars like De Cicco, Green Bud, Spartan Early etc. are early types and can be harvested in 6-7weeks after transplanting.
- These cultivars may not perform well under unfavourable conditions especially at lower temperature.
- Cultivars like Waltham 29, Green Mountain, Coastal Atlantic etc. are sensitive to buttoning and can be grown as an early or late crop.
- The medium strains like Green Sprouting Medium take about 100days to maturity, while the late strains like Green Sprouting Late are biennials and may be harvested on the onset of winter or after its end.
- At present a large number of F₁ hybrid cultivars are being marketed by the different seed companies of Japan, U.S.A. and Europe.

Some of F₁ hybrids are

- **Extra Early and Early** : Southern Comet, Premium Crop and Laser
- **Mid season** : Cosair, Excalibur and Emerald Corona
- **Late** : Late corona, stiff, kayak and Green surf

Some of the important varieties grown in Northern India are

Pusa Broccoli Kt. Sel. 1:

- Developed through selection at IARI, Regional Station Katrain (Kullu Valley).
- Compact light green heads, weighing around 250-400g, plant height 40-50cm and ready for harvesting in 85-95days after transplanting.

Palam Samridhi (DPGB I):

- Sprouting broccoli having compact green heads, free from yellow eyes and bracts, average head weight is 300-400g, plant branched.
- It also bears sprouts in the axil of leaves which adds to the total yield, ready for harvest in 85-90days after transplanting, average yield 150-200q/ha.

Palam Haritika:

- Sprouting broccoli having dark green straight leaves, the main head formed deep inside the leaves.
- Late in maturity and gets 150 days for harvesting, free from yellow eyes, average yield 200-250q/ha

Palam Kanchan:

- Yellow coloured heading type broccoli, leaves are large, green and straight with white midrib.
- Gets ready for harvesting in 140days, average yield 250-300q/ha.

Palam Vichitra:

- Purple coloured heading type broccoli, medium foliage, open green leaves having green tinge, heads are firm and solid.
- Gets ready for harvesting in 115-120days, average yield 225-250q/ha

Punjab Broccoli 1:

- This variety is developed by PAU, Ludhiana, matures in 65-70days, bears large number of spears, foliage dark green with smooth leaf surface, heads and spears are dark green with bluish tinge.

NURSERY MANAGEMENT

- Same as for cabbage

SEED RATE

- The seed rate for raising seedlings to plant in one hectare area is about 300-400g.

SPACING

- 45 x 45 or 60 x 45 cm

SOWING TIME

- It varies in different parts of the country.
- In plains, sowing is done in October whereas in mid hills it is done in September.
- In high hills, seeds are sown in month of May-June.
- The time of transplanting depends upon the climatic condition and the kind of variety.
- The sowing of an autumn crop is limited and sowing is undertaken in autumn to harvest them in late spring or early summer by over wintering them.

NUTRIENT MANAGEMENT

NUTRIENT MANAGEMENT

- Light soils should be supplied with heavy quantity (200-250q/ha) of organic matter either through incorporation of farmyard manure or compost or through green manuring.
- Requirements of manures and fertilizers depend upon soil fertility, soil status and cultivar.
- Besides this, apply 100-125kg N, 60-80kg P₂O₅ and 25-50kg K₂O per ha should be applied depending
- It is better to apply nitrogen in split doses.
- It has been reported that warm weather, heavy fertilization and wide spacing results in hollowness of main stem.
- Besides macro nutrients, broccoli has light requirement for molybdenum and boron.
- The deficiency symptoms are likely to appear if fertilizers are not applied.

IRRIGATION

- Broccoli requires more water than cauliflower however, care should be taken that light irrigation at regular intervals is done.
- After transplanting irrigation are done at 10-15days interval.
- Uneven moisture after the heads have formed, cause head splitting or head bursting.

HARVESTING

- The broccoli heads resembles with cauliflower consisting of clusters of green flower buds.
- Early types mature in 45-50days, mid in 60-100days and late after 100days of transplanting.
- The head is cut along with a few leaves and stem (10-15cm).
- From the remaining main stem, lateral shoots are formed and these produce comparatively small heads.
- Usually only the central head is harvested.
- It is very important that broccoli is harvested at the correct time i.e. it is picked up before the buds open and when the bud clusters are compact.
- The heads are cut-off long with 15cm of the stem attached.
- The head may be 15-25cm in diameter and weigh about 200-600g.

YIELD

- he yield of broccoli ranges from 50-150q/ha depending on variety, time of planting and length of harvesting period.

PACKING AND STORAGE

- Broccoli is more perishable than cauliflower.
- Just after harvesting, heads and shoots are kept in cold storage until they are sold.
- Otherwise the buds and leaves became yellowish and give an unattractive appearance.
- The yellowing could be avoided by storing the broccoli in a oxygen free atmosphere. Broccoli emits ethylene in storage.
- For freezing, stems are cut to 10-15cm in length.
- The shelf life of broccoli heads & sprouts is significantly affected by temperature and not much influenced by relative humidity. Broccoli can be stored at 32⁰F for 8-10days.
- At temperature 12–17°C and RH between 75%. It can be easily stored for 3days. Under cool storage (3°C & 88% RH) the shelf life of heads can be extended upto 31days.
- Packaging in LDPE (Low density polyethylene) bags helps in keeping the broccoli more fresh and green under low temperature.

SEED

PRODUCTION

Seed Production Methods

- Methods of seed production is exactly the same as in cauliflower since the transplanting method is not successful because there is practically no rest period between the sprouts/curds stage and flowering in broccoli.
- It is easier to grow sprouting broccoli for seed than cauliflower because it can tolerate other climatic conditions and takes lesser duration than cauliflower for seed production.
- Transplanted seedlings are allowed to grow, over winter, flower and produce seed at the same place i.e. *in-situ* method.
- Besides all cultural practices required for head production of broccoli, the following essential points should be taken care of while the broccoli is grown for seed production purpose.
- Maintain proper isolation distances between two varieties.
- Raise seeds either by
 - Stump method or
 - Seed to seed method or
 - Head to seed method

Stump method (Rarely followed)

- The stump to seed method gives the lowest seed yield.
- Seed to seed method is used for the production of market seed.
- For stocks/breeder's seed, it is better to use head to seed method.
- For both foundation and certified seed, use seed to seed method.

Seed to seed method (Generally followed/Recommended)

- The plants are allowed to over winter in their original position where they are first planted in the seedlings stage (*in-situ*).
- The seed crop matures 10-15days before or earlier than that of head to head method.
- The most essential requirement of this method is the high quality foundation seed required for raising head crop.

Head to seed method (Generally not followed/ not recommended)

- It is followed for breeder/nucleus seed only but otherwise not remunerative.

Cultural Practices for Seed Production

- Apply 100kg of nitrogen/ha in two equal splits, first at seed stalks emergence and second at flowering and seed setting stage. Apply whole quantity of phosphorus and potassium @ 60-80kg/ha depending upon soil test at planting time.
- Optimum time for raising nursery is May-June for the production of head crop and March-April for replanting heads for the seed crop.
- Do hoeing, if required.
- Do earthing up at head formation stage.
- Be particular about irrigation. Maintain uniform moisture through irrigation at regular intervals.
- Rogue out all off types and diseased plants.
- The heads with more number of non-wrapper leaves, less loose and with heavy frames should be eliminated.
- The colour of leaves, head size, shape and maturity of the crop may also form basis of an effective selection.
- Harvest seed crop in 2-3 lots to avoid shattering of seeds.
- Thrash the seeds with the help of wooden sticks, clean the seeds and allow drying and grading for small, light, ill developed rotten and split seeds.
- Store the seeds in air tight containers under well ventilated dry and cool places.
- Under proper storage condition broccoli seeds remain viable for about 4 years.

Seed Yield

- **Seed yield of sprouting broccoli is about 5-6 q/ha.**

SEED

CERTIFICATION

STANDARDS

A. Field Standards

a. General requirements

Isolation

- Isolation is very important for the maintenance of purity of different cultivars.
- In *Brassicas*, there are two distinct groups which do not inter-cross with each other.
- Isolation is necessary when two crops of the same group are grown at the same locations.

- It would always be better to avoid more than one crop at a particular location.
- Maintain at least 1600m isolation distance for the production of breeder's seed while 1000m for certified seed.
- Seed fields should be isolated from the contaminants.

Contaminants	Minimum distance (meter)	
	Foundation	Certified
Fields of the other varieties	1600	1000
Fields of the same variety not conforming to varietal purity	1600	1000

b. Specific Requirements

Factors	Maximum permitted (per cent)	
	Foundation	Certified
Off types	0.10	0.20
Plants affected by seed borne disease	0.10	0.50

B. Seed Standards for broccoli seed production

Standards	Foundation	Certified
Pure seed (minimum) %	98.0	98.0
Inert matter (maximum) %	2.0	2.0
Other crop seeds (maximum) %	0.05	0.20
Total weed seeds (maximum) number/kg	0.05	0.20
Objectionable weed seeds (maximum) number/kg	--	--
Germination (minimum) %	70.0	70.0
Moisture content in seeds (maximum)%	7.0	7.0

KNOL-KHOL

BOTANICAL NAME : *Brassica oleracea* var. *gongylodes*
COMMON NAME : Ganth gobhi or kadam
CHROMOSOME NO : 2n=2x=18
FAMILY : Cruciferae

AREA AND PRODUCTION

- Knol-khol is not very widely grown in our country except in Kashmir, West Bengal and some of South Indian states.
- Since in India, it is grown on very small area, hence, exact statistics, regarding area, production and productivity is not available.

ORIGIN AND HISTORY

- It is reported to have originated in Mediterranean center of origin.
- It was developed in Northern-Europe in the fifteenth century.
- According to Encyclopedia Britannica, khol rabi was first described in eighteenth century as another cabbage of European origin.

NUTRITIVE VALUE (per 100 g of edible portion)

Energy (kcal)	29	Riboflavin (mg)	0.04
Moisture (%)	90.3	Niacin (mg)	0.3
Protein (g)	2.0	Ascorbic acid (mg)	66
Fat (g)	0.1	Ca (mg)	41
Carbohydrates (g)	6.6	P (mg)	51
Vitamin A (IU)	20	Fe (mg)	0.5
Thiamin (mg)	0.06		

CLIMATIC REQUIREMENTS

- Though in temperate countries, early bolting is a problem, especially in early cultivars, yet this doesn't seem to be of much significance under Indian conditions with only two cultivars that are generally grown commercially.

- Early maturing varieties have a problem of premature bolting at 12-14⁰C and require above 15⁰C temperature for cultivation.
- Seeds germinate well at 15-30⁰C.
- The temperature of 18-25⁰C is considered to be optimum.
- Duration of vernalization and stage of growth has significant effect on bolting.
- If the low temperature occurs at early stage of growth for considerable time, the plant will start bolting quickly.
- The occurrence of long oval knob in some varieties with round or flat round tubers is an indication of vernalization effect on tubers.

SOIL CONDITIONS

- Knol-khol can be grown in all types of soils but the fertile soils produce good quality uniform sized knobs.
- It can be grown in wide range of sandy soils.
- Early cultivars grow well in light soils, where as late maturing ones perform better in heavy soils.
- However, well drained soils give higher yield.
- The optimum pH of the soil for knol-khol cultivation is 5.0-6.8.
- Most of the knol-khol varieties are somewhat tolerant to salt.
- In saline soils, plant show die-back of leaf margins and dark foliage and become more susceptible to disease like blackleg.

VARIETIES

AND

CULTIVARS

Early Purple Vienna:

- Leaves are purplish in colour.
- The knobs are globular to round large in size, purple skin with light green flesh.
- It takes 55-60days for knob formation.

Early White Vienna:

- It is an early variety.
- Plants are dwarf, short topped having medium green foliage.
- The knobs are globular to round.
- Flesh is tender and crisp.
- It takes about 50-55days for knob formation after transplanting.

Large Green:

- It is a late variety with vigorous growing plants and dark green foliage.
- It has flat round and green knobs. It has been found quite suitable for growing in Himachal Pradesh.

Purple Vienna:

- It is a late variety having purple coloured leaves and stems.
- Knobs are big in size with purple coloured spots.
- Knobs become ready for harvesting in 55-60days after transplanting.
- An average yield of this variety is 150-200q/ha

King of North:

- It takes about 60-65days to harvest after transplanting.
- It has dark green, flattish round knobs.
- Dark green leaves are well spread over the knobs.

White Vienna:

- It is an early variety.
- Plants are dwarf, short topped having medium green foliage.
- The knobs are globular, round, crisp and having tender flesh.
- It takes about 50-55days to harvest stage after transplanting.

Palam Tender Knob:

- Early variety with light green knobs and gives average yield of 250-275q/ha.
- Better shelf life.

Average yield of Knol khol varieties is 200q/ha

CULTURAL PRACTICES

NURSERY MANAGEMENT

- Knol khol is basically a transplanted crop and the procedure is similar to that of cabbage and cauliflower.

TRANSPLANTING

- Normally, the seedlings become ready for transplanting in 4-6 weeks after sowing.
- After hardening and before uprooting of seedlings for further transplanting, the nursery beds should be watered to make soil wet.
- This will minimize the root injury when the seedlings are uprooted and fast establishment of seedlings.

SOWING

TIME

Planting Time: Under North eastern plains.

	Seed sowing	Transplanting
Early crop	August	September
Main crop	September	October
Late crop	October	November

SEED RATE

- About 1000-1500g seed is required to raise Knol khol crop in one hectare area.

SPACING

- The planting distance may be 30-40cm from row to row and 20-25cm from plant to plant, according to the variety, soil fertility and intercultural operations.
- When planted at closer spacing, the knob size may be reduced and shape may be elongated.

NUTRIENT MANAGEMENT

- Quantity of manure, nitrogen, phosphorus, and potash should be given as per the nutrients available in the soil, which is determined by soil test.
- Well decomposed FYM@ 100q/ha should be mixed thoroughly in the soil before planting.
- The nitrogen, phosphorus and potash are applied in the ratio of 100:60:40-60kg/ha, respectively.
- Entire quantity of FYM, phosphorus and potash and half quantity of nitrogen should be applied at the time of field preparation time.
- The remaining half quantity of N is top dressed 30-40 days after transplanting.

WATER MANAGEMENT

- Knol-khol plants are very sensitive to soil moisture stress.
- When plants face shortage of water during the early stage of growth. The initiation of knobs swelling will be delayed and yield will be reduced if the water is insufficient at this stage. This cannot be reversed even if plentiful of water supply is given at the later stages of the growth for higher yield.
- At least six irrigations must be provided during entire growth period which will come out to be nearly 300mm water.
- Knol-khol is generally irrigated by furrow method of irrigation, but excessive irrigation in early stages causes superficial rotting of knobs and washing of the nutrients.
- Late crop is irrigated at 10-15days interval depending upon the weather conditions..

INTERCULTURAL OPERATIONS

- The regular intercultural operations are required to keep the crop free from weeds and to raise a healthy crop.
- Two to three weedings are required.
- Weeds can also be controlled by pre-plant application of weedicides like Lasso @1.5-2kg/ha a.i./ha
- Earthing up is essential to cover the exposed roots and for this, one or two hoeings should be done.

HARVESTING

- The harvesting should be done before the knob gets over mature.
- The over mature knobs have poor edible quality because of more fibre content.
- Usually the knobs may be harvested when they are of 6-8cm diameter.
- In late maturing varieties, sometimes, bigger knobs of 10-12cm diameter are also harvested.
- For harvesting, the stem is cut just above the ground or can be pulled easily by hands.

YIELD

- The yield of this crop varies with the variety, climatic conditions and as per the management practices.
- The yield per hectare varies from 12-30tonnes under Indian conditions.
- Individual tuber may weigh 200-250g

STORAGE

- It can be stored successfully for 25-30days below 2°C at 95-100per cent RH.

SEED PRODUCTION

Method of Seed Production

- The seed of Knol-khol is usually produced by *in-situ* methods.
- The transplanting method however, may be practiced to raise the nucleus seed.

***In-situ* method**

- The crop is allowed to over winter and produce seed in its original position where they were planted at the seedling stage.

Transplanting method

- In this method the mature plants are uprooted during autumn.
- The leaves all around the knob and top are removed keeping in crown intact.
- The selected true to the type of the knob, is pushed into the soil, so that knob almost touches the soil.
- Follow all cultural practices (as in case of table crop) to ensure a good crop stand.

Pollination

- Like other cole crops, knol-khol is a naturally cross-pollinated crop due to sporophytic self-incompatibility.
- The pollination is generally done by bees and flies.

Roguing

- Selection of knobs is done during February to March, when the knobs are well developed only true to type plants are retained.
- Off-type and diseased plants are removed.
- Subsequent roguing is done at flowering stage.
- Care is necessary in nucleus seed production to select right type of plant at the time of flowering stage.
- Remove all undesirable plants.
- Subsequent roguing of off type, diseased plants affected by disease such as phyllody, black leg, soft rot and leaf spot may be done from time to time as required.

Harvesting and Threshing

- Knol-khol start seed stock elongation from last week of March onwards when mean temperature rises to 10-13°C.
- Flowering and pod formation starts during the last week of April at the mean temperature of 13-18°C.
- From end of April to end of May, the crop is in full flush of fruiting and flowering.
- The ripening of pods commences by last week of June and harvesting continues up to 1st week of July.

- At the mean temperature below 20°C during June and July, maturity of crop is delayed at least by fortnight and harvesting may continue up to June end.
- To avoid shattering of the seed whole crop is harvested in 2-3lots with sickles.
- Generally, early plants are harvested first, and when the pod colour is brown and about 60-70per cent of the rest of the crop changes to yellow brown, it is harvested completely and piled up for curing.
- After 4-5days, it is then threshed with sticks and sifted with hand sifters.
- After thorough drying, seeds are cleaned and stored.

Seed Yield

- Seed yield is about 500-650kg/ha.
- Seeds are round, 1.5-2.0mm in diameter and brown in colour.
- One thousand (1000) seed weight is about 3.2g.

SEED CERTIFICATION STANDARDS

Field Inspections

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

A. a. Isolation

Field General

Standards requirement

- Seed field should be isolated from the contaminants as shown in the table below:

Contaminants	Minimum distance (meter)	
	Foundation	Certified
Fields of other varieties	1600	1000
Fields of same varieties not conforming to varietal purity	1600	1000

b. Specific requirements

Factors	Maximum permitted (%)	
	Foundation	Certified
Off types	0.10	0.2
Plants affected by seed born disease	0.10	0.2

B. Seed Standards

Factors	Standards for each class	
	Foundation	Certified
Pure seed (minimum) %	98.0	98.0
Inert matter (maximum) %	2.0	2.0
Other crop seeds (maximum) number/kg	5	10
Weed seeds (maximum) number /kg	5	10
Germination (minimum) %	65	65
Moisture (maximum) %	7	7
Moisture content for vapour proof containers (maximum) %	5	5

BRUSSELS SPROUT

AIM: This crop gets its name from the city of Brussel's in Belgium, where it has been grown for several hundred years. The sprouts resemble miniature cabbages and are borne in the axils of leaves along and around the main stock progressively from the bottom upwards. The sprouts are usually cooked and also pickled. This is very nutritious winter season crop of temperate regions. The present chapter will make the students understand regarding its production technology, importance, seed production technology and plant protection measures.

BOTANICAL NAME : *Brassica oleracea* var. *gemmifera*

CHROMOSOME NO : $2n=2x=18$

FAMILY : Cruciferae

ORIGIN : Belgium

DISTRIBUTION

- It is an important vegetable in European countries.
- This vegetable, although a popular vegetable in England and its continents, is sparingly cultivated in the United States of America.
- From Belgium it has been introduced to England (1810).
- Some parts of Long Islands in New York are also well known for Brussels Sprouts production.
- In India, it is widely grown in Kodai kanal and Nilgiris hills of Tamil Nadu and Maharashtra.
- Exact statistics regarding area, production and productivity are not available.

NUTRITIVE VALUE (per 100g of edible portion)

Energy (Kcal)	45	Riboflavin (mg)	0.16
Moisture (%)	85.2	Niacin (mg)	0.9
Protein (g)	4.9	Ascorbic acid	102

		(mg)	
Fat (g)	0.4	Calcium (mg)	36
Carbohydrate (g)	8.3	Phosphorus (mg)	80
Vitamin-A (IU)	550	Iron (mg)	1.5
Thiamin (mg)	0.10		

CLIMATIC REQUIREMENTS

- Brussel's sprout requires a cool climate.
- It is somewhat sensitive to temperature.
- In warm weather, bud clusters become loose quickly.
- It can tolerate frosty conditions.
- However, the best quality sprouts are produced in the sunny weather and light frost during nights.
- Suitable temperature for seed germination is 12-16°C and for optimum growth is 16-20°C.

SOIL

- Sandy and silt loam soils are most suited for Brussels sprouts.
- It grows well in drained upland soil.
- Soils must have capability for retention of good moisture.
- Soil pH should be 5.8 to 7.2 for better growth.

VARIETIES / HYBRIDS

Two types of varieties are there on the basis of growth of the plant

1. Dwarf
2. Tall

Hilds Ideal:

- It is an introduction and recommended by IARI, Regional Station, Katrain (Kullu Valley).
- Plant height varies from 60-65cm with 45-55sprouts/plant and number of leaves varies from 45-55.
- Average diameter of sprouts is 7.0-8.0cm and each sprout weighs about 7-8g.
- Sprouts are compact with good flavour.
- It takes about 115days for first picking after transplanting..
- Average yield per plant varies from 250-400 .
- Picking at 10days interval is recommended to get the higher quality sprouts, as they start bursting if not harvested at time.

Jade Cross:

- It is an early hybrid which matures in 90days after transplanting.
- Sprouts are firm, dark green, closely packed on long stems.
- It can be grown under wide range of growing conditions.
- Some other important varieties are Improved Long Island, Danish Prize, Early Morn, Amager Market and Frontier Zuerg.

SOWING TIME

- Brussels sprout is sown in June-July and seedlings are transplanted from July to September (for early crop) and October to middle November (for the late crop) in northern parts of the India.
- In eastern India, sowing is generally started from mid to late September.

- Sowing is delayed further in the southern hills except in the western and southern peninsular, where this crop can be grown almost round the year by selecting proper cultivar.
- In hills, especially in high hills, seeds are sown in April-June for summer/autumn crop.
- In the hilly areas which receive heavy rains, the summer and autumn crops are rather limited and sowing is done in autumn to harvest them in later spring or in early summer by over watering them.

SEED RATE

- About 200-500g seed/ha is required for raising the seedlings.

Methods and Management

METHODS OF TRANSPLANTING

- The seedlings are transplanted when they are 6 to 8 weeks old.
- The planting is done on the flat land, ridges or in furrows depending upon climate and soil condition.
- For early planting, ridge method will be more suitable, especially, in areas where the rains occur at the time of planting.
- In saline soils, planting should be done in furrows.

SPACING

- Generally, recommended on the basis of maturity of cultivars, optimum planting distance for early cultivars is 45 x 45cm or 60 x 30cm. For mid maturity group, the distance is 60 x 45cm and for late maturity group, the planting distance is 60 x 60cm.
- For tall varieties and places having longer growing periods, spacing is 90 x 90cm.

NUTRIENT MANAGEMENT

- Brussel's sprout require more manures and fertilizers than cauliflower and cabbage because of comparatively longer growing period.
 - FYM @20-25 tonnes/ha,
 - Nitrogen @200kg/ha,
 - Phosphorous @100kg/ha and
 - Potassium @100kg/ha should be provided for getting higher yields.
- Whole quantities of FYM, phosphorus and potassium and one third quantity of nitrogen should be applied in the soil at the time of field preparation. It is advisable to top dress the remaining two doses of nitrogen after a gap of one month.

WATER MANAGEMENT

- First irrigation should be given just after transplanting of seedlings.
- The first irrigation should be very light.
- As Brussel's sprouts require moist conditions, subsequent irrigations should be given at frequent intervals

INTERCULTURAL OPERATIONS

- In order to provide good aeration to the root zone, one or two hoeing may be done.
- Hoeing will also help in keeping down weeds, if any.
- However, if growing weeds are very close to the plants, they should be pulled out by the hands.
- Sometimes, removal of terminal buds and lower leaves may results in early and good sprouts.

TOPPING

- Removal of apical point is done in order to harvest the whole crop at one time.
- In normal crop also, it is done in some regions after Ist or IInd picking when the temperature is low.

HARVESTING

- The sprouts are harvested when they are firm and well developed, usually 1-2inch in diameter.
- The sprouts become ready for harvesting in approximately 120days after transplanting in north Indian conditions.
- Regular harvesting at right stage enhances further growth of the plants and formation of new more heads.
- The sprouts are picked by cutting leaving a short stalk on the main stem, rather than to break them off for the formation of new more sprouts/heads.
- A total of 3-5pickings are obtained in a common cultivar.
- Sprouts should be solid, dark or at least light green.
- Sprouts with small, loose leaves at the base are considered poor in quality.
- Loose sprouts are sometimes marketed as "Blowers".
- The freezing industry requires a sprout less than 3cm in diameter.

YIELD

- The average yield is about 60-80q/ha.

STORAGE

- The recommended storage condition for Brussel's sprouts is 0-1°C with 90-95 per cent RH for about 3-5weeks.
- CA storage at 5-7per cent CO₂ and 2-5 per cent O₂ helps to maintain quality at 4 or 10°C during storage.

SEED PRODUCTION

SEED

PRODUCTION

Land requirements

- Land to be used for seed production of Brussel's sprouts should be free from volunteer plants.

Climatic Requirements

- Brussel's sprout thrives best in a relatively cool, moist climate with moderate rainfall, well distributed during the growing season.
- It can withstand frost in the head stage.
- It requires a dormant period of cool temperature for initiation of seed stalks and flowers.
- Cool temperature, however, is effective only after stem has attained at least 1cm diameter. In temperate climates, this occurs during the winter after the first season growth.
- Flowering and seed production follow in the second year.
- Headed plants form seed stalks when exposed to mean temperature of about 2.22°C to 10°C for 42-56 days to eight weeks.
- In India, seed production of Brussel's Sprout is possible only in hilly areas.

Isolation Distance

- Foundation seed : 1600m
- Certified seed : 1000m

Methods of Seed Production

- Being a biennial, Brussel's sprouts require two seasons to produce seed.
- In the first season, the heads are produced and in the following season seed production follows.
- The seed crop can be left in-situ or replanted during autumn.
- In-situ method is usually followed for certified seed and the latter for nucleus seed production.
- In In-situ method, the crop is allowed to over winter and produce seed in their original position i.e. where they are first planted in the seedling stage.
- In the transplanting method, the mature plants are uprooted.
- After uprooting, the plants are immediately reset in a well prepared new field.

Methods to produce seeds of Brussel's sprouts:

- Seed production of Brussel's sprout is same as that of cabbage except that *in-situ* (seed-to-seed) method is followed since the plant does not withstand planting.
- However the plant with earthen ball may withstand planting well.

- After transplanting, the crop is allowed to over winter in the field.
- Flowering and seed- setting take place in spring-summer (from mid march to mid may).
- The plants after receiving the vernalization stimulus bolt and flower in the spring when the temperature rises.
- The flower stalk arises from the terminal growing point and also from some of the upper sprouts.
- First the main flowering stalk with branches develops from the terminal bud and the other flowering branches come from the axillary buds i.e. sprouts.
- Therefore, do not harvest the upper sprouts to allow more number of flowering branches. Flowering takes place from April to May.
- The ways and means to enhance seed set are similar to those followed for other crops.

Roguing

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

Brief Cultural Practices (In-situ method) **Time of Sowing and Transplanting**

- The sowing time of different varieties should be so adjusted as to complete head formation by the end of October or first week of November, when the mean temperature falls to 10°C or below, at this temperature, the heads stand best for over wintering.
- Early varieties should be sown from mid July onwards and transplanted when the seedlings are four to six weeks old, during the second fortnight of August.
- This sowing time must be strictly adhered to, as the crop from early sowing has matured heads during September (20°C).
- The heads sometimes get infected with bacterial stalk rot, which is very severe.
- The late crop, planted during September does not form heads and bolts directly during spring and the seed grower is not able to ascertain purity of the crop.
- The mean temperature of 22.5°C, 20°C and 14°C of August, September and October, respectively afford optimum requirements for growth and head formation.
- The late transplanted crop starts head formation during spring and continues up to June and usually does not produce seed stalks.

Preparation of land for transplanting

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

Source of seed and seed rate

- Obtain nucleus/breeder/foundation seed from source approved by a seed certification agency.
- For main season and late varieties take 375-400g seed/ha and for early varieties, 600-750g seed/ha.

Method of raising nursery

- The seeds are sown in raised nursery beds in a similar manner as described earlier in commercial production of Brussels sprouts.

Transplanting

- Four to six weeks old seedlings are transplanted.
- Transplanting should preferably be done in the evening and the field irrigated immediately afterwards.

Spacing

- For late varieties 60 x 60cm, medium varieties 60 x 45cm and for early varieties 45 x 45cm spacing should be followed.

Nutrient management

- Brussels sprouts grow satisfactorily only when the supply of organic matter is liberal.
- For good crop, apply 20 to 25 tonnes of farmyard manure per hectare at the time of land preparation.
- Apply half dose nitrogen (50 kg/ha), 200kg/ha phosphorous and 100kg/ha of potash by drilling, or by broadcasting, sufficiently before transplanting the seedlings.
- Give another dose of 50kg/ha nitrogen as surface application at the time of seed stalk emergence during April.
- Extra application of nitrogen may be given as and when there is a need before flowering starts, depending upon the condition of the crop.

Irrigation

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

Hoeing and weeding

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

Staking

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

Handling the mature head

- After the planted crop has fully developed, crop with good heads is selected at the end of autumn and these plants are marked for seed production.
- Handling of plants can also be done carefully so that good and true to type plants are selected for seed production.

Harvesting and threshing

- Brussels sprout starts seed stalk elongation by the end of March when the mean temperature rises to 10-13°C.
- Flowering and pod formation starts during the last week of April at mean temperature of 13-18°C.
- By last week of May, the crop is in full flush of flowering and fruiting.
- The ripening of pod commences at the temperatures below 20°C during June and July, the maturity of crop is delayed at least by a fortnight and the harvesting may continue up to July end.
- To avoid shattering of seeds, the whole crop is harvested in two or three lots with sickles.
- Generally, the plants are harvested first by hand when the pod colour is brown and about 60-70 per cent of the rest of the crop changes to yellowish brown, it is harvested completely and piled up for curing.
- After 4-5 days of curing, is then threshed with sticks and sifted with hand sifters.
- After thoroughly drying seeds are cleaned and stored.

SEED YIELD

- 300-400kg per hectare.

SEED

CERTIFICATION

STANDARDS

Field Inspection

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

A. Field standards

a. Isolation distance

General

requirements

- Seed fields should be isolated from the contaminants as shown in the table:

Contaminants	Minimum distance(meters)	
	Foundation Seed	Certified Seed
Fields of other varieties	1600	1000
Fields of the same varieties not conforming to varietal purity	1600	1000

b. Specific requirements

Factors	Maximum Permitted (percent)	
	Foundation Seed	Certified Seed
Off types	0.10	0.20
Plants affected by seed Borne diseases (Black leg, Black rot, soft rot)	0.10	0.50

B. Seed standards

Factors	Standards for each class	
	Foundation Seed	Certified Seed
Pure seed (Minimum) %	98	98
Inert matter (maximum) %	2	2
Other crop seed (maximum in) number/kg	5	5
Weed seeds (maximum) number/kg	5	5
Germination (minimum) %	65	65
Moisture (Maximum) %	7	7
For vapour proof containers	5	5

(Maximum %)		
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DISEASES

DISEASES

Damping-off of seedling

Pathogen: *Phytophthora* spp., *Pythium* spp., *Fusarium* spp. and *Rhizoctonia solani*

- Seedlings are killed both at pre and post-emergence stages.
- Infected seedlings topple down to the ground.

Control measures:

- Treat the nursery beds with formalin (1part formalin: 7parts water) and cover the treated beds with polythene sheets for 15-20 days before sowing.
- The seeds should be sown only when the soil becomes completely free from formalin vapours.
- Drench the nursery beds with a mixture of mancozeb (0.25%) and carbendazim 50WP (0.05%) at the initiation of post emergence damping-off symptoms.
- Always sow hot water-streptocycline treated seeds in nursery beds.

Black leg (*Phoma lingam*)

- It occurs in areas with rainfall during the growing period.
- Seed borne and hence occurs from the early stage.
- Stem of affected plant when split vertically shows severe black discolouration of sap stream.
- Whole root system decays from bottom upwards.
- Often, the affected plants fall over in the field

Control measures:

- Hot water treatment is effective. Also spray the seed crop with copper oxychloride or with an organomercuric compound
- Pusa Drum Head variety of cabbage is tolerant under field condition.

Curd rot/Black spot

Pathogen: *Fusarium* spp., *Sclerotinia sclerotiorum*, *Alternaria brassicae*, *A. brassicicola*, *Botrytis cinerea*, *Erwinia carotovora* and *Bacillus polymixa*

- Curds start rotting from any portion.
- The rotting usually starts after some injury.

Control measures:

- Protective spray with a mixture of mancozeb (0.25%) and Streptocycline (0.01%) is given to the curds particularly if there is a likelihood of frost.
- Repeat same after 8-10days interval.
- Small rotten areas on the curds may be cut with a knife and painted with Bordeaux mixture (Copper sulphate 800g + lime 800g + water 200L) or copper oxychloride (0.3%).

Stalk rot/Watery soft rot

Pathogen: *Sclerotinia sclerotiorum*

- Leaves lose their shine and droop down.
- Stalks rot from inside, become hollow and filled with black sclerotia.
- Curds lose compactness followed by development of characteristic soaked white rot.
- Water soaked lesions also appear on bolting shoots later exhibiting white silvery appearance followed by complete wilting.
- There is no pod formation in diseased plants.

Control measures:

- Follow cauliflower- paddy rotation.
- Pick out diseased leaves and destroy them.
- Spray the crop at 10-15day interval with carbendazim 50WP (0.05%) and mancozeb (0.25%) starting from earthing up stage at 10-15 days interval till bolting stage.

Downy mildew

Pathogen: *Peronospora parasitica*

- White mildew growth underside leaves followed by yellowing on corresponding upper side.

Control measures:

- Spray the crop with mancozeb (0.25%) at the appearance of the disease and repeat after 10-15days interval.
- Give a spray of metalaxyl + mancozeb (0.25%) in the nursery at the appearance of the disease.

Black rot

Pathogen: *Xanthomonas compestris pv. compestris*

- At the point of infection on the leaves, tissues turn yellow and chlorosis progresses towards centre forming “V” shaped lesions with the base towards the mid-rib.
- The veins and veinlets of the chlorotic tissues become dark.
- The infection on head results in brown to black discoloration of the surface which at later stages leads to rotting.

Control measures:

- Soak seeds in tap water for 30 minutes followed by hot water dip at 52°C for 30 minutes and finally in streptocycline solution (0.01%) for the same duration.
- The seed treatment may be got done by the growers from the University /nearest Research Station laboratories.
- Give fortnightly spray of streptocycline (0.01%) after curd formation.

Bacterial soft rot (*Erwinia carotovora*):

- A weak parasite which penetrates the plants through damaged tissue e.g. lesions caused by other pathogen.
- In the field, it occurs only following black rot or after mechanical injury of nearly mature cabbage head.
- Infection favours by high humidity.
- The affected plants show a soft, slimy, bad smelling rot that under favourable conditions rapidly spreads throughout the plant.

Control measures:

- Controlling other diseases and preventing damage can keep down the disease.
- Spraying 100-200 ppm streptocycline or plantomycin combined with copper oxychloride (0.3%) at 15 days interval.

Integrated spray schedule for disease control in cole crops

a. Before sowing

- Treat the nursery beds with formalin (1 part formalin: 7 part water) 20days before sowing and rake it well.
- Soak seeds in tap water for 30 minutes followed by hot water dip at 52°C for 30 minutes.
- Give a subsequent dip in Streptocycline solution (0.01%) for 30 minutes.
- Get the seed treatment done in University/ Research Station laboratories.

b. Post-emergence stage

- Drench the nursery beds with a mixture of mancozeb (0.25%) and carbendazim 50 WP (0.05%) after disease appearance against post –emergence damping-off and root rots

c. After transplanting

- A week after earthing up, spray the crop with carbendazim 50WP (0.05%) and repeat at 15 days interval.

d. After curd formation stage

- Protective spray with a mixture of mancozeb (0.25%) and streptocycline (0.01%) be given twice at 8-10day interval.
- Spray boric acid @ 0.1% as protective spray and repeat after 8-10 days.

- Pick out diseased leaves and destroy them.
- Small rotten areas on the curd may be cut with a knife and painted with Bordeaux mixture (Copper sulphate 800g+Llime 800g +100L water) or copper oxychloride (0.3%).

e. Curd formation to pod setting stage

- Spray the crop at 10-15days interval with a mixture of carbendazim 50WP (0.05%) and Mancozeb (0.25%) from the curd initiation stage to pod setting stage.
- Repeat after 10-15days interval.

PESTS

Cutworms

- Damages seedlings in the newly planted crop.
- Stems are chewed near the soil level during night.
- Some cutworms climb the host and feed on unopened buds.
- Many cutworms prefer wilted plant material and sever the plants sometime prior to feeding.

Control measures:

- Use of well-decomposed manure helps in reducing the incidence.
- Collection and destruction of larvae after flooding of fields/ beds.
- Soil drenching with chlorpyrifos (0.04%) or spraying of cypermethrin (0.0075%) on foliage and soil surface reduces the incidence.

Cabbage aphid

- The colonies of the aphid are seen on leaves, bud and inflorescence.
- Damage is caused by nymphs and adults who suck cell sap from plant parts.
- Due to sucking of the sap curling of leaves takes place.

Control measures:

- During September/October when cole crops are transplanted, a month or so after transplanting a spray of malathion (0.05%) may be given.
- The activity of this pest remains low due to low temperature during winter, however, during February, when the temperature rises again a spray of the same insecticide may be given and it is repeated after 15 days if the attack persists.

Caterpillars

- Cabbage caterpillars and cabbage semi loopers cause serious damage to plants by devouring the foliage from mid-February onwards.

- Damage is caused by caterpillars of *Pieris brassicae* which feed in groups in the earlier stage and scrap the leaf surface but later on they eat up the entire leaves leaving only the harder mid rib.
- Besides, larvae of some other lepidopteran pests also cause damage.

Control measures:

- The yellow egg masses of the cabbage butterfly can be collected and killed by crushing.
- Spray of neem seed kernel extract (4%) and application of malathion (0.05%) also help in reducing the population of caterpillars.

Painted bug

- In seed crop, nymphs and adults suck sap from the foliage and pods thus resulting in shriveled seeds and poor yield.

Control measures:

- The pest can be controlled by spraying the crop with oxy-demeton methyl (0.025%) or dimethoate (0.03%) as and when the attack is noticed.
- Repeat spray if required.
- After spray observe 10-12 days waiting period.

Red ant

- The crop is attacked by red ants in many places.
- The insect feeds on the bark and root hairs of newly transplanted seedlings.
- The attacked plants dry up and die subsequently.

Control measures:

- Mix malathion dust (5 %) or follidol M dust (2 %) @ 20-25 kg per hectare in the basins of plants at the time of transplanting.
- In seed crop, rogue out undesirable heads before spray.
- During bloom, spray endosulfan (0.05%) in the evening to avoid poisoning to the pollinators and advise local pollinators to close down bee hives for the following day.
- Observe a waiting period of two weeks in the head crop.

Diamond back moth

- Damage is caused by the larvae which in earlier stage attack the leaves and later on feed on the exposed leaves making holes of variable size.

Control measures:

- Sprinkler irrigation after every third day in evening hours is effective.

- Spray application of endosulfan (0.05%) is also effective.
- Same insecticide should not be applied repeatedly.

Snails and slugs

- Damage the growing tips of plant and also the surface of curd in cauliflowers.
- They are problematic when crop is irrigated with sewerage water.

Control measures:

- Baiting with metaldehyde and bran (1: 25 in 12 L of water).
- Alum may be sprayed as a repellent @ 2% solution.

PHYSIOLOGICAL DISORDERS (CAULIFLOWER AND SPROUTING BROCCOLI)

- Manifest in different types of disease syndromes.
- Some physiological disorders depend mainly on hereditary factor, whereas, other are fluctuation occurring in temperature, air, water, humidity, organic and inorganic nutrition.

Riceyness

- It manifests in the elongation of peduncle bearing flower buds rendering curds, granular, loose and somewhat velvety.
- A premature initiation of floral buds is characterised by riceyness in cauliflower and is considered to be of poor quality for marketing.
- Riceyness mainly develops during the warm weather.
- Hereditary factors have also been reported for riceyness.
- Heavy dose of nitrogen and high relative humidity also contributes to riceyness.

Control Measures:

- It can be controlled by cultivation of genetically pure seed and appropriate varieties with recommended cultural practices.
- Harvest while the curd is still firm, compact, white and fairly smooth; if it gets too mature, it will become grainy or ricey.
- Proper management of soil moisture and fertility during the development of head or curd.

Fuzziness

- It appears as the flower pedicels of velvety curds elongate.
- The anomaly is both hereditary and non-hereditary.
- Cultivation of cauliflowers, out of their normal season encourages fuzziness.

- Sowing good quality seed in right season under proper cultural practices minimizes fuzziness.

Leafiness

- This disorder is commonly seen by formation of small thin leaves from the curds which reduce quality of curd.
- Prevalence of high temperature during curding phase aggravates leafiness.

Control measures:

- It can be controlled by selection of varieties according to their adaptability and seasons.

Buttoning

- Development of small curds with inadequate foliage in cauliflower is known as buttoning.
- It is also referred to as premature heading.
- The leaves are so small that cannot cover the formed head.

Causes of buttoning

- Transplanting of more than 6 weeks old (over aged) seedlings.
- Planting of early variety late and vice versa lead to buttoning.
- Hot and dry weather is unfavorable for vegetative growth of plants.
- When soil moisture becomes limiting factors, it checks the growth of the plants, which in turn, causes early formation of curds without maintaining their further enlargement.
- Transplanting of seedlings, obtained from poorly managed nursery bed.
- Slow plant growth in the nursery, overcrowding, and insufficient water, lack of weeding, bad condition of the soil, excessive salt concentration, low lying area or field with shallow and poor top soil may also cause buttoning.

Control measures:

- Nursery should be properly looked after to avoid any check in the plant growth.
- An adequate amount of nitrogen and water should be applied.
- Do not delay transplanting.
- Cultural practices should be carried out well in time and water logging and overcrowding should be avoided.

Blindness

- It means the plant without terminal buds or when the growing point collapse at an early stage and the terminal buds fail to develop and plant becomes blind.
- It occurs in over wintered plants and any cultural practice interfering in growth of the terminal bud may lead to blindness.

- It is characterised by the leaves that develops which are large, dark green, thick and lathery owing to the accumulation of carbohydrates.

Control measures:

- It can be controlled by avoiding young plants from low temperature exposures and avoid damage to seedlings from insect-pests/rodents.

Bracting

- The bracts are underneath the prefloral meristem, which corresponds to axillary buds.
- These bracts or leaves come out of the curd resulting 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 causes this disorder.

Control measures: Control of temperature during curding

Purple colouring

- Sometimes various pigmentations are occurred on the curd due to fluctuation in temperature.

Possible reasons:

- Fluctuation in temperature

Chlorosis

- In cauliflower, magnesium deficiency causes chlorosis when grown on highly acidic soils.
- Chlorosis shows on intervenial and yellow mottling of lower leaves.
- The affected leaves turn bronze in colour and become stiff.

Control measures:

- Use of fertilizers containing soluble magnesium keeps the disorder under control.

Premature seeding/bolting

- It means premature formation of seed stalks i.e. before the formation of heads or failure of leaves to form a solid head.

- The possible causes of bolting include early sowing of seeds, warm winter, extreme change in temperature, poor growth of seedlings and varietal characters.

Control measures:

- Use resistant cultivars, avoid planting/transplanting/setting plants too early into the field and prevent the stimulation of early plant growth.

Browning (Brown Rot or Red Rot)

- It is caused by boron deficiency which is influenced by soil pH.
- The availability of boron decreases at neutral soil reaction.
- It is characterized by sign on the young leaves that becomes dark green and brittle.
- Sometimes, the downward curling of older leaves followed by development of blister occurs when boron deficiency is severe.
- Curds may also show irregular water soaked spots, which later change to a rusty brown colour.
- In later stages, the stem become hollow with water soaked tissues surrounding the walls of the cavity.
- In more advanced stages, a pinkish or rusty brown area develops on the surface of the curd and hence is known as red or brown rot.

Control measures:

- This may be controlled by application of borax or sodium borate or sodium tetra borate at the rate of 20 kg/ha as soil application.

Whiptail

- Deficiency of molybdenum causes “whiptail syndrome” especially, in high acidic soils.
- The young cauliflower plants become chlorotic and may turn white, particularly along the leaf margins.
- The leaves also become cupped and wither and eventually the leaf dies and the growing point also collapses.
- In older plants, the lamina of the newly formed leaves is irregular in shape, frequently consisting of only a large bare midrib and hence the common name “Whip tail”.

Control measures:

- It can be corrected by application of lime or dolomite limestone to raise the soil pH up to 6.5.
- Apply 1.0 kg of sodium or ammonium molybdate per hectare.

Black Speck

- A physiological disorder in cauliflower common with the popular snowball cultivar.
- Black speck could be due to nutrient imbalance.
- Tip burn and internal browning in cabbage and Chinese cabbage is due to the inadequate transport of calcium to rapidly growing tissues.

Control measures:

- Foliar spray, with calcium nitrate may control the problem or alternatively by a reduction in nitrogen fertilizer

PHYSIOLOGICAL DISORDER OF CABBAGE

Cracking

- Leaves may grow through head.
- Possible Reasons
- Excess N fertilizer
- Hot dry weather.
- Plant the crop at a time so that the crop develops in mild or cool weather

Control measures:

- Do not allow soil dry out.
- Fertilize properly.

PHYSIOLOGICAL DISORDERS OF CHINESE CABBAGE

Tip Burn: Most common disorder.

- Calcium deficiency results in rotting of leaf margins.

Control measures:

- Two foliar applications of CCC at 1120 or 2240 ppm combined with CaCl₂ at 2g/L or 4 applications of CaCl₂ alone reduced the appearance of tip burn.
- Spraying 5 times with 0.7% CaCl₂ + 50 ppm NAA.

Bolting

- Premature seed stalk development may take place due to sudden rise in temperature.

Control measures:

- Timely planting checks this disorder

PEA

BOTANICAL NAME : *Pisum sativum L.*

COMMON NAME : Matar

CHROMOSOME NUMBER : 2n=14

FAMILY : Leguminosae

USES

- Pea is highly nutritive vegetable containing high percentage of digestible proteins (very valuable for the vegetarians) along with carbohydrates and vitamins A and C, also very rich in minerals like Ca and P
- Excellent food for human consumption taken either as vegetable or in soup.
- Large proportion is processed (canned, frozen or dehydrated) for consumption in the off-season.
- Being N fixing legume, recognized as a soil building crop
- Seeds contain trypsin and chymotrypsin which could be used for contraceptive, ecobolic, fungistatic and spermicidal. Pea stem is a nutritive fodder.
- Pea is being used in a growing snack market.

NUTRITIVE VALUE AND USES (per 100g of edible portion)

Energy (kcal)	84	Riboflavin (mg)	0.14
Moisture (%)	78	Niacin (mg)	2.9
Protein (g)	6.3	Ascorbic acid (mg)	27
Fat (g)	0.4	Ca (mg)	26
Carbohydrate (g)	14.4	P (mg)	116
Vitamin A (IU)	640	Fe (mg)	1.9
Thiamin (mg)	0.35		

ORIGIN AND HISTORY

- The geographical origin of "*Pisum sativum L.*" is yet uncertain. However, *Pisum* is considered to have been originated in "Ethiopia" from where it spread during pre historic times to the Mediterranean region, central Europe, the near East and subsequently to rest of the world.

- Pea has been assigned to Mediterranean and the African center of diversity.
- *Pisum elatius* a wild species is considered as its ancestor.

AREA AND PRODUCTION

- The area under this crop in India was 370 thousand ha having a production 3517 thousand tonnes with a productivity of 9.5MT/ha (NHB, 2011).

CLASSIFICATION

- On the basis of species, the cultivated pea is divided into two types.
- The field pea with coloured flowers (*Pisum sativum* var. *arvense* L.) and garden pea with white flowers (*Pisum sativum* var. *hortense* L.). From practical stand point, *Pisum sativum* can be divided into following groups.

A. According to seed

- Round or smooth-seeded cultivars
- Wrinkled seeded cultivars

B. According to height of plant

- Bush or dwarf types.
- Medium tall types.
- Tall types.

C. According to maturity period

- Early season : 65-80days
- Medium season :90-100days
- Main season : 110-120days.

D. According to use of pods

- Fresh market types
- Freezing types
- Canning types
- Dehydration types.

E. According to pod walls

a. Types with thin pod walls

- Types with smooth seeds
- Type with wrinkled seeds.

b. Types with thick pod walls

- Type with smooth seeds
- Type with wrinkled seeds.

CLIMATIC REQUIREMENTS

- Pea seed can be germinated up to the minimum temperature of 5°C.
- The optimum temperature for germination is about 22°C.
- Pea can tolerate cold, but severe frost causes considerable injury to the freshly opened flowers.
- The optimum temperature for better growth and yield is 13-19°C.
- High temperature reduces the pod quality as sugars in the seeds changes to hemicelluloses and starch.
- Temperature above 27°C shortened the growing period and adversely affects pollination.
- Germination at high temperature results in tall plants whereas low temperatures at early growth stages promote branching and dwarf growth habit.

SOIL CONDITION

- Pea can be grown on many types of soil from light sandy to clay soil.
- Light soils are good for early crop whereas heavy soils are found suitable for main crop and produce high yield.
- It is very sensitive to saline and alkaline conditions.
- Most favourable range of pH is from 5.5 - 6.0.

VARIETIES

VARIETIES

a) **Early** **Smooth** **Seeded**
Meteor:

- Plants are 35-40 cm tall, dark green, flowers borne generally singly; pods dark green, 8.7 cm long, well filled with 7 seeds, having shelling percentage of 45.
- Pods mature in 58-60 days, suitable for early October sowing.

Alaska:

- This is an early smooth seeded canning cultivar with bluish green seeds.
- Plants are about 45cm tall.
- Pods are borne singly, light green in colour 7 x 1.25cm.

b) **Early** **Wrinkled** **Seeded**
Arkel:

- It is an early, wrinkled seeded and most popular exotic variety.
- Plants are dwarf.

- Pods are green and sickle shaped.
- Yield potential of this variety is 100q/ha and shelling percentage is approximately 40.

Early December:

- It is a selection from the cross T.19 × Early Badger.
- It is dwarf, producing light green pods, 7 cm long.
- It has higher number of pods per plant than Early Badger but is somewhat late in flowering.

Matter Ageta 6:

- It is a dwarf, dark green and early maturing Indian cultivar and is ready for first picking after 40-50 days from sowing, producing 6-7 seeds per pod.
- It produces 50 per cent of its total yield in the first picking.

Palam Triloki:

- Early maturing, about 10 days earlier in maturity than recommended variety 'Arkel' besides having higher yield potential with an average of 70-75 q/ha.
- It has long, bright green, round, well filled pods containing 8-10 seeds with 48-50 % shelling.

VL Ageti Matar 7:

- It is developed at Vivekananda Parvatiya Krishi Anusandhanhala, Almora by crossing Pant Uphar and Arkel.
- It is an early maturing variety with a green pod yield potential of 100-125q/ha.
- It matures 5 days earlier than Arkel, which helps to control damage caused by powdery mildew disease and frost.

c) Wrinkled-Seeded Main Season and Late Bonneville:

- A medium tall, double podded cultivar, flowers in 50-60 days and first blossom appears at 13-15th node.
- Pods are light green, straight, about 9 cm long and 6-8 seeded with shelling percentage of 45.

Lincoln:

- It is a dwarf to medium tall, single podded cultivar, flowering in 55-60 days and first blossom appears at 11-12th node.
- Pods are dark green, 9.5-10 cm long, 6-7 seeded with shelling percentage of 45 and it is suitable for late sowing.
- Pods retain good colour after harvest and good for canning.

Azad P-1:

- Plants are 80-90 cm tall having dark green foliage.
- Pods are smooth, dark green and 8-10cm long.
- Shelling percentage is 50-55.
- Pods are slightly curved at the distal end.
- This variety can tolerate powdery mildew and rust.

P-88:

- It is developed from a cross between Single Pusa-2 and Morrasis-55.
- The plants are 75-85 cm tall.
- The numbers of seeds per pod range from 7-8.
- The matured seeds are wrinkled and bold.
- It is highly susceptible to the powdery mildew disease.

VL-3:

- Medium tall, pods medium long (7-7.5cm) containing 7-8 seeds/pod, green in colour.
- Gets ready in 100-110 days, slightly curved towards suture at distal end, wrinkle seeded.
Average yield 140-150q/ha

Solan Nirog (Sel. 8-1):

- It is developed from UHF, Solan.
- Pods are 8-10 cm long, dark green with 8-9 seeds/pod.
- It matures in 90-95 days and resistant to powdery mildew disease.

Palam Priya (DPP-68):

- It is developed from HPKV Palampur. Medium tall, flowers borne in double almost throughout the plant.
- Profuse bearer, pods are attractive, light green, straight, 8-9cm long, 7-9 seeds/pod.
- Shelling is 45-50 %, wrinkle seeded, sweet, ready in 90-100days.
- Average yield 120-130q/ha, slow mildewing.

Punjab-89:

- Medium maturity, bright green, very long pods (9-10 cm) with more number of seeds/pod (9-10) and high shelling percentage (45-50%).
- More pods/plant (20-25) borne in doubles almost in every node, medium growth habit and sweet in taste (17.2° Brix TSS).
- Average yield 135 q/ha

Palam Sumool:

- Medium in maturity having very long (12-15cm), dark green and flattish round pods containing 8-10bold seeds.
- High yield potential (100-120 q/ha), 45-48% shelling, sweet in taste (TSS 180° brix), and resistant to powdery mildew disease

c) **Round Seeded Main Season and Late**

Kanwari:

- This is a tall-growing, double podded cultivar, flowering in 65-75 days and first blossom appears at 15-17th node.
- Pods are about 8.5cm long, yellowish green, and 5.6 seed with a shelling percentage of about 40.
- A mucilage excretion on the pods is a characteristic of this variety.
- It is largely grown in hills and the plains around Ambala, as a non irrigated crop It is also suitable for growing as a grain type although the presence of black colour lowers the market value of the grain.

e)
Sylvia:

Edible

Podded

Type

- It is a tall growing cultivar flowering in 60 days and first blossom appears at 14-16th node.
- Pods are borne singly, yellowish, 12 cm long and sickle shaped.
- Pods have general appearance of a medium sized French bean pod.
- Staking is desirable and it is suitable for late sowing.

Oregone 523:

- A commercial freezing variety of USA with field resistance to pea enation mosaic virus, red clover vein mosaic virus and race 1 of *Fusarium oxysporum* f. sp. *pisii*.

Others

varieties

are

1. Early Smooth- Seeded

- Asauji
- Lucknow Boniya
- Early Superb

2. Early Wrinkle-Seeded

- Early Badger
- Little marvel
- Kelvedon wonder

3. Wrinkled-Seeded Main Season and Late

- T.19
- Delwiche commando
- Khaper Kheda
- N29
- Perfection New Line
- Thomas Laxton
- GC-14

4. Edible-Podded Cultivar

- Punjab Meethiphali
- Aparna
- Pershotsuit
- Khar Kovskii Usatyi
- Vica
- Alaska 81
- Taichung 13
- Pervenets

- Trounce
- Apex

SOWING TIME

- For Rabi crop, seeds are sown in October to middle of November in plains.
- Pea is cultivated in hills from middle of March to end of May.
- In North India, three sowings are done, during August, November–December and during March-April

SEED RATE

- Early varieties :100-120 kg/ha
- Mid season and late varieties: 80-90kg/ha.

METHODS OF SOWING

- Seeds can be sown on flat or slightly raised beds either by broadcasting or behind desi plough in furrows, which are covered by usual planting.

SPACING

- Early Varieties - 30cm × 5-10cm
- Main season - 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.
- It is to be mixed thoroughly with seed and dried in shade before sowing.
- This 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 carbendazim (2.5g/kg of seed) to save the crop against *Fusarium* wilt.
- If both seed inoculation and fungicide treatments are to be given, then firstly the seeds are treated with fungicide followed by inoculation with *Rhizobium* culture.

NUTRIENT MANAGEMENT

- FYM @150-200q/ha is to be applied 15 days before sowing the seeds.
- Nitrogen, phosphorus and potassium should be applied in the ratio of 50:75:40 kg/ha, respectively.

- Entire quantity of phosphorus, potash and half quantity of nitrogen is to be thoroughly mixed in the soil at the time of field preparation.
- The remaining nitrogen is to be top dressed at flowering time along with irrigation.

USE OF PLANT GROWTH REGULATORS

- Foliar spray of MH at 25mg/L, before flowering has given best pod yield in pea.
- Seed treatment with cytozyme @ 1 per cent improve the fresh pod yield in pea

IRRIGATION

- The water requirement of pea is very low and it can be grown even without irrigation
- In general, one pre-sowing irrigation is essential for proper germination.
- Two or three light irrigations at 10-15 days interval especially at flowering, fruit set and at grain filling period are essential for good yield.

INTERCULTURE OPERATIONS

- Hoeing and earthing up are to be done after 2-3 weeks of sowing and second at flowering initiation to get higher yield.
- Hoeing helps in removing the weeds and pulverizes the soil for proper aeration.
- 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.
- The useful method of weed control practised in India is mechanical or manual.
- Manual weeding is uneconomical and time consuming.
- Chemical weed control has been reported to be effective as compared to hand weeding.
- At the same time, it is cheaper and less time consuming.
- Application of Lasso @ 0.75 kg a.i/ha or Tribunal @1.87 kg a.i. /ha as pre-emergence application have been recommended under wide range of agro-climatic condition.

HARVESTING AND YIELD

- The maturity of pea is tested mechanically with a tendrometer.
- Generally, three to four pickings are taken during the season.
- Harvesting should be done either in the morning or late in the afternoon.
- About 50-60q of green pods per hectare are obtained in case of early varieties
- Shelling percentages of pea cultivars ranges from 30-56 per cent depending upon varieties.
- The peas are harvested when the pods are fully green and well developed.
- The seeds should be near full size and should not have begun to harden.
- The high quality of pea is associated with tenderness and high sugar content.
- During maturity, sugar contents decreases rapidly and there is an increase in starch and other polysaccharides and insoluble nitrogenous components such as protein.
- Calcium migrates to seed coat and toughness of skin increases during ripening.
- 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.
- Picking should be done either early in the morning or late in the afternoon. Picking during mid day deteriorates the quality of pea by heat.

YIELD

- Early varieties give 60-85 q/ha where as main season varieties yields 100-150q/ha green pods per hectare.

HEAT UNITS

- A heat unit system is used in commercial pea production to predict relative maturity dates and to schedule planting dates.
- This system uses 4.4°C as the thresh hold temperature or base temperature & 29.4°C as the maximum temperature.
- The daily heat units accumulating during the development of a cultivar are calculated from the daily temperature mean.
- Heat units accumulate slowly during the cool spring & rapidly as the season progresses.
- With this information, the expected time of maturity of a cultivar can be determined from the mean temperature of the few seasons.
- For early cultivar 1534 heat units whereas for late cultivars 3942 heat units are required.
- The edible types are picked when pods have reached full length and seeds are just developing.

POST HARVEST HANDLING

- Green peas loose much of their sugar content unless they are promptly cooled to 0°C.
- Hydro cooling is the preferred method for pre cooling.
- At 0°C & 95-98% RH, green peas can be stored for 1-2 weeks.
- If the crop is packed with crushed ice, storage may be extended for 1 additional week.
- It can be stored better for 2 weeks in cold storage at 0°C & 85-95 % RH. Temperature at 21.5°C becomes unfit for sale at the end of 5 days.

STORAGE

- Peas can also be stored in crushed ice for about 2 weeks.
- The pods will freeze at 10°C and 90-95 per cent relative humidity.
- Fresh unshelled peas may be kept for two weeks at 0°C.

DISEASES

Fungal Diseases

Powdery mildew : (*Erysiphe polygoni*)

- It is characterized by white powdery mass on foliage, pods and stems.

- It is favoured by hot and dry climate.

Control Measures:

- Spray dinocap@ 0.05per cent or wettable sulphur@ 0.2 per cent or carbendazim @ 0.05 per cent. Repeat after 10-15 days if necessary.

Fusarium wilt: (*Fusarium oxysporum* f. sp. *pisi*)

- The disease is characterised by yellowing of lower leaves and stunting of plants.
- Optimum temperature for development of disease is 25-28°C.

Control Measures:

- Since wilt is soil borne, a long crop rotation is recommended.
- Seed treatment with carbendazim (2.5g/kg seed) for two hours followed by spraying with carbendazim (0.05%) is recommended.
- Avoid early sowing in badly infested soils. Follow three years crop rotation in infested areas.

Ascochyta blight: (*Ascochyta pinodes*, *Ascochyta pinodella*, *Ascochyta pisi*)

- Infected plants wilt.
- Roots become brown.
- On stems and leaves, brown spots are observed.

Control Measures:

- Use bold and healthy seed.
- Treat seed with carbendazim (2.5g/ kg seed).
- Spray carbendazim (0.1%) or mancozeb (0.25%) before appearance of flowers on infected plants.
- Repeat after 10-15 days if needed.

Bacterial Diseases

Bacterial blight: (*Pseudomonas syringae* pv. *pisi*)

- The disease affects all the aerial parts of plant.
- It appears as spots on leaflets which are round, oval or irregular 2-5 mm in diameter and reddish with translucent center having dark brown margins.

Control measures:

- Use clean healthy seed. Remove affected plants and weeds.
- Treat seed with Streptocycline @ 0.01 per cent for 1-2 hours.
- Spray the same chemical @0.01 per cent and repeat after seven days if needed.

Viral Diseases

Pea mosaic:

- The diseased plants are pale, weak and dwarf.
- The young leaves and stipules show general mottling.
- Light brown discoloured areas are seen on petioles, stems and tendrils.

Control measures:

- Control insect vectors carefully, pull out affected plants and burn them
- Grow resistant varieties.

PESTS

Pea thrips:

- Pea thrips may be problem in very dry weather.
- Adult feed inside the flower, while young ones feed on leaves and pods.
- They lay their eggs in the pods.
- Mottled patches appear which later turn brown.
- Yield is severely affected if attack persists.

Control measures:

- Spray the crop with cypermethrin (0.0075%) or dichlorvos (0.04%) as soon as the attack is noticed.
- If harvesting coincides with spray, spray immediately after harvest and wait for 10-15 days for another harvest.

Pea leaf miner

- More serious damage is caused by larvae.
- They make prominent whitish tunnels in the leaves which interfere with proper photosynthesis activity of plants.
- The manufacture of the food by leaves is severely affected.

Control measures:

- The population of the pea leaf miner is naturally kept under control by a large number of larval and pupal parasitoids which include Braconids and Eulophids.
- Application of oxy-demeton methyl (0.025%) or dichlorvos (0.04%) during the second week of February helps in reducing the population of this pest.

Pea pod borer:

- Caterpillars feed on foliage and later bore into the pods to eat the developing seeds.

Control measures:

- Spray carbaryl (0.1%) on the crop. Repeat after 15 days if attack persists.

SEED PRODUCTION

- The cultivation practices which are followed for table crop are same for seed crop also. In addition to this,
- Isolation distance of 10 meter for certified and 20 meter for foundation seeds between two cultivars should be followed.
- Rogue out off type and diseased plants before flowering and during pod setting stage.
- Harvesting the crop when pods are fully ripe and plants start drying.

SEED CERTIFICATION STANDARDS

A. Field Standards

a. General requirements

Isolation

- Pea seed fields should be isolated from the contaminants as shown the table given below:

Contaminants	Minimum Distance (meters)	
	Foundation	Certified

	Seed	Seed
Fields of other varieties	10	5
Fields of the same variety not conforming to varietal purity requirements for certification	10	5

b. Specific requirements

Factors	Maximum permitted (per cent)	
	Foundation Seed	Certified Seed
Off types	0.10	0.20

B. Seed Standards

Factors	Standards For Each Class	
	Foundation Seed	Certified Seed
Pure seed (minimum %)	98	98
Inert matter (maximum) %	2	2
Other crop (maximum) Number/Kg	--	--
Weed seeds (maximum) Number/kg	--	10
Other distinguishable varieties (maximum) Number/ kg	5	10
Germination including hard seeds (minimum) %	75	75
Moisture (maximum) %	9	9
For vapour-proof containers (maximum) %	8	8

BROAD BEAN

AIM: The broad bean is a hardy plant and can withstand sufficiently cold temperatures. This is the only bean which is sown in autumn and is grown as a winter crop. The present chapter will make the students familiar with its importance, production technology, seed production practices and plant protection measures.

BOTANICAL NAME : *Vicia faba* L.
CHROMOSOME NUMBER : 2n=12, 14
FAMILY : Leguminosae
CENTRE OF ORIGIN : North Africa and South Caspian Sea.

- The Broad bean (*Vicia faba* L.) also known as faba bean or horse bean is a minor leguminous crop grown in localized areas in India but is an important food crop of South America.
- It is the only bean grown as a winter crop.
- Broad bean is used as green, shelled and dry beans and as a feed for livestock. Plants have distinguishing features like square and erect growing stems which grows up to 30cm (dwarf varieties) to 100 cm (tall varieties).
- It is pollinated by insects. Clusters of white black branched flowers arise in the axils of the leaves.
- The pods are borne upright in clusters of 3-5 or more fleshy beans.
- Broad bean is being grown on small scale in Utter Pradesh, Punjab, Haryana, Kashmir, Rajasthan, Karnataka, Madhya Pradesh and Bihar.
- The pollen grains and green pods cause allergy to some people which is known as favism (Haemolytic anaemia)

NUTRITIVE VALUE (per 100 g of edible portion)

Energy (kcal)	48	Thiamin (mg)	0.08
Moisture (%)	85.4	Niacin (mg)	0.8
Protein (g)	4.5	Ascorbic acid (mg)	12
Fat (g)	0.1	Calcium (mg)	50
Carbohydrate (g)	7.2	Phosphorus (mg)	64
Vitamin-A (IU)	15	Iron (mg)	1.4

CLIMATIC REQUIREMENTS

- Broad bean is a hardy plant.
- It is grown mainly at higher altitudes where the climate is relatively cool.
- It is the only bean, which can withstand cold (up to 4°C), therefore, it is grown as winter crop.

SOIL CONDITIONS

- It prefers rich, well drained loamy soil with pH range of 5.5 to 6.0.
- Acidic soils are not good for broad bean.
- It can tolerate salinity up to some extent.
- Land should be prepared thoroughly by giving repeated ploughings to get fine tilth.

VARIETIES

Pusa Sumeet:

- Plants are 75 cm tall having on an average 5-7 branches/plant.
- A plant bears about 100pods.
- The pod length and thickness is 6.0cm and 1.3cm, respectively.
- It has attractive dark green pods and borne in cluster.
- The average yield potential is 180q/ha.
- Besides the above varieties “Selection BR-1” and “Selection BR-2” are black and yellow seeded varieties, respectively developed from Bihar.
- Jawahar Viva 73-81 is a dormant type, reported from Madhya Pradesh.
- Moreover some exotic varieties introduced from abroad are given below.

Some Exotic Varieties introduced from Abroad
Long pod type:

- Aquadule Claudin, Imperial White Long Pod, Masterpiece Green Long Pod, Imperial Green Long Pod, Red Epicure.

Windsor Type:

- Imperial White Windsor, Giant four seeded Green Windsor, Imperial Green Windsor

SEED RATE AND SOWING

- Sowing is done in the month of September-October and February-March.

- About 70-100 kg/ha seed is required for cultivation.
- The seeds are sown in shallow furrows of 15cm width with a spacing of 75cm.
- In each furrow, two rows of seeds are sown at a spacing of 25cm in a zigzag manner along the furrows.
- It can be sown in a single row system with spacing of 45x15cm.

NUTRIENT MANAGEMENT

- The field is given deep digging and farmyard manure is applied at the rate of 10 tonnes/ha along with NPK at the rate of 20:50:40kg/ha, respectively.
- Entire quantity of phosphorus, potash and half quantity of nitrogen is to be thoroughly mixed in the soil at the time of field preparation.
- The remaining nitrogen is to be top dressed at flowering time along with irrigation.

Use of PGR

- In beans, the success of pollination, fertilization and fruit set depends on the prevailing weather conditions.
- Certain plant growth regulators like PCPA @ 2ppm, alpha-naphthyl acetamide @ 2-25ppm or beta-naphthoxy acetic acid @ 5-25ppm, when sprayed at prevailing temperature or when normally pods do not set, induce fruit set.
- Thus by spraying some plant growth regulators, early, higher and total yield can be obtained.

IRRIGATION AND CULTURAL PRACTICES

- Immediately after sowing, the field has to be irrigated.
- This is followed by light irrigation on the third day.
- Thereafter, light irrigation should be given at regular interval of 12-15days.
- Regular intercultural operations should be carried out by hand weeding and hoeing to keep the weeds under check and to provide a good environment for crop growth.
- Tall varieties may be given support with wooden sticks or twigs against wind.
- Place stakes or canes at one meter interval on both sides of the double rows close to the beans.
- Then tie around the stakes with twine 30-60cm above the ground.

HARVESTING, YIELD AND STORAGE

- The pods are ready for harvesting in 3-4months for spring sowing and 6-7months for autumn sowing.
- Very young pods are preferred by most people.
- The beans are harvested at the green shell stage as needed for home use or for market and those remaining on the plant are used as dry shell beans.
- A pod yield of 7-10tonnes/ha and green bean yield of 1.8-2.0q /ha is expected.

DISEASES OF BROAD BEAN

DISEASES

- Yellow mosaic, Anthracnose, *Phytophthora* pod rot, rust, angular leaf spot, ash stem blight and *Rhizoctonia* root rot are some of the diseases affecting bean crop.
- The disease can be effectively controlled by spraying copper oxychloride @0.3per cent.
- Root rot can be controlled by drenching captan @0.2per cent.
- Foliar fungal diseases can be controlled by spraying mancozeb @0.25per cent.
- Rust can be controlled by spraying wettable sulphur @0.2per cent and fungicides like hexaconazole (0.05%) etc.

PESTS

Thrips

- Thrips may be problem in very dry weather.
- Severely infested flowers wilt, fade and drop prematurely without bearing fruits.
- They lacerate the leaf tissue and imbibe the oozing sap.
- Pale and silvery sheens appear on the affected leaves.
- Some thrips are also vectors of viral diseases.

Control measures

- Spray the crop with cypermethrin 0.0075% or dichlorvos 0.04% as soon as the attack is noticed.
- If harvesting coincides with spray, spray immediately after harvest and wait for 15 days for another harvest.

Mites

- These are very small pests and remain mostly on the under surface of leaves.
- Damage is caused by the larvae, nymphs and adults by sucking the cell sap from under side of leaves, flower buds and flowers.
- When population is high, it results in bronzing and curling of leaves and discolouration of flowers and leaves.
- Webbing of leaves, sepals and petals occur which give untidy look to the plants.
- The infestation is more in dry weather and under poly house conditions.

Control measures

- Remove the old and infested leaves and burn them.
- Try to avoid dry conditions and spray frequently with plain water at least twice a week with sprinkler.
- Observe the plants regularly for mite population and if incidence is noticed, spray the crop with insecticides like profenofos (0.05%) or fenazaquin (0.0025%) or propargite (0.057%).

RADISH

BOTANICAL NAME : *Raphanus sativus* L.
 FAMILY : Cruciferae
 CHROMOSOME NO : 2n = 18
 ORIGIN PLACE : Europe and Western Asia
 USES AND IMPORTANCE

- 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.
- It is a good source of vitamin C containing 15-40mg per 100g of edible portion.
- Pink skinned radishes are generally richer in vitamin C than white skinned ones.
- The young tender pods are also used as vegetable.
- A salt extracted from roots, dried and burnt to white ash is said to be used in stomach trouble.
- The juice of fresh leaves is used as diuretic and laxative.
- Seeds are said to be peptic, expectorant, diuretic and carminative.
- Young tender pods of rat-tail radish are used as vegetable—no edible root is formed in this radish.
- It is a short duration crop and highly productive, so preferred as intercrop or in relay and sequential cropping.
- The characteristic pungent flavour is due to the presence of volatile isothiocyanates (4-methyl thio-3-butenyl isothiocyanate) – MTB-ITC.
- The colour of the pink cultivars is due to the presence of anthocyanin pigments.

NUTRITIVE VALUE (per 100 gram of edible part)

Moisture (%)	94.4	Phosphorus (mg)	22
Protein (g)	0.7	Iron (mg)	0.4
Fat (g)	0.1	Sodium (mg)	33
Mineral (g)	0.6	Potassium (mg)	138
Fibre (g)	0.8	Vitamin-A (IU)	5
Carbohydrate (g)	3.4	Riboflavin (mg)	0.02
Calories (kcal)	17	Nicotinic acid (mg)	0.5
Calcium (mg)	35	Vitamin-C (mg)	15
Oxalic acid (mg)	9		

Types:

Spring radishes	Winter radishes
Very common, rapid growing and quick maturing (20-30 days)	Slow growing and late maturing (50-90 days)
Relatively small roots	Large roots
Root quality deteriorate quickly and mildly pungent	Stores better and have characteristic strong flavour

- Radish contains alkaloids known as isothiocyanate though it is good source of carbohydrates and minerals. Pink colour of radish is due to the presence of anthocyanin and white colour varieties are not rich in Vitamin-C.
- Radish is also grown for its young edible pods present in the species *Raphanus caudatus* besides *Raphanus sativus*
- There are two distinct groups of radishes viz. European or Temperate and Asiatic or Tropical Type:

Varieties:

Asiatic/tropical/subtropical type	European/Temperate Type
Produce seeds in plains	Seed production is limited to high hills.
Pusa Desi, Pusa Reshmi, Pusa Chetki, Punjab Safed, Japanese White, Punjab Pasand, Arka Nishant, Chinese Pink, Hisar Mooli No. 1, Kalyanpur No. 1, Kalyani White, CO-I, IPVR-I, IPVR-II, C-2, Jaunpuri Mooli, Early Miino White.	Pusa Himani, White Icicle, Rapid Red White Tipped, Scarlet Globe, Scarlet Long, Silver Queen, Kvartha (Short duration suitable for protected cultivation). French breakfast, Palam Hriday

A. European/ Temperate Type

- They are quick growing and short duration type (25-30 days).
- Produce roots of good quality, less pungent and smaller in size.

The important varieties belonging to this group are as follows:

White Icicle:

- Roots cylindrical ending in a stump, 12-15cm long 2-3cm thick, skin slim, flesh white, mildly pungent flavour, sweet and free from green top.
- Ready for harvesting in 25-30 days.

Pusa Himani:

- Developed at IARI Regional Station, Katrain by crossing a temperate variety (Temperate Black) and popular Asiatic type (Japanese White).
- Roots are 30-35cm long, 10-12cm in length, skin is pure white and flesh is crisp and sweet flavoured with mild pungency.
- Ready in 55 days for harvesting after sowing.

Rapid Red White Tipped:

- It is an early variety and produce short foliage.
- Roots are small, round and red in colour with green top foliage.
- Flesh is white, crisp and pungent.

Scarlet Globe:

- Roots are round, 2cm in diameter, red in colour and flesh is crisp and pure white.
- It becomes ready for harvesting in 25-30 days after sowing.
- Roots become pithy if they are not harvested at maturity.

Scarlet long:

- Leaves are 15-20cm long and light green in colour.
- Roots are long and tapering to a point, red with soft and white flesh.
- Ready for harvesting in 30-40 days after sowing.

B. Asiatic or Tropical Type

- Asiatic types don't require chilling temperature for bolting and set seed freely under tropical conditions.
- Hence their seed can be produced under tropical conditions.
- The important varieties include

Pusa Desi:

- Developed by IARI, New Delhi through selection from a local collection.
- Roots are 30-35cm long, white, more pungent and tapering with green stem end, ready for harvesting in 50-60 days after sowing.

Japanese White:

- It is a Japanese introduction made at IARI Regional Station, Katrain (Kulu valley, H.P).
- Roots are cylindrical ending in a stump and 25-30cm long.
- Flesh is pure white, crisp, smooth and mildly pungent, harvested 45 days after sowing.
- Produce seeds only in the hills and bolting is very less.

Pusa Chetki:

- It was developed by IARI, New Delhi through Selection from the germplasm of Denmark.
- Roots are medium sized, pure white, slim, mild pungent and soft with blunt end.
- Roots become ready for harvesting in 40-45days after sowing.

Pusa Reshmi:

- Developed by IARI, New Delhi.
- Roots are 30-35cm long, white, slightly green with tapering end.
- Roots mature in 55-60 days after sowing.

Kalyani White:

- Roots are pure white, 25-30cm long, uniform in growth and blunt tipped.

- It requires 45-50 days for maturation.

Kalyanpuri No. 1:

- Developed through selection from a local collection and was recommended for commercial cultivation in U.P.
- Root is 22-25cm long, slim, white with green topped.
- It is less affected by saw fly, aphid and white rust.

Naduani:

- It is a popular variety of Himachal Pradesh and developed through selection from local material.
- Roots are long, slim, light pink with tapering to a point.

Chinese Pink:

- It has 12-15cm long pink coloured roots.
- The lower end of roots is white.
- Roots are crisp and mildly pungent.
- Roots mature in 50-55 days.

Hisar Mooli No 1:

- Developed by CCS, Haryana Agricultural University, Hisar.
- Roots are long, soft, white and straight.
- It requires 50-55 days to mature.

Jaunpuri Mooli:

- It is a local variety of Jaunpur district of Uttar Pradesh.
- Roots are much long (40-45cm), thick (7-10cm) and white.
- On an average, each root weighs 2.5-3.0 kg.

Punjab Pasand:

- Developed by Punjab Agricultural University, Ludhiana, Punjab.
- It is an early maturing variety.
- Roots are long, pure white, semi-stumped and free from hairs.
- It is suitable for sowing in main season.

Punjab Safed:

- Developed by Punjab Agricultural University, Ludhiana, Punjab.
- Roots are long (30-40 cm), thick (3-5 cm), pure white, tapering, smooth, mild in taste, medium pungent with good flavour and free from forking.

- It is a quick growing type with roots remaining edible for 10 days after attaining full size.

Punjab Ageti:

- Developed by Punjab Agricultural University, Ludhiana, Punjab.
- Roots are red skinned at the top and white at the lower half, tapering long (25.5 cm) medium thick (2.9 cm), less pungent with smooth few hairs.

SOIL

- The soil of selected field should be deep, light and friable.
- The field should be well drained.
- It can grow on slightly acidic soils (pH 5.5-6-8).

CLIMATIC REQUIREMENTS

- Radish is well suited to a cool moderate climate especially in the vegetative stage but due to its rapid growth it has a wider distribution.
- For seed production, a less humid climate is required.
- Long spell of hot dry period is not suitable for seed production.
- Temperature of 32°C can cause injury to stigma and pollen may fail to germinate.

SEED RATE

- Asiatic Varieties : 8-10 kg ha
- Temperate Varieties : 10-12 kg /ha.

SPACING

- Row-row spacing for Asiatic types is 45cm and for temperate type is 20-30cm.
- The plant to plant spacing is 6-8 cm for Asiatic type and 3.5cm for European type.

SOWING TIME

- In North India, radish can be grown throughout the year, but the main season is from August to January.
- The European varieties can be sown from September-March.
- In South India, radish can be grown throughout the year but the best period is from April to June and October to December.
- In the hills, radish is sown from March to October.

Schedule of growing radish throughout the year in the plains

Variety	Sowing time	Harvesting time
Pusa Chetki	Early April-Mid August	Early May- September

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

METHOD OF SOWING

- Seeds should be sown on flat beds or on the ridges.
- Sowing depth should be 1.5-3.0cm for semi-long types and for round cultivars, it is 1.0-1.25 cm.

NUTRIENT MANAGEMENT

- Incorporate 100-150 q/ha of well rotten Farm Yard Manure after the first ploughing.
- Apply chemical fertilizer mixture @ 80-100kg N, 40-60Kg P and 80-100kg K/ha.
- Entire quantity of FYM, phosphorus and potash and half quantity of nitrogen should be applied at the time of field preparation.
- The remaining half quantity of N is top dressed 20-30 days after transplanting.
- Potassium application increase the vitamin C content in radish

IRRIGATION

- Irrigate the crop once in 6-7 days depending upon weather conditions.
- Before sowing, soil must be moist.
- Moist condition was found to be better than wet condition.
- A light irrigation is given after sowing.
- Uniform moisture through light irrigations before harvesting facilitates easy removal/pulling of roots from the soil.
- Uneven moisture supply causes harsh, fluffy and pungent roots.

INTERCULTURAL OPERATIONS

- One weeding should be given 15-20 days after sowing.
- Thinning of plants must be carried out 15-20 days after sowing keeping a distance of 5-10cm between plants in a row.
- 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.

HARVESTING

- European varieties are harvested 25 - 30 days after sowing.
- Roots will become fluffy or pithy if kept in the field for a longer time.
- The Asiatic varieties are uprooted 40-45 days after sowing and they remain edible for longer duration compared to European varieties.
- The crop should be irrigated before the pulling out of roots as it facilitates easy uprooting of the roots.

YIELD

- The yield of Asiatic cultivars varies from 150-200 q/ha while it varies from 50-70 q/ha in case of European cultivars.

DISEASES

DISEASES

FUNGAL DISEASES

White rust: (*Albugo candida*)

- Rust like white raised pustules is formed on leaves and stems.
- Often these pustules coalesce to form large irregular erupted patches.
- Host epidermis ruptures easily giving a white powdery appearance to lesion.
- Fungus survives season to season in plant debris, in soil and also mixed with seeds.
- Moist cool (20-25°C) weather favours the disease development.

Control measures:

- Treat the seed with carbendazim @3g/Kg seed.
- Apply copper oxychloride (0.3%) for effective control.
- Obtain seed from healthy plants.

Alternaria blight: (*Alternaria brassicicola*)

- Symptoms appear on leaves, stem, pods and seeds.
- On leaves, round yellow spots are formed.
- Centre of spot dries and drop-off.
- Disease is seed borne and also survives from season to season on diseased crop material.
- Hot and moist weather conditions are conducive for development of disease.

Control measures:

- Treat the seed with thiram 75WP @3g/kg seed.
- Spray copper oxychloride @ 0.3 per cent or mancozeb @ 0.25 per cent at 8-10 days interval.

Powdery mildew:

- All plant parts are covered by white powdery growth.

Control measures:

- Before observing symptoms, spray dinocap (0.05%) or wettable sulphur (0.2%) at 10-15 days interval.

VIRAL

DISEASES

Radish mosaic:

- Characteristic symptoms of this disease are mosaic and mottling of young leaves often associated with interveinal chlorotic area which gradually increase in size.
- Finally coalesce to form irregular characteristic patches.
- Affected plants are stunted and their leaves are reduced in size.
- Disease is readily transmitted to radish by sap inoculation but not through the seeds.

Control measures:

- Disease spread can be minimized by the application of malathion @ 0.05 per cent twice or thrice at 10-15 days interval.

PESTS

PESTS

Aphids : (*Myzus persicae* , *Brevicoryne brassicae*)

- This is most important insect harming radish crop.
- Both adults and nymphs suck the sap of leaves.
- The cloudy and humid atmospheric conditions are favourable for rapid increase of aphid population.

Control measures:

- Remove and destroy affected plant parts and spray malathion (0.05%).
- Harvesting should be done 7-10 days after application of insecticides.

Flea Beetle : (*Phyllotreta* spp.)

- Flea beetle attacks leaves and makes small circular holes.
- They are active in sunny weather during spring.

Control measures:

- Remove weeds hosts, follow the phytosanitary measures and spray carbaryl (0.1%).
- Repeat spray if attack persists.

Mustard saw fly : (*Athalia promixa*)

- It sometimes causes severe damage to radish and turnip.
- Affected leaves and fruits show holes.
- It attacks crop in both flowering and vegetative phase.

Control measures:

- Follow hand picking in kitchen garden and spray malathion (0.05%) or Endosulfan (0.05%).

PHYSIOLOGICAL DISORDERS

1. Akashin

- It is a disorder of radish caused due to boron deficiency.
- Also caused due to high day and night temperature (30/20°C) as well as by low soil moisture.

Management: Spray 1-2 ppm of boron to rectify this disorder.

2. Pore extent or pithiness:

- It does much damage to the quality of the radish destroying the commercial value.
- Pores are formed by the collapse of parenchymatous cells in root tissues caused by excessive root growth in comparison with the corresponding assimilation ability of leaf tissue.
- Pore development is a sign of senescence and its degree differ among cultivars.
- Possible reasons: Delay in harvesting is the main reason to cause this disorder

Management: Harvesting should be done at appropriate time.

3. Elongated root or Forking: i.e. secondary elongating growth in the root.

Possible Reasons: Excess moisture during the root development, occurs on heavy soils due to soil compactness

Management: Use of undecomposed organic manure is recommended.

SEED PRODUCTION

For seed production, the radish varieties can be divided broadly in two groups.

A. Temperate Varieties/ European types:

- Which produce satisfactory seed in the temperate hills by over wintering.
- These varieties flower very late in plains.
- Seeds of such varieties are produced in hills only.
- Those temperate varieties viz. White Icicle, Rapid Red White Tipped, Pusa Himani, Scarlet Long and Scarlet Globe, which are very quick in root development in plains, but behave just like winter varieties both from winter and spring sowing.
- Autumn sown crop gives higher seed yield and mature earlier.

B. Tropical Varieties/ Asian types :

- Which produce seeds freely in plains. (e.g Pusa Reshmi, Pusa Chetki, Japanese White, Chinese Pink).
- The seeds of these varieties are usually produced in plains, but good quality seed of some of these varieties i.e. Japanese White can also be produced in hills.

Methods of Seed Production

- Root to seed method
- Seed to seed method

Time of Sowing

- For seed production purpose, adjust sowing time in such a way that roots must get ready by the onset of winters for receiving chilling stimulus particularly in European types.
- For hills: Autumn sowing preferably may be done in early October.
- Spring sowing can also be done in March, as soon as land is prepared.
- However autumn sowing gives higher seed yield.

Preparation of Field

- Prepare the field to fine tilth by 2-3 ploughings and 3-4 harrowing followed by levelling.

Spacing

- 45 cm X 45 cm

Nutrient Management

- In addition to root crop, apply 200-250q/ha of well rotten Farm Yard Manure at the time of preparation of land.
- At the time of final levelling, also apply 35kg nitrogen, 50kg, phosphorous and 50kg potassium per ha as basal application.
- Another dose of 35 kg /ha nitrogen is top dressed, when the roots just start growing.

Irrigation

- Irrigate the crop at 8-10 days interval depending upon weather conditions
- During early warm weather it is advisable to irrigate the crop at 4-5days interval.

Interculture

- One weeding and earthing up during the early stages of growth are necessary for proper emergence of seed stalk.

Selection of Roots

- Uproot the plant when they have attained maturity (30-70days) depending upon the variety.
- After harvesting, each root is critically examined for foliage and root characteristics namely, size, shape, colour, texture, sponginess etc.
- Roots having off type foliage or roots not conforming to varietal characteristic must be rejected.
- The diseased, malformed, forked or any other undesirable types are also rejected.

Preparation of stecklings from selected roots

- After selection, the top is cut off in such a way as to leave small underdeveloped leaves together with about 2cm of petioles of older leaves.
- It is usual practice to cut 1/3rd of lower root portion in Asiatic types but whole roots are used in European varieties.
- These are reset/replanted in well prepared fields at a spacing of 60x45cm in Asiatic and 45x45cm in European types.

Flowering and fruit setting

- Honey bees are chief pollinating agents.
- It has been demonstrated that seed yield in radish is greatly influenced by number of honeybees visiting the flowers.
- Nectar secretion, pollen formation and bee activity was influenced by environment.
- It has been proved that radishes grown for seed production should not be located too close to field of major honey producing plants such as clover because the bee tends to visit these plants in preference to radish.
- It is a cross pollinated crop due to the presence of self incompatibility especially sporophytic self-incompatibility.
- A temperature of 32°C or higher causes stigma to become dry and pollen fail to germinate.
- A period of dry weather might cause formation of underdeveloped Pods.
- Combination of cold storage and GA₃ spray (100ppm) after replanting leads to highest percentage of flowering in White Icicle, Pusa-Himani and Japanese White.

Isolation requirements

- Radish is cross pollinated by insects, chiefly honeybees.
- Seed field should not be located too close to cover crops.
- Seed field must be away from field of other radish varieties, fields of same varieties not conforming to varietal purity requirement for certification.
- At least 1600 meters for foundation seed production and 1000 meter for certified seed production should be kept.

Roguing

- Plants with off-type foliage and the direct bolters are eliminated from the field prior to flowering and crop is left to seed.
- When roots are lifted, they are critically examined for true to type, besides small sized, over sized stecklings, diseased, forked and off types should be discarded.
- Normally 3 roguing are done, mainly before maturity of roots for off types foliage, at time for replanting for verifying root characteristic such as size, shape, colour, texture etc. and last at flowering stage for early and late plants affected by designated diseases like black leg and black rot and eliminate them).

Harvesting and threshing

- The crop is cut when plants are fully matured.
- Crop is cut with sickle and brought to threshing floor for threshing.
- There is more often difficulty in threshing the seeds from pods.
- The pod does not break easily to allow the seed to escape.
- It is therefore, important to thoroughly dry them before commencing the threshing.
- Radish pod do not dehisce even after maturity.
- Threshing can be done by beating with the sticks.

- Seeds afterwards should be dried to 6 per cent moisture before storage.

Seed Yield

- Asiatic types : 9-12q/ha,
- European types : 4-5q/ha
- 1000 seed weight is about 10g.

SEED 1.

CERTIFICATION Field

STANDARDS Inspection

A. Mother root production stage

- Minimum of two inspections should be made as follows:
- Inspection should be done after 20-30 days of sowing in order to determine isolation, volunteer plants, out crosses, off types and other relevant factors.
- Second inspection is done after mother roots have been lifted to verify true characteristic of roots.

B. Seed production stage

- A minimum of one inspection is done during flowering to check isolation, off type and other relevant factors.

2. a.

Field General

Standards Requirements

Isolation

Contaminants	Minimum distance (Meters)			
	Mother root production stage		Seed production stage	
	Foundation	Certified	Foundation	Certified
Fields of other varieties of same species	5	5	1600	1000
Field of same variety not conforming to varietal purity requirements for certification and for rat tail radish (<i>Raphanus caudatus</i>)	5	5	1600	1000

b. Specific Requirements

Factors	Minimum Permitted (%) limits	
	Foundation	Certified
*Roots not conforming to the varietal Characteristics including for seed roots	0.10	0.20
**Off Types (Plants)	0.10	0.20
Plants infected by seed borne diseases	0.10	0.50

- Max permitted at second inspection at mother root production stage.
- **Max permitted after flowering and at seed production stage.
- Seed borne disease to be considered shall be **Black rot** and **Black leg**

3. Seed Standards

Factors	Standards for each class	
	Foundation	Certified
Pure seed (minimum) %	98.0	98.0

Inert matter (maximum) %	2.0	2.0
Other crop seed (maximum) Numbers/kg	5	10
Total weed seeds (maximum) Numbers/kg	10	20
Germination (minimum) %	70	70
Moisture (maximum) %	6.0	6.0
For vapour proof containers (maximum) %	5.0	5.0

CARROT

BOTANICAL NAME	<i>Daucus carota L.</i>
FAMILY	Umbelliferae
CHROMOSOME NUMBER	2n=18
ORIGIN	Europe and South-Western Asia
COMMON NAME	Gazar, Gajor

USES

- It is valued as a nutritive food mainly because of high carotene content.
- It is used as a salad, cooked and used in preparation of soups and stew etc.
- It increases the quality of urine and helps 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 preparing various types of sweets especially Gajar Halwa in northern India.
- Carrot seed oil is used for flavouring liquors and all kind of food substitutes.
- Carrot seeds are aromatic, stimulant and carminative.

NUTRITIVE VALUE (per 100 g of edible part)

Moisture (%)	82.2	Iron (mg)	0.7
Protein (g)	1.1	Sodium (mg)	35.6
Fat (g)	0.2	Potassium (mg)	108

Mineral (g)	0.6	Vitamin-A (IU)	11000
Fibre (g)	1.2	Riboflavin (mg)	0.05
Carbohydrate (g)	9.7	Nicotinic acid (mg)	0.6
Energy (kcal)	42	Vitamin-C (mg)	8
Calcium (mg)	37	Thiamine (mg)	0.06
Oxalic acid (mg)	5	Sulphur (mg)	27
Phosphorus (mg)	30	Copper (mg)	0.13

CLIMATIC REQUIREMENTS

- Carrot is widely adapted to cool climate but generally restricted to regions with low rainfall during summer and early autumn.
- A dry warm atmosphere is desirable for maturing plants that are tough and woody.
- A temperature range of 7.2 to 23.9°C is considered optimum for seed production.
- Good colour and growth of carrot roots has been observed in the temperature range of 15.6-21.1°C
- Seed production is suited to those regions which are away from coastal areas, where condition is drier for maturing seed.
- For temperate type cultivars, a chilling temperature of 4.8-10°C for 4-6 weeks is desirable as cold stimulus (vernalization) any time during the development of roots. Seed stock formation takes place only when these plants are subjected to a temperature of 12.2-21.1°C. Plants grown continuously at a temperature region range of 21.1-26.7°C fail to develop floral primordia.

AREA AND PRODUCTION

- Carrot is the most ancient vegetable grown during spring, summer and autumn in temperate countries and during winter in tropical and sub tropical climate.
- It is grown throughout India all the year round in one pocket or the other.
- The exact area in carrot is not available, however in 2008; the area under root and tuber crops (Combined) was 2.18 million hectares with an annual production of 44.6million tonnes (NHB, 2010).

SOIL

- The soils of selected fields should be light, deep and fields should be well drained with pH range from 6.6-7.1.
- Deep, loam and loamy soils are preferred for good crop.
- For early crop, a sandy loam soil is preferred, but for higher yields, silt or silt loam soils is desirable. Long, smooth and slender roots desired for fresh market are successfully grown on deep well drained light soils.

CULTIVARS

European Type or Temperate type Varieties	Asiatic or tropical type varieties
1. Produce seeds in plains.	1. Produces seeds in hills.
2. Do not require any low temperature treatment for flowering.	2. Requires chilling (4.8-10°C) for flowering, resulting in its cultivation to hills.
3. Long and red coloured roots with white or creamy core.	3. Medium and orange coloured roots with centre core.
4. Rich in lycopene.	4. Rich in carotene.
Pusa Yamdagini, Jeno, Emperor, Chantaney, Danvers, Early Nantes, Nantes, Nantes Half Long, Ooty, Solan Rachna.	Pusa Kesar, Pusa Meghali, Sel-333, No. 29, Hisar Gairic, Pusa Rudhira, Pusa Ashita.

- Many cultivars, some indigenous but mostly introduced are grown in India
- Important exotic types grown in India are Chantenay, Danvers, Nantes, Early Horn, Early Gem and Solan Rachna for their long tapering roots and excellent quality.
- Chantenay and Danvers are known for its long tapering roots and excellent quality.
- Early Horn and early Gem are famous for their earliness and for their mild flavoured roots.
- The carrot cultivars may be classified on the basis of shape of their roots or on their temperature response to flowering.

A. Classification based on shape of roots

1. Long rooted: Roots may be 25 cm or more in length, generally tapering and perform best in comparatively light soil.

2. Half long rooted: Root length does not usually exceed 20 cm.

- Roots cylindrical with straight or sloppy shoulder, e.g., Nantes
- Roots tapering with blunt or semi blunt tip, e.g. Chantenay, Emperor.

3. Short stump rooted: These cultivars are suitable for growing in heavy soils

- Heart shaped e.g. Oxheart
- Oval e.g. Early Scarlet Horn
- Round e.g., French Forcing

B. Classification based on temperature response to flowering

1. **Temperate or European or biennial types:** These cultivars are biennial in characters and require low temperature (4.8-10°C) treatments for flowering to occur. These do not produce seeds in the plains of India, e.g. Nantes, Chantenay, Imperator, Danvers, Zeno, Oot-1, Pusa Yamdagni etc.
2. **Tropical, Asiatic or Oriental or annual types:** These cultivars do not require any low temperature treatment for flowering; they seed freely in the plains of India. Examples are Pusa Kesar, Pusa Meghali, Sel. No. 29 and Sel. No. 233.

Pusa Kesar:

- This is a selection from a cross between Local Red and Nantes Half Long.
- The roots develop on narrow central core which is also sufficiently red coloured.
- It contains high amount of carotene (38mg/100g edible portion) than Local Red (26mg/100g).
- Root stay about a month longer in the field than Local Red without showing any sign of bolting.
- The percentage of forked roots is also lower than in local red.
- Pusa Kesar can tolerate high temperature than Nantes.

Nantes:

- It is an european cultivar which can be grown in plains of India for root production but not for seed production.
- The roots are half long, slim, well shaped, cylindrical with stumped and forming a small thin tail, deep orange red cortex.
- It ranks first in quality, but has a weak, brittle top which makes pulling difficult.
- This cultivar is suitable for cultivation in cooler months.

Chantenay:

- It is an excellent cultivar for canning and storage.
- Roots are 11-15cm long and 3-5cm in diameter with tapering to blunt end, deep orange cortex and core.
- Royal Chantenay and Red Cored Chantenay are another cultivars belonging to this group.

Danvers:

- This cultivar is grown for fresh market as well as for processing.
- It is mid season cultivars with large and strong foliage.
- Roots are 12.5-15 cm long, 2.8-4.5 cm in diameter with tapering to short tapering or slightly rounded end, deep orange cortex and a slightly more yellow core.

Imperator:

- It is cross between Nantes and Chantenay and is grown for fresh market.
- It is mid season to late maturity cultivar with large and strong foliage.
- Roots are 15-17.5 cm long and 2.5-4.5 cm in diameter with short tapered end, deep- orange cortex and slightly pigmented core.

Pusa Yamdagni:

- It is derived from the cross between EC 9981 x Nantes Half Long. It takes 86-130 days to produce harvestable roots, which are long and orange and have a self-coloured core. It is earlier than Nantes Half Long and yields 16-144% more than Nantes Half Long.
- Roots attractive, round, medium tops, orange coloured, medium length (18-21 cm) and soft textured.
- Gets ready in 100-108 days, average yield 225-250q/ha, rich in carotene (915.14mg/100g of edible portion).

SOWING TIME

- August-November is the optimum time of sowing for Asiatic group while for European types it is October-November.
- In higher hills, the seed sowing is done during March to July depending upon the temperature.

SEED RATE

- 5-6 kg/ha

SPACING

- 30 × 10 cm

Method of Sowing

- For better development of roots, sowing on ridges is preferred over flat sowing.
- Double row ridges 75cm apart produces large number of well developed roots than single row ridges.
- The seed takes about 8-10 days for germination.
- For uniform germination the ridges should remain moist till germination takes place.
- Hence the field should be irrigated just after sowing.
- Afterwards, when plants are 5 to 6 cm in height, thin out the plants to a distance of 6 to 7 cm.

NUTRIENT MANAGEMENT

- For getting good yield, 200-300q/ha well rotten Farm Yard Manure is thoroughly mixed in soil 15-20 days before sowing of seeds.
- Add 40-60 kg/ha N, 40-50 kg/ha P and 80-100 kg/ha of K.
- Half quantity of N and full quantity each of P and K and Farm Yard Manure should be applied at the time of sowing.
- Remaining quantity of N may be given 30-45 days after seed sowing.

IRRIGATION

- Irrigate the field just after sowing.
- Optimum level of moisture in the field is essential for better germination growth and development of roots.
- Crops should be irrigated at an interval of 5-7days depending upon rain or weather conditions.

INTERCULTURAL

Thinning

- Thinning is the most important operation during carrot cultivation as thick sowing is done because of small sized seed.
- The thinning operation is done 20-30 days after sowing to maintain 10 cm plant to plant distance

Weeding

- Weeds are a serious problem and timely control of weeds is essential to avoid heavy loss in yield of top quality roots due to weed competition.
- Timely weeding, hoeing and earthing up therefore should be done.

OPERATIONS

- Generally two weedings at 15-20 and 30-35 days after sowing are sufficient to control the weeds.
- Pre emergence application of propazine @ 1.12kg/ha or Amiben @ 2.24-4.48kg/ha or Diuron and monuron @ 1kg/ha controls weeds very effectively.

HARVESTING

- Harvesting of roots depends upon the variety.
- Hence, size of the roots can not be taken as reliable criteria to harvest the crop.
- However, in general the crop becomes ready for harvesting in 65-85 days depending upon the variety.
- Sometime delay in harvesting even make it unfit for consumption.

YIELD

- The temperate types are poor yielder and produce about 100-150q/ha whereas tropical types yield higher i.e. 250-300q/ha.

DISEASES

Fungal

Diseases

Leaf blight or *Alternaria* blight : (*Alternaria radicina* and *Alternaria dauci*)

- It is predominant in winters.
- On the foliage, small dark brown to black spots with yellow edges appear at first mostly along the leaf margin.
- The number of spots gradually increases and the interveinal tissues die.
- In moist weather the blackening and shriveling progress so rapidly that entire field resembles frost injury.
- Disease is seed borne.

Control measures:

- Crop rotation should be adopted.
- Seed treatment with captan or thiram @ 3g/kg of seed before sowing will be helpful.
- Later on spray mancozeb (0.25%) at an interval of 7-10 days.

Leaf spot or *Cercospora* blight : (*Cercospora carotae*)

- It is a wide spread disease of carrot.
- Symptoms appear first as elongated lesions along the edge of leaf segment, resulting in a lateral curling.
- In dry weather, the spots are light tan in colour whereas in humid weather the spots are darker in colour.

Control measures:

- Dipping seeds in 0.1 per cent carbendazim solution for 5 minutes is suggested.
- Crop rotation and sanitation are necessary.
- Spray with copper fungicides or Zineb@ 0.25-0.3per cent as and when the attack is noticed.

Powdery mildew : (*Erysiphe spp.*)

- It appears first on leaves, but later may spread on flowers, stem and fruits.
- Symptoms first appear as faint, slightly discoloured and tiny checkers from which white powdery spots spread to form various sized areas.

Control measures:

- Before observing symptoms, spray dinocap (0.05%) or wettable sulphur (0.2%) at 10-15 days interval.
- Sulphur dust is most effective. It is applied even after the appearance of the disease as this fungicide is both eradivative and protective.

Viral

Diseases

Carrot Yellows:

- First appear on leaves which become yellow sometimes accompanied by vein clearing.
- Dormant buds in the crown grow out into chlorotic shoots which give a 'witches broom' appearance on the tops.
- Older leaves are reddish, twisted and may eventually break off.
- The disease is transmitted by six spotted leaf hopper (*Macrostelus divisus*).

Control measures:

- Spray insecticides to control the hopper e.g. Dimethoate (0.05%) or Carbaryl (0.15%).

Root

Diseases:

Watery soft rot: (*Sclerotinia sclertiorum*)

- Infected roots become soft and watery and white mycelium with black sclerotia is formed.

Gray mold rot: (*Botrytis cinerea*)

- The affected tissue is water soaked and light brown and later become spongy.

- Gray mold appear in moist atmosphere.

Black rot: (*Alternaria radicina*)

- It is a wide spread disease.
- Foliage symptoms are just like those caused by *Alternaria* blight.
- On roots, black sunken areas irregular to circular in outline may develop.

Control measures of root diseases:

- Store roots at 0-2°C to keep storage decay at a minimum level.

Bacterial

Diseases

Bacterial soft rot : (*Erwinia carotovora* pv. *carotovora*)

- The infected tissue softens, becomes watery or slimy and as the rot progress the watery extrusion becomes more evident.
- A foul odour from decayed roots distinguishes it from the soft rot.

Control measures:

- Careful handling of roots during harvesting, grading or transit so that all bruises on root surface can be avoided.

PESTS

Carrot Rust Fly:

- Larva burrows into the roots, often causing it to become misshapen and subject to decay, leaves become rusty or dried.

Control measures:

- Mix folidol M (2%) or malathion dust (5%) @ 20-25kg/ha in the soil at the time of soil preparation.

Aphids

- These are small in size, both adults and nymphs suck sap from leaves and flowers due to which, the plant become weak and leaves curl.

Control measures:

- Spray malathion (0.05%) at 15days interval on root crop. On seed crop, spray oxydemeton methyl (0.025%).

Mustard saw fly: (*Athalia promixa*)

- Adult feed on pods and leaves which show holes.
- Seed crop is also adversely affected.

Control measures:

- Mix folidol M (2%) or malathion dust (5%) @ 20-25kg/ha in the soil at the time of soil preparation.

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.
- Increases as the amount of N in the soil increases
- Early cultivars tend to split more readily than late ones.

Correction:

- Maintain optimum moisture in the field
- Harvest the crop at right maturity stage.
- Grow resistant varieties
- Sow the seeds at close spacing
- Supply recommended dose of nitrogen

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.

Correction:

- Incorporate calcium containing fertilizers in the soil.
- Harvest the roots at optimum maturity.

3. Forking: A common disorder in carrot and radish formed by the enlargement of secondary root growth.

Possible Reasons:

- Excess moisture during the root development is the cause. It occurs on heavy soils due to soil compactness.

Correction:

- Avoid excessive moisture
- Avoid heavy soil for root production

Method of Seed Production

- Like other biennial crops root to seed and seed to seed method can be followed.
- In the seed to seed method, root rot is usually very high as compared to the replanted method.
- The whole roots with the tips cut (to examine the colour) are planted, keeping the crown exposed.

Root to seed method

First Season:

- Mother roots production

Time of Sowing

- Sowing of seed crop should be done from 15th June to 15th July depending upon duration of variety, climatic condition and areas where seed production is to be done. Generally, severe winters and mild summers with less rainfall is considered best for quality seed production.

Preparation of Field

- Prepare the field to a fine tilth by repeated ploughings and harrowing followed by levelling.

Nutrient Management

- In addition to root crop, apply 150-200q/ha of well rotten FYM at the time of preparation of land.
- At the time of final leveling, also mix entire quantity i.e. 40-50kg/ha each of P and K and nitrogen @75-100kg/ha is top dressed after weeding.

Irrigation

- It should be done at 8-10 days interval depending on the weather and crop requirement. critical stages are umble formation and seed setting.

Selection of roots for transplanting

- Uproot the plants when they have fully developed roots for making stecklings
- Selection of root is made on the basis of varietal characteristics, size of tops whether short or heavy, colour of skin, shape and size of roots etc.
- The colour of flesh, colour and size of core are most important root characters to be considered.
- The core should be of the same colour as the flesh and as small as possible.

Planting of selected roots

- In case of European cultivars, after meeting the low temperature requirement, the selected roots after their tops are clipped and the tips pruned (stecklings) are reset in a well prepared field.

Method of replanting

- The trimmed roots are reset in field at a distance of 45× 30 cm or 45× 45 cm
- The soil is then firmed, pressed and topped around the roots.
- Soon after transplanting, the field is irrigated.

Flowering and Seed Setting

- Carrot plant bear compound umbels.
- It is king umbel (primary umbel) or umbel of the first order that flower first.
- Secondary, tertiary and other orders of umbels flower at an interval of 8-12days from each-other.
- The temperate cultivars start bolting by third week of April in hills of India.
- Flowering starts by end of May.
- Bolting and flowering in tropical types occurs during early spring.
- The seed setting in late formed umbel is extremely poor.

Pollination

- Insects are the pollinating agents in carrot. Hence bees and house flies seem to be the most important pollinators.
- The carrot flower is protandrous hence it ensures cross pollination.

Isolation

- Seed field must be isolated from fields of other varieties and fields of same varieties not conforming to varietal purity. The most important requirement for certification is to maintain at least 1000m distance for foundation seed production and 800m for certified seed production.

Roguing

- Rouging should be done at three stages.
 - Early: check for off type foliage
 - Lifting and replanting: check for root characteristics like shape, size, colour, texture, sponginess, forked and cracked roots.
 - Flowering stage: check for isolation, diseased plants and weeds.

Harvesting and Threshing

- The best time of harvest is when the secondary umbels (heads) are fully ripe and tertiary heads begin to turn brown.
- Seed is commonly harvested by hand picking. 2-3 pickings are required.
- After drying heads are threshed and cleaned.
- After cleaning, the seed is rubbed by hand to remove the bristles on the surface and graded by means of sieves.
- Before storage the seed moisture content should be reduced to 8 per cent.

Seed Yield and 1000 Seed Weight

- At present, expected yield of open pollinated cultivars in the temperate region is about 500-600kg/ha.
- The 1000 grain weight is 0.8gm.

SEED CERTIFICATION STANDARDS

A. Field Inspection

Mother root production stage

- A minimum of 2 inspections should be made as follows:-
- The field should be inspected after 20-30 days of the sowing in order to determine isolation, volunteer plants, out crosses, off-types and other relevant factors.
- The 2nd inspection should be done after the mother roots have been lifted to verify the true characteristics of roots.

Seed production stage

- A minimum of 4 inspections should be made as follows:
- The first inspection should be done before flowering in order to determine isolation, volunteer plants, out crosses and other relevant factors.
- The second and third inspection should be done during flowering to check isolation, off types and other relevant factors.
- The fourth inspection should be done at maturity to verify the nature of umbels.

1. Field Standards

a. General Requirements

Isolation:

Carrot seed field should be isolated from contaminants as shown in table:

Contaminants	Minimum Distances (m)			
	Mother root production		Seed production stage	
	Foundation	Certified	Foundation	Certified
Fields of other variety	5	5	1000	800
Fields of same variety. not conforming to varietal purity requirement for certification	5	5	1000	800

b. Specific requirements

Factors	Max. Permitted (%)	
	Foundation	Certified
*Roots not conforming to varietal characteristics including forked roots	0.1	0.2
**Off types (Plants)	0.10	0.20

- *Maximum permitted at second inspection at mother root production stage.
- **Maximum permitted at after flowering and at seed production stage.

C. Seed Standards

Factors	Standard for each class	
	Foundation	Certified
Pure Seed (Minimum) %	95	95
Inert Matter (Maximum) %	5	5
Other crop (Maximum) Number/ kg	5	10
Total weed seed (Maximum) Number/	5	10

kg		
Other distinguishable var. (Maximum) Number/ kg	5	10
Germination (Minimum) %	60	60
Moisture (Maximum) %	8	8
For vapour proof containers (Maximum) %	7	7

TURNIP

BOTANICAL NAME	<i>Brassica rapa</i> Linn <i>Syn.Brassica campestris var. rapa</i>
FAMILY	Cruciferae
CHROMOSOME NUMBER	2n=20
ORIGIN	Mediterranean area of European types and Eastern Afganistan and adjoining area of Pakistan is another primary centre
COMMON NAME	Salgam, Shalgam, Shaljam

INTRODUCTION

- Turnip is quick growing root vegetable.
- It is a herbaceous biennial for seed production and an annual for use as a vegetable.
- Both roots and leaves are edible.
- Turnip produces napiform types of roots.

USES:

- It is grown for elongated roots as well as for its foliage.
- Fresh roots are consumed in salads 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 also good source of Ca, P and Fe.
- The greens are mostly fed to animals and seldom used as green vegetables.

NUTRITIVE VALUE (per 100 g of edible part)

Moisture (%)	91.6	Phosphorus (mg)	40
Protein (g)	0.5	Iron (mg)	0.4
Fat (g)	0.2	Vitamin-A Leaves (IU)	15660
Fibre (g)	0.9	Riboflavin (mg)	0.04
Carbohydrate (g) :	6.2	Vitamin-C Roots (mg)	43
Calories (kcal)	29	Leaves (mg)	180
Calcium (mg)	30	Thiamine (mg)	0.04

CLIMATE

- Turnip is a cool season crop and can tolerate frost and mild freezing temperatures.
- Hot weather and inadequate supply of water results in deterioration of root quality, roots become woody, tough and bitter in taste.
- Temperatures below 10°C induces flowering.
- The most favourable weather for the development of root is 10-13°C air-temperature and 18-23°C soil- temperature.
- High light intensity favours ascorbic acid content.

SOIL

- Soil should be deep friable, and field should be well-drained.
- Turnip is moderately tolerant to acid soils having pH 5.5 to 6.8.
- The land should be deep ploughed and harrowing should be done till good tilth.

VARIETIES

Asiatic/tropical/subtropical type	European/Temperate Type
More pungent & better for pickles, earlier & more heat tolerant	Sweeter and more palatable
Pusa Kanchan, Pusa Sweti, Punjab Safed 4	Purple Top White Globe, Golden Ball,

	Snow Ball, Early Milan Red Top, Pusa Chandrima, Pusa Swarnima.
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Turnip cultivars can be put under different groups on the basis of morphological characters of their root and top.

1. White Fleshed

a) Purple-topped

- **Flat type:** Purple Top Milan
- **Globe type:** Purple Top White Globe

b) Green topped

- **Globe type:** Green Top White, Green Globe
- **Long type:** Cowhorn

c) White topped

- **Flat type:** White Milan, White Flat Dutch
- **Globe type:** White Stone, Quick Silver
- **Half long type:** White Egg, White Gem
- **Long type:** Lily White

2. Yellow Fleshed

- **Purple-topped globe-type:** Aberdeen Purple Top
- **Bronze or green-topped, globe type:** Aberdeen Green Top, Amber Globe
- **Yellow-topped, globe type:** Yellow Globe, Golden Ball, All Seasons

3. Foliage Cultivars

- Flat Japan, Shogoin, Seven Top

Turnip varieties can be put into two distant groups viz.

Temperate Type (European Type):

- They are biennial because they require two seasons for seed production.
- They produce seed only in the hills of India.
- They are quick growing, early and low yielding but excellent in quality.
- They require temperate climate for seed production.
- Purple Top White Globe (PTWG), Snow ball, Golden ball, Pusa swarnima, Pusa chandrima, Early Milan Ted Top and Early White Milan are some important varieties.

Tropical Type (Asian Type):

- They are high yielding but poor in quality.
- They are slow growing and remain edible for a long period.
- They can produce seed both in temperate and sub tropical climate but it is not economical to produce their seeds in hills due to slow growing nature in the temperate climate and thus require more time, land occupation period and labour.
- Pusa Kanchan (A cross between European and Desi type), Pusa swati and Punjab Safed are some of the cultivars.

A few important cultivars grown under both the types i.e. temperate and tropical are given below:

European or Temperate Types:
Purple Top White Globe:

- It is large rooted and heavy yielding variety developed at IARI.
- Roots nearly round, large, smooth, skin purplish red on upper portion which extends above soil surface, lower portion creamy coloured.
- Flesh white, firm and crisp.
- Best for dehydration, matures in 60-65days after sowing.
- Average yield 250-300q/ha.

Golden Ball:

- It was bred at IARI Regional Station, Katrain, Kullu Valley, HP.
- It gives globe shaped, smooth, yellow roots with sweet and yellow flesh.
- Yield varies between 200-250q/ha.

Snow Ball:

- It is an early variety.
- Roots are medium sized, round, smooth and white.
- Flesh is white, fine grained, and tender with sweet taste.

Early Milan Red Top:

- It is an extra early maturing variety and ready for harvesting within 45 days after sowing.
- Very high yielding variety with deep flat roots having purplish red tops and white underneath.
- It has pure white, crisp and mildly pungent flesh.

Pusa Swarnima:

- This variety has been developed at IARI Regional Station, Katrain by hybridization between Japanese White (Asiatic type) x Golden Ball (European type).
- Roots are flattish round, 6-7cm in length and 7-8 cm in diameter, light creamy, yellow skin with pale amber colour flesh, fine texture and flavour.

- The seeds are sown directly in the main field.
- When the plants are 10-15 days old, thinning is done to keep them at 10-15 cm in rows.
- Sowing is also done in ridges by opening shallow furrows.
- In normal cases, seeds germinate after 4-6 days of sowing.

NUTRIENT MANAGEMENT

- Apply FYM @ 150-200quintals/hectare during field preparation.
- Besides this apply 60-80kg N, 40-50kg of both P and K.
- Half N, and full quantity of P and k should be applied at the time of field preparation and the remaining N should be top dressed along with earthing up at the time of root initiation.

IRRIGATION

- There should be adequate moisture in soil at the time of sowing.
- Usually rainy season crop does not require any irrigation except during long dry spells.
- On the other hand, summer season crop requires irrigation at 5-6 days interval.
- Light irrigation should be given before harvesting to facilitate lifting

EARTHING UP

- Earthing up is usually done 20-25days after sowing to provide good condition for root development.
- Earthing up and top dressing of Nitrogen is done simultaneously at the time of root initiation.

HARVESTING

- Early varieties become ready for harvesting in 60-80 days after sowing whereas late varieties take 90-120 days.
- Fully developed roots are harvested either by pulling the roots or lifting the roots with the help of khurpi or shovel.
- Timely harvesting is quite important for quality roots.
- Harvesting roots of 5-7.5 cm diameter would be ideal and larger roots are often coarse in texture and bitter in taste.
- The roots are cleaned, tops are cut and roots are graded according to size.

YIELD

- The yield of turnip varies from 200-300q/ha depending upon the variety, climate, type of soil and management practices.

POST HARVEST HANDLING

- Keeping quality of turnip is very poor.
- Roots may be washed to improve the appearance, quality and reduce the decay.
- Dipping the roots in hot paraffin will help reduce shrinkage and improve the appearance.

DISEASES & PESTS

Powdery Mildew: (*Erysiphe cruciferarum*)

- Affected plants show powdery patches of varying size on leaves.
- Dry atmosphere is favourable for development of this disease.

Control measures:

- Irrigate the crop regularly.
- Remove leaves as soon as disease appears and destroy them.
- Before observing symptoms, spray dinocap (0.05%) or wettable sulphur (0.2%) at 10-15 days interval.

Downy Mildew: (*Peronospora parasitica*)

- Affected leaves show grayish white patches on under surface of leaves.
- Leaves turn yellow and later die.

Control measures:

- Remove affected leaves and destroy them.
- Spray Zineb @ 0.2 per cent.

Soft Rot: (*Erwinia carotovora*)

- Affected roots become soft from inside while outer skin remains hard and firm.

Control measures:

- Uproot affected plants along with roots and destroy.

Dry Rot:

- Affected roots show drying symptoms, and brown, sunken canker like areas develop on the roots.

Control measures:

- Avoid the attack of slugs and snails.
- These cause wounds on turnip which facilitate bacterial entry.
- Affected plants can be uprooted and destroyed.

Turnip Yellow Mosaic Virus:

- Affected plants do not grow properly, root development slows down and the quality deteriorates.
- The disease is transmitted by flea beetle.

Control measures:

- Remove affected plants, control flea beetle population and remove cabbage plants as they serve as collateral host of mosaic virus.

PESTS

Flea Beetle: (*Phyllotreta* sp.)

- They make small holes in the leaves. Besides, they transmit Turnip Yellow Mosaic Virus.

Control measures:

- Hoeing may reduce population of this pest.
- Also spray carbaryl (0.1%) as soon as the attack is noticed.

Wire Worms:

- They bore roots and make tunnels.

Control measures:

- Regular cultivation will reduce the incidence.

Mustard Saw Fly: (*Athalia promixa*)

- It feeds on leaves and pods, and damages the seed.
- The affected leaves and fruits show holes.

Control measures:

- Mix follidol M (2%) or malathion dust (5%) @ 20-25 kg/ha in the soil at the time of soil preparation.
- Spray malathion (0.05%) or dichlorvos (0.04%) as soon as the attack is noticed.

PHYSIOLOGICAL DISORDERS

Brown Heart

- It is caused due to the deficiency of boron.
- The disorder is prevalent in very acidic soil where boron is deficient.
- The symptoms are characterized by the appearance of grey or brown colour in the inner portion of the affected roots.
- The roots become unfit for consumption.

Correction:

- Avoid the sowing in too acidic soils.
- Maintain adequate soil moisture to prevent drought condition.
- Incorporate borax @10-15kg /ha in the soil before sowing
- Spray the crop with boric acid (0.2%), 2-3 times at vegetative stage.

SEED PRODUCTION

- Turnip bears hermaphrodite flowers even though it is highly cross-pollinated crop.

- Honey bees are main pollinators.
- Therefore, maintain 1600m and 1000m isolation distance for foundation and certified seeds, respectively between two different varieties and between the crops like rape, mustard, chinese cabbage and rutabaga.
- Raise seed crop either by seed to seed method or root to seed method.
- Seed crop is sown at wider distance of 45 cm apart on ridges.
- Sow seeds in the month of August to September.
- Apply 100 quintal of Farm Yard Manure during field preparation, 40kg of P at the time of transplanting the roots and 25kg of K before flowering per hectare.
- Application of 25kg of N in pre-bolting stage is beneficial.
- In the month of November, roots are uprooted, selected and foliage as well as top of roots are clipped (preferably 2/3rd tops and 1/2 of the roots) and are replanted at a distance of 45 x 45cm.
- Light irrigation is done just after replanting of roots.
- Rogue out all off-types and diseased plants.
- First roguing is done 20-30days after sowing, second when roots are lifted and replanted and third during flowering and pod formation stage.
- In higher hills, roots are uprooted by the end of October and replanting is done in the month of March-April. Initiation of seed stalks and flowering starts by the end of April depending upon variety, time of planting, area where seed production is being done.
- Harvesting is done in May end depending on the altitude of the seed production site preferably when 60-70per cent pods turn yellow brown.
- Delay in harvesting results in shattering of seeds.
- Harvesting, threshing and curing operations are like other cole crops.
- Thresh and winnow seeds and dry in sun and store in cloth bags under cool, dry and well-ventilated place.
- Turnip seeds remain viable for about 3-4 years under good storage conditions.

Seed Yield:

- 600-800kg/ha depending upon environmental factors and the varieties used.

SEED CERTIFICATION STANDARDS

A. Fields Standards

a. General requirements

Isolation

Seed fields should be isolated from the contaminants as shown in the table given below:

Contaminants	Minimum distance (meter)	
	Foundation	Certified
Fields of the other varieties	1600	1000
Fields of the same variety not conforming to varietal purity	1600	1000

b. Specific Requirements

Factor	Maximum permitted (per cent)	
	Foundation	Certified
Off-type	0.10	0.20
Other crop plants	--	--
Objectionable weed plants	--	--
Diseased plants	0.1	0.50

B. Seed Standards

Factor	Standards for each class	
	Foundation	Certified
Pure seed (minimum) %	98.0	98.0
Inert matter (maximum) %	2.0	2.0
Other crop seeds (maximum) Number/ kg	0.05	0.10
Total weed seeds (maximum) Number/ kg	0.10	0.20
Objectionable weed seeds (maximum) Number/ kg	--	--
Germination (minimum) %	70	70
Moisture (maximum) %	6.0	8.0

BEET ROOT

AIM: Beet root or garden beet or table beet is an important home and market garden crop of India grown during winter season for its fleshy enlarged roots. It can be eaten raw as salad, cooked with other vegetables and with meat and is also grown for processing. Beet root is rich in minerals and vitamin-C. The garden beet, sugar beet, swiss chard, mangel and palak, all belong to the same genus and species *Beta vulgaris*. The present chapter will make the students familiar with its importance, production technology, seed production practices and plant protection measures.

BOTANICAL NAME	Beta vulgaris L
COMMON NAME	Chukander
CHROMOSOME NUMBER	2n=18
FAMILY	Chenopodiaceae
ORIGIN	Mediterranean region

USES

- Beet root (Chukandar) is not so popular vegetable crop in India.
- Its root contain high percentage of sugar. It is also rich in protein, Ca, P, Fe & vitamin C.
- It is mainly used as salad in five star hotels in India, and also cooked as vegetable preferably mixed with other vegetables.
- Beet root is also suitable for pickling.
- Beet root is short stem plant, the simple leaves bear close spiral arrangement of leaves at the crown.
- Large sized beets are used for canning.
- The colour of the leaves may vary from dark red to light green.

PIGMENTATION

- Red colour of table beets is due to *betacyclin*, a nitrogen containing compound, with chemical properties similar to anthocynins. Also contains a yellow pigment betaranthin.

AREA AND PRODUCTION

- Though, the exact area in beet root is not available, however in 2008, the area under root and tuber crops (combined) was 2.18 million hectares with an annual production of 44.6million tones (NHB, 2010).

NUTRITIVE VALUE (per 100 g of edible portion)

Moisture (%)	87.7	P (mg)	55
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Protein (g)	1.7	Fe (mg)	1
Carbohydrate (g)	8.8	Vitamin-C (mg)	10
Fats (g)	0.1	Thiamine (mg)	0.04
Energy (kcal)	43	Riboflavin (mg)	0.09
Fat (g)	0.1	Energy(Kcal)	43

CLIMATIC REQUIREMENTS

- It is essentially a cool weather crops, hence it grows best in winters in plains of India.
- It is rich in sugar and intense red in colour.
- High sugar content is accumulated under cool weather.
- High temperature for root growth result in poor colour development of the root.
- The optimum temperature for root growth is 18-21°C obtained always in cool climate and at a temperature below 10°C for couple of week's results in bolting which affects root development.
- Mild climatic conditions are suitable for beet growing under warmer conditions.
- Beet root shows alternate white and coloured circles when sliced.
- Excessive hot weather causes 'zoning' – the appearance of alternating light and dark red concentric circles in the rot.
- It is a direct sown crop and can be harvested in 120-130days, whereas, transplanted crop comes to harvest in 135 to 150days.

SOIL

- Soil should be rich in organic matter.
- Preparation of land should be done by ploughing deeply and harrowing till it becomes well pulverized and finally prepared seed bed retains adequate soil moisture which induces early germination and provides favourable conditions for root development.
- Beet root is sensitive to high acidity as it is slightly tolerant to acidity (pH as low as 6.0 only).
- This is only vegetable which can successfully be grown in saline and alkaline soils up to 9 to 10 pH.

VARITIES

VARIETIES

Beet cultivars are usually classified on the basis of shape of roots.

1. Flat: Flat-Egyptean

2. Short-top shape: Flattened at top and bottom with rounded sides and conical or tapered base, e.g. Crosby Egyptian, Early Wonder, Asgrow Wonder
3. Round or globular: Roots are round or globular in shape, e.g. Detroit dark Red, Crimson Globe.
4. Half-long: Length is short than long types, e.g. Half-Long Blood, Winter Keeper.
5. Long: Roots are long, may grow as much as 40 cm, quite popular in Europe, e.g., Long Dark Blood.

**Characters of some of the varieties are explained as under:
Crimson Globe:**

- Top of this variety is medium to small.
- Leaves are large, bright green with coppery shade, prominent venation and younger red veins.
- Roots are round to flat round and medium red, small shoulders, dark crimson red with indistinct zones.
- It is non corrosive in taste when taken raw.
- It gets ready for harvesting in 80-90 days after maturity.

Crosby Egyptian:

- Roots are flat globes with a small tap root and a smooth exterior.
- The internal colour is dark purplish red with some indistinct zoning.
- The top is medium tall green with red veins.
- It reaches edible maturity in 55-60days after sowing and shows pronounced white zoning, when grown in warm weather.

Detroit Dark Red:

- Top is small with dark green glossy foliage having maroon tinge.
- Prominent venation of maroon colour is found in this variety.
- Mid rib is thin from dorsal side but looks broad because of spreading maroon shade to its nearby areas.
- Older leaves are prominently maroon shaded.
- Roots are smooth, uniform, and attractive with small collar and perfectly round with deep red skin.
- Flesh is very dark, blood red with light zoning, tender, round, fine grains and corrosive in taste when taken raw.
- It is a heavy yielding cultivar maturing in 80-100days.

Early Wonder:

- The roots are flattened globe with rounded shoulders and skin is smooth and dark red
- The interior is dark red with lighter red zoning.
- The top is heavy, green with red veins.

- It takes about 55-60 days after sowing to reach edible maturity.

Ooty-1:

- It is a selection from the local type and released from TNAU, Coimbatore in 1992.
- It can grow up to 40 to 52cm in height.
- The roots are blood red in colour with thin skin and good quality.
- It contains 1.52 per cent protein, 10.25per cent carbohydrate and 6mg/100g vitamin C.
- It can be used as a salad.
- It yields on an average 310-450q/ha of roots.
- It can be grown throughout South Indian hills.

SOWING

TIME

Plains

Northern plains	:	September	–	November.
Southern plains	:	July	–	November.

Hills

March- July.

- The seed is sown in raised beds or furrows and before sowing seeds are soaked in water over night for better germination.

SEED RATE

- It requires about 8-10 kg of seed for cultivation in one hectare.

SPACING

- 30-45 x 8-10 cm at a depth of 2-3 cm on ridges

NUTRIENT MANAGEMENT

- For getting good yield, 200-250 quintals of well rotten farmyard manure should be applied during field preparation.
- Besides, 200-250q Farm Yard Manure, 60-70 kg nitrogen, 100-20kg phosphorus and 60-70kg potash per hectare should also be applied.
- Application of half to two third of total nitrogen along with whole quantity each of Farm Yard Manure, phosphorous and potash is given as basal dose.
- The remaining half-to-one third quantity of nitrogen is applied after three to four weeks of sowing.
- Further, light sandy soils require more nitrogen and potassium.

IRRIGATION

- Irrigate the field immediately after seed sowing. Light but regular irrigations should be given to maintain the optimum level of moisture in the field for better germination.
- The crop requires 300 mm of water which should be supplied through 4-6 irrigations.
- Stagnation of water is harmful.

INTERCULTURAL OPERATIONS

- Earthing up is essential to cover the exposed root.
- One or two hoeings should be done.
- Pre-emergence application of pyrazone at 1.5-2.0 kg a.i. /ha or Pendimethan at 1.0 kg a.i. /ha is recommended for effective weed control.

THINNING

- The seed of beet root is multigerm which produce 3-4 seedlings per seed ball.
- Hence, thinning is an important operation. Remove extra seedlings leaving a single robust plant per seed ball.
- The thinning should be done n the seedlings attain 3-4 leaves.
- Also remove weak, diseased and insect attacked plants to maintain the distance of 8-10cmbween the plants in a row.

HARVESTING

- The crop is ready for harvesting in 55-70 days after sowing.
- Harvest the roots when they attain the size of 3-5 cm in diameter.

YIELD

- 250-300q/ha

DISEASES & PESTS

Damping off: (*Pythium spp. and Rhizoctonia solani*)

- Affected seedlings collapse at the ground level and die.
- Affected roots are usually discoloured and often become reddish brown.
- Excessive moisture is favourable for damping off disease.

Control measures:

- Provide good drainage, treat the seed with cerasan (2g/kg seed), avoid overcrowding of the seedlings, thin out seedlings which are large enough to handle and remove all affected seedlings and destroy them.

Sclerotium root rot: (*Sclerotium rolfsii*)

- Affected leaves become yellow and wilt.
- The roots start to decay.
- Presence of strands of fungal mycelium and brown sclerotia on the decaying roots is often seen.

Control measures:

- Collect the crop residue and destroy it.
- Uproot the affected plants and destroy them.
- Drench the plants with carbendazim (0.1%) around the roots.

Downy mildew: (*Peronospora schachtii*)

- It may occur at any stage of growth.
- All above ground parts may be affected.
- On the leaves, spots of different sizes up to 4 cm in diameter appear.
- The affected portions become light green on the upper surface, while on the under surface the mildew (fungal growth) is noticed.
- The infected leaves may become small and thicker than normal, and are often curled downward at the edges.

Control measures:

- Control measures include field sanitation, crop rotation, use of resistant cultivars and seed treatment with fungicides.
- Spray with 0.3 percent Zineb thrice at an interval of 15 days is also an effective control measure.

BACTERIAL

DISEASES

Bacterial blight: (*Pseudomonas syringae* pv. *aptata*)

- Leaves show circular to irregular leaf spots, which have a tan center with a dark margin.
- Disease also shows symptoms on leaf edges.
- These spots later coalesce causing the leaves to have a ragged appearance.

Control measures:

- Follow proper sanitation and crop rotation.

VIRAL

DISEASES

Beet yellowing virus:

- It is sometimes serious.

- It is a viral disease and transmitted by aphids.
- Conspicuous mottling with chlorotic zonate ring spots are common symptoms.
- These may become necrotic with age.
- Virus infected plants remain stunted and may lose some leaves.

Control measures:

- Follow proper crop rotation and sanitation practices.
- Isolate the healthy plants which may act as secondary hosts.
- Control the insects and destruction of infected plants also prevent the spread of the disease.

PESTS

Beet leaf miner: (*Pegomyia sp.*)

- It makes tunnels inside the leaves.
- The larva feeds on the tissues between the upper and the lower layer of leaf, thus causing serious injury to the leaves making it unfit for manufacture of food, consequently the plant growth is checked.

Control measures:

- Destroy all fallen leaves and other plants refuse after harvesting of roots.
- Spray systemic insecticides like oxy-demeton methyl (0.025%) on underside of leaves.

Beet web worm: (*Hymenia sp., Loxostege sp.*)

- The caterpillar sometimes causes very serious damage.
- The adults lay eggs on the leaves and the larvae attack the foliage, either by spinning small webs among the tender leaves or feeding on the underside, protected by small webs.

Control measures:

- Manage the insect by spraying malathion (0.05%).

Physiological

Heart rot or Crown rot

Disorders:

- The disorder is caused by boron deficiency.
- The leaves die in the crown which is covered with small deformed leaves.
- The older leaves wilt and become necrotic.
- The entire crown becomes necrotic and starts to decay.
- The inner portion of affected roots turns black and become unfit for consumption.

Correction:

- Soil application of borax (10-15 kg/ha) or foliar spray of boric acid (0.2%), 2-3 times at vegetative stage can check it.
- Avoid the sowing of beet in acidic soils.
- Avoid drought conditions by supplying reduced irrigation.

Speckled yellows

- It is due to the deficiency of manganese.
- The leaves of the affected plants show yellowish-green chlorotic mottled areas which become necrotic resulting into breaking of lamina.
- The leaf margins roll upward and turn into an arrow-shaped outline which remains upright.

Correction:

- Apply manganese sulphate @ 5-10 kg/ha or foliar spray of manganese sulphate (0.2%) 2 to 3 times
- Avoid planting on very sandy and alkaline soils.

SEED

Methods of Seed Production

- Both seed to seed and root to seed methods can be employed for raising seeds of beet root.
- However, the usual method of production of beet seed is by root to seed method.

Root to seed method First season

- Raising of roots- as discussed for table crop

Time of Sowing

- Unlike other crops, garden beet does not have any tropical type. Hence their seeds can only be produced in the hills of India.
- Like carrot, beet requires exposure to low temperature of 4.4 -7.7°C for 6-8 weeks for initiation of flower stalks.
- In hills, the best time is from mid July to the end of July.
- Late varieties can be sown from last week of June to mid July.

Roguing

- Before uprooting, the standing crop is examined for foliage according to varietal characteristics in the field.

PRODUCTION

- All plants showing differences in leaf colours are discarded.
- In variety ‘Crimson Globe’, the leaf character is marked by maroon shade over dark green background.
- The plants having light background of light green foliage exhibit corresponding light colour of skin as well as of flesh with distinct zoning in certain cases.
- In variety “Detroit Dark Red” the leaves are dark purple coloured.

Harvesting of Roots for Transplanting

- After harvesting, each steckling is critically examined for foliage and root characteristics namely size, shape, colour, texture, sponginess etc.
- For examining the interior, cut their 1/4th foliage and 1/3rd root portion.
- Steckling having off type foliage or roots not conforming to varietal characteristics must be rejected.
- The diseased, malformed, forked or any other undesirable types are also rejected.

Second

Season

Preparation of selected roots for transplanting

- After selection of tap root, the tops of the roots are trimmed taking care not to injure the crown and replanted in a well prepared field.
- Planting of whole roots is advantageous.

Method of Transplanting

- The trimmed roots as described earlier are reset in the field at a distance of 60 x 60 cm or 60 x 45 cm.
- The soil is then firmed and tapped around the roots.
- Soon after replanting, the field is irrigated.

Manures and Fertilizers

- Apply 100-150 quintals/ha of well rotten FYM at time of preparation of land.
- At the time of final levelling, mix in the soil 50kg each of nitrogen and phosphorus and 100kg Potash per hectare as basal application and 50kg Nitrogen per hectare as top dressing during hoeing and earthing up stages.

Irrigation

- First irrigation is given just after replanting. Irrigate the crop at 8-10 days intervals depending on the weather conditions.

Roguing

- Seed stalk elongation in beet starts early in April, the first flower opens in May only.

- The crop is in full bloom from mid May to mid June.
- One roguing during this period should be done to remove early bolters, off type plants and diseased plants.

Flowering

- The inflorescence, which normally develops in second year, is botanically a large spike.
- The flowers are almost sessile; these arise in clusters of 3-4 in axils of bracts of the inflorescence axis and its secondary branches.
- The flowers are small inconspicuous without corolla, but with green calyx which become thicker towards base as the fruit ripens.
- Fruits are aggregate formed by the cohesion of two or more fruits and held together by swollen perianth (calyx) base and thus forming an irregular dry cork-like body, known as seed ball or so called seed, if there is a single flower, a single germ seed will develop.

Pollination

- Beet root is highly cross pollinated crop.
- Flower produce abundant small and light pollen grains which are carried by wind leading to wind pollination.
- The whole face of flower bud development takes 35 days to become in bloom, there are 6 development stages through which bud passes before it opens into a flowers.
- Anthesis takes place between 7 am to 5 pm with peak period between 11am to 1pm. The flower opens mostly during mid-day.
- In the individual flowers, anthesis is completed within two hours and hastened by high temperature and low humidity.
- Another dehiscence takes place between 8.30 am to 6.30 pm with peak period between 12.30 pm to 2.30 pm depending upon the temperature and humidity.

Isolation

- Seed fields must be isolated from fields of other varieties and fields of same variety not conforming to varietal purity requirement of seed certification by five meters at mother root production stage and by 3000 meters for foundation seed production and 1000 meters for certified seed production.

Inspections

i) Mother root production stage

- A minimum of two inspection shall be made as follows:
- The first inspection should be done after 20-30days of sowing in order to determine isolation, off types and other relevant factors.
- The second inspection should be done after the roots have been lifted to verify the true characteristics of roots

ii) Seed production stage

- A minimum of two inspection shall be made as follows:
- The first inspection should be done at pre-uprooting stage.
- Other two inspections should be done one at uprooting and replanting stage and the final at pre-flowering stage in order to determine isolation and other relevant factors.

Seed Yield

- Seed yield is 800-1000 kg/ha.
 - **SEED CERTIFICATION STANDARDS**
- **SEED CERTIFICATION STANDARDS**
- **A. Fields Standards**
 - General requirements**
 - Isolation**
- Seed fields should be isolated from the contaminants as shown in the table given below:

Contaminants	Minimum Distance (meters)			
	Mother Root production stage		Seed production stage	
	Foundation	Certified	Foundation	Certified
Fields of other varieties	5	5	3000	1000
Fields of the same variety not conforming to varietal purity requirements for certification and fields of the Swiss chard and Spanish beet	5	5	3000	1000
Fields of garden beet, sugar beet etc.	5	5	3000	1000

- **b. Specific Requirements**

Factor	Maximum permitted
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	(per cent)	
	Foundation	Certified
*Roots of other varieties not conforming to Varietal Characteristics	0.10	0.20
** Off types	0.10	0.20
Objectionable weed plants	--	--
Diseased plants	0.1	0.50

- * Maximum permitted a second inspection at mother root production stage.
- ** Maximum permitted at and after flowering at second production stage.
- **B. Seed Standards**
-

Factor	Standards for each class	
	Foundation	Certified
Pure seed (minimum) %	96	96
Inert matter (maximum) %	4	4
Other crop seeds (maximum) Number/ kg	5	10
Weed seeds (maximum) Number/ kg	5	10
Germination (minimum) %	60	60
Moisture (maximum) %	9	9
For vapour proof containers (maximum)%	8	8

RHUBARB

BOTANICAL FAMILY

NAME:

Rheum

rhaponticum
Polygonaceae

ORIGIN : Temperate Asia, probably Siberia

AREA AND PRODUCTION

- Rhubarb is a native of the cooler areas of Asia, probably Siberia but it is grown in Europe and England for its large, thick leafstalks or petioles which are used for sauces.
- Most commonly, the plant's stalks are cooked and used in pies and other foods for their tart flavour.

- It is used in the diet in place of fruits.
- It was introduced into Europe in 1608 and was first grown in Italy.
- The first mention of its use in America was in 1778, but by 1806 it was in common use.

NUTRITIVE VALUE (per 100 gram of edible portion)

CHO (g)	3.80	Vitamin A (IU)	100
Ca (mg)	130	Moisture (%)	93.30
Vitamin B ₂ (mg)	0.04	P (mg)	21
Protein (g)	0.74	Fibre (g)	0.75
Fat (g)	0.13	k (mg)	360
Niacin (mg)	0.3	Mg(mg)	21
Na(mg)	6	Ash(g)	1.10

CLIMATE

- The vegetative parts of the plant are killed at temperature less than 3°C.
- The rhubarb crowns and rhizomes are resistant to cold and dry conditions.
- The plant thrives in the regions where the crowns remains frozen all winters and where the soil remains dry throughout the summers.
- The plant requires temperatures below 10°C to break dormancy.
- At relatively low temperatures, for growth, the stalks develop the pink colour, while at high temperatures the green colour predominates.
- Rhubarb does not grow well in regions, where the mean temperature during summer is 24°C, or the winter mean temperature is much above 4.4°C.

VARIETIES

- Rhubarb can be grown as an outdoor plant and as a forcing plant.
- Cultivars of rhubarb may also be chosen according to the color of their petioles.
- For outdoor production, the cultivar Mac Donald, Sunrise and Ruby have large red stalks.
- They are vigorous and upright growing.
- Valentine is another red stalked cultivar that is popular for growing in home gardens.
- For forcing, Timperley, Early Victoria, Crimson Red and Sutton are used.
- Victoria a green stalked cultivar, a heavy yielder and excellent for commercial purposes.
- Sutton is a pink- stalked cultivar.

PLANTING

- Rhubarb is usually propagated by dividing the crowns formed during the previous season.
- Crowns are divided in late fall or early spring.
- Plants must be divided and reset every 4 years to keep the bed in vigorous condition.
- Plants not divided may become large and stalks may become more numerous than desired.
- Seed stalks should be removed as they appear.
- Seed propagation is used in the development of new varieties
- The crowns are planted during the spring where the freezing temperatures are common.
- The crowns are planted in autumn where the temperature is not freezing.
- Good drainage is essential for growing rhubarb.

SPACING

- Row to row : 120-180 cm
- Plant to Plant : 60-120 cm
- Commonly used spacing for commercial rhubarb planting in rows 120 cm apart with plants 120 cm apart in row.
- Trenches are dug prior to planting, generally 15 cm deep.
- Crown pieces are placed 5 cm below the surface of the soil in the trench. Soil is pulled over the soil and firmed.

NUTRIENT MANAGEMENT

- Rhubarb grows best in soils with a pH range of 6 to 6.8.
- The crop has a high demand for calcium and magnesium.

- Rhubarb is a heavy feeder, therefore will perform best on sandy loam to loam soil with a good organic matter level and better drainage
- To achieve early field production, plantings need to be made on light soils with a southerly exposure.
- Well rotten Farm Yard Manure @ 500q/ha should be applied before ploughing specially in the soil with low organic matter.
- A green manure crop is desirable to be incorporated one year before planting Rhubarb.
- About 100-150Kg each of N, P and K should also be applied for good results.
- The nitrogen should be applied in the form of 2-3 applications with the first application at bud break stage.
- Try to avoid putting nitrogen fertilizer too close to the roots as it can burn the small feeder roots.
- Phosphorus is not very mobile, so select a planting site that is high in phosphorus.
- If additional phosphorus is required it can be broadcasted with nitrogen and potassium early in the spring and mixed into the soil with a light cultivation between the rows.

Lime:

- It should be applied to maintain the soil pH in the range 6.0 to 6.8 (rhubarb will tolerate soil acidity as low as 5.0 but yields and fertilizer efficiency will suffer).

Micronutrients:

- Boron may be necessary for the health of buds and roots. Apply 1 to 2 kg Borax per hectare as soil application.

USE OF GROWTH REGULATORS

- Gibberellic acid is useful in rhubarb forcing to break dormancy and to permit early production and to increase yields.

IRRIGATION

- The rhubarb plant responds well to moisture, although reliable yields can be obtained with minimal watering.
- Irrigation prior to harvesting is necessary to increase crop yield
- Delay irrigation after harvest until plant injuries have healed.

WEED MANAGEMENT

- Various types of mulch may be used between the plants and in the rows (most commonly straw).
- Weeds can be controlled by frequent shallow cultivation before sprouting.
- Grass weeds can be controlled with glyphosate or round-up@ 2-3kg a.i./ha, or with Gramoxone or Paraquat @2.25-3.75 l/ha.

1. MULCHING

- Straw may be applied in late fall or during the winter as a mulch to keep down weeds and ensure a cleaner harvest environment from soil.

CULTURE

AND

CARE

First Growing Season:

- Plant only in fields that are as clean as possible from perennial weeds.
- Cultivation should be shallow throughout the growing season.
- Hand hoeing should be preferred and contact herbicides like Gramoxone may be sprayed between the rows with the crop shielded.
- Flower stalks should be cut off as soon as they appear.
- One or two side dressings of nitrogen may be necessary.
- No crop should be harvested during the first season.
- In the fall, well rotted manure and/or straw should be applied to the soil surface.

Following years:

- Cultivate occasionally to keep weeds in check but be careful not to cultivate too deep or close to the crown and fleshy roots.

HARVESTING

- Harvesting is not done during first year of growth.
- Leaves of field-grown plants are usually serially harvested, a few at a time over a number of weeks with new growth replacing those from base of crown.
- Petioles are not removed by cutting to avoid the virus spread.
- Red varieties tend to yield about half that of the green varieties.

- Field yields can vary depending on the age and vigour of the stand and can range between 150-400q/ha in a single cutting harvest season.
- Harvest begins in late May or early June depending on location and can last for 8 to 10 weeks. Rhubarb is harvested by hand.
- The stalks are pulled rather than cut.
- The leaves are removed in the field and only the stalks are marketed.
- Harvesting in the same year following planting is possible but has been found to reduce productivity in the long run.
- Second year harvests are preferred.
- A healthy stand should remain productive for 5-10 years.

GRADING, PACKING AND STORAGE

- The harvested stalks are washed and tied in bundles of 0.5kg or more and they are packed in boxes lined with paper for shipping.
- Grading should be done according to the length of stalk, colour and quality.
- It can be graded as I and II grade.

STORAGE

- Harvested stalks remain in good condition for about 4 weeks when stored at 1 to 2°C and 92% Relative Humidity.
- The storage life can further be extended by wrapping in moisture proof film and storing at 0°C and 90% Relative Humidity.
- Hot water treatment for 2 minutes at 52°C doubles shelf life at 21°C.

FORCING

- Production of rhubarb stalks during the winter is called “forcing of rhubarb” in regions where the climate is suitable for production of vigorous crowns.
- The roots of three-year-old plants dug out late in the fall are left outside for two weeks till they are frozen thoroughly to allow the buds to be in rest period.
- A thin layer of soil is spread to prevent evaporation of moisture.
- These frozen roots are then replanted in the field.
- These frozen roots are then taken in to hot beds in specially constructed forcing structure or in any dark or semi dark locations where moderate temperatures can be maintained.
- Windows should be covered to exclude light.
- Now the buds are allowed to sprout. Under dark/semi dark conditions, the stems develop a rich pink or red colour and good quality.
- The optimum temperature for proper development of stalks is 15.6°C and the growth is very poor at 10°C.
- The crowns are placed on the floor of the forcing structure as close as practicable and covered with 5-7.5 cm of soil.
- By the high temperature, the crowns will sprout and stalks grow out.
- After reaching a length of 45 cm, they can be harvested, packed and sent to market.

DISEASES & PESTS

Leaf Spots : (*Ramularia and Ascochyta spp*)

- These fungi cause circular or angular spots, variable in size having big centers surrounded by a red zone.
- When affected tissue dies, it may drop out, leaving large ragged holes in the foliage.
- These fungi overwinter in infected plant debris and propagation stock.

Control measures

- Remove and destroy leaves following the first heavy frost.
- During harvest, remove stems with spotted leaves first.

Botrytis rot : (*Botrytis cinerea*)

- The fungus may cause a leaf, stem and crown rot of forced rhubarb.
- Disease intensifies where there is poor air circulation and high humidity.

Control measures

- Follow strict sanitation.
- Apply recommended fungicides like copper oxychloride @ 0.3per cent at first appearance of disease and repeat at 7 days interval.

Root and crown rots: (*Pythium and Phytophthora spp*)

- Plants become unthrifty.
- Leaves may turn yellow to red and collapse.
- The crowns, when sectioned, exhibit a brown-black decay.
- Large roots lack small feeder roots.
- Larger roots may have large brown-black lesions.

Control measures

- Purchase healthy propagation stock.
- Select well drained fields.
- Remove and destroy the diseased plants.

VIRAL DISEASES

- Several viruses are known to occur in rhubarb but turnip mosaic, arabis mosaic and cherry leaf roll virus are the most common.
- These viruses have wide host range and cause mottling and ring spotting of leaves.
- They may be introduced through infected planting stock.

Control measures

- Obtain and plant healthy nursery stock.
- Avoid planting virus free crowns near virus contaminated crowns.

PESTS

Potato stem borer: (*Hydraecia micacea*)

- The first stage of the insect attacks only weeds and couch grass in particular.
- Later they move into plants with thicker stems, such as rhubarb.
- They may move from stem to stem, boring into the centre of the stalk.
- The adult moths lay their eggs on the stems of grasses in August.
- The eggs do not hatch until the following spring.
- Damage can be expected in June and early July.
- Serious infestation can lead to an unmarketable crop.

Control measures

- This pest is not a serious problem when couch grass and other weeds are controlled in and around the rhubarb plantation.
- Weeds should be controlled to make the field less attractive for egg laying by the adult moth.
- In early spring burning of affected fields or field margins will effectively control this pest.

Tarnished plant bug: (*Lygus lineolaris*)

- Adults are very active and quick moving.
- They damage rhubarb by piercing their mouth parts in leaves and stalks thus causing wilting and distortion of leaves.
- This bug is a pest of new plantings.

Control measures

- Keep plantings and adjacent areas weed free.
- Avoid planting adjacent to legumes.
- If attack is severe, apply dimethoate (0.03 %) or oxy-demeton methyl (0.025 %).

Slugs

- Slugs may be a problem in plantings with heavy soils, poor drainage and in weedy situations.
- Slugs feed at night by rasping the surface of stems, leaving unsightly scars, which reduce the salability of the stem.

Control measures

- Provide good soil drainage.
- Keep weeds under control.
- Remove leaves and trash from the field when harvesting.
- Do not use manure and/or mulches in areas of field prone to slug damage.

Black bean aphid: (*Aphis fabae*)

- Heavy population of this pest causes curling or wilting of leaves.
- There is also potential for the spread of virus by this aphid.

Control measures

- Spray malathion (0.05%) or oxy-demeton methyl (0.025 %).

Flea Beetle:

- These can cause damage to new plantings by their feeding activity on the leaves.
- They are especially active during hot dry weather.

Control measures

- Remove weed hosts, follow the phytosanitary measures and spray carbaryl (0.1%).
- Repeat spray if attack persists.

SEED PRODUCTION

SEED PRODUCTION

- Rhubarb grown for seed production is planted in a field for 2 years in which the stalks and petioles are not harvested.
- After 2 years of growth, the roots are ready to be dug for seed production.
- It should be exposed to the low temperature to break the dormancy.
- The crown and roots used for seed production must be dug before the soil freezes, taken for storage, and held where dehydration and water loss are at a minimum until it used for planting.
- When ready for planting, the crowns are packed together on 4-5 ft wide beds with soil and water added to initiate growth, and then placed in the dark.

Land Requirements

Before planting this polygonaceous crop, consider the following important factors:

- No polygoneous crop (Sorrel) or related weed (dock plants) has been present in or near the field for at least 2 years, preferably 4 years.
- Polygoneous crop like Buckwheat and polygoneous crops waste should not have been dumped on these fields.
- Soil should be well drained.
- Rhubarb prefers deep, fertile loamy soils and does best in slightly to moderately acid soils.

Methods of Seed Production

- There are two major methods used to produce seeds in Rhubarb:
 - Seed to seed method
 - Root/crown to seed method
- Out of these two methods, root or crown to seed method is commercially used for quality seed .production.

Rouging

- Timely and regular interval rouging for off type, diseased plants affected by crown rot and viral diseases
- Weed like dock plant etc. is removed at regular interval.
- Rest of the cultural practices is same as described for table crop.

Harvesting and Yield

- The best time to harvest a seed crop is at stage when the highest yield of best quality seeds will be obtained which is standardized by experience.
- Seed crops are harvested when plant start drying in the field and seed are usually dried on the plant before harvesting.

- Plants are manually harvested by cutting at ground level or whole plant pulls up and threshed to remove the seeds.
- Seed crop starts giving seed harvests from three years age onwards.
- Seed yield varies between 2.5-4.0 q/ha.

Seed Packaging

- Well dried seeds are packed in the plastic bags, tin cans, cloth bags etc.

Seed Storage

- Seed can be stored at 0– 2°C and a relative humidity of 95-100 per cent for 1-2 years.
- Good air circulation is also essential.

SEED CERTIFICATION STANDARDS

A. Field Inspection

a) Mother roots/ crowns production stage:

- Minimum two inspections are required to produce quality seeds.
- The first inspection is done 20-30 days after the sowing in order to determine proper isolation, volunteer plants, out crosses, off types and other relevant factors.
- The second inspection is done after the mother roots have been lifted to verify the true characteristics of roots.

b) Seed production stage:

- A minimum of one inspection is done during flowering to check isolation, off types and other relevant factors.

B. Field standards

a. General requirement

Isolation:

Seed fields should be isolated from the contaminants as shown below:

Contaminants	Minimum Distance (meters)			
	Mother Root production stage		Seed production stage	
	Foundation Seed	Certified Seed	Foundation Seed	Certified Seed
Fields of the other varieties of the same species	5	5	1600	1000
Fields with	5	5	1600	1000

same variety not confirming to varieties purity requirement				
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b. Specific Requirements

Factor	Maximum permitted (per cent)	
	Foundation Seed	Certified Seed
Off type	0.10	0.20
Plant affected by seed borne diseases	0.10	0.50

B. Seed Standards

Factors	Foundation	Certified
Pure seed (minimum) %	98	98
Inert matter (maximum) %	2	2
Other crop seeds (maximum) Number/ kg	5	10
Weed seeds (maximum) Number/ kg	10	20
Germination (minimum) %	60	60
Moisture (maximum) %	7-9	7-9
For vapour proof containers (maximum)%	5	5

SPINACH BEET OR INDIAN PALAK

TYPES OF SPINACH: There are two types of spinach.

1. Desi or common palak (Spinach beet or beet leaf or beet leaf spinach or Indian Palak or Desi Palak).
2. Vilayati palak or English Spinach (spinach)

DIFFERENCE BETWEEN SPINACH BEET AND SPINACH

Sr.No.	Spinach Beet	Spinach
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1.	Botanical name is <i>Beta vulgaris</i> var. <i>bengalensis</i> Hort	Botanical name is <i>Spinacea oleracea</i> L
2.	Chromosome number 2n=18	Chromosome number 2n=12
3.	Leaves with margins	Leaves with lobed leaf margin
4.	Produce hermaphrodite flowers	Produce staminate, pistillate and hermaphrodite flowers
5.	Tolerates high temperature and grow well in hot weather	Purely a cool season crop and can not tolerate high temperature. In warm weather and long days it quickly tend to flower

SPINACH BEET

BOTANICAL NAME	<i>Beta vulgaris</i> L. var. <i>bengalensis</i> Roxb
CHROMOSOME NUMBER	2n=2x=18
FAMILY	Chenopodiaceae
COMMON NAME	Palak, Saag, Indian Spinach, Indian Palak, Desi Palak

USES

- Rich source of vitamin A as compared to spinach and carrot
- Also contains high quantity of ascorbic acid and iron
- 100g of leaves supply as much essential amino acids as 100g of any non vegetarian food like meat and fish
- Its succulent leaves and stems forms a nutritious dish after cooking
- The herbaceous parts are mildly laxative besides other medicinal values.

ORIGIN AND HISTORY

- The spinach is probably native of Indo-Chinese region.
- Spinach is a nutritive leafy vegetable.
- It is rich in vitamins and minerals.
- The Romans used it as feed for animal and man.
- In Germany, it was first described in 1557, where it is referred as Roman beet.

- The crop was introduced in USA in 1800.
- It has some medicinal properties also, the herbaceous parts of palak are mildly laxative, beside other medicinal values and it is a leafy vegetable which is highly suitable for hydroponics.

NUTRITIVE VALUE (per 100 g of edible portion)

Energy (kcal)	46	Thiamin (mg)	0.26
Moisture (%)	86.4	Riboflavin (mg)	0.56
Protein (g)	3.4	Niacin (mg)	3.3
Fat (g)	0.8	Ascorbic acid (mg)	70
Carbohydrate (g)	6.5	Ca (mg)	380
Vitamin-A (IU)	5862	P (mg)	30

CLIMATIC REQUIREMENTS

- Spinach beet is a cool season crop.
- It can withstand frost better than other vegetable crops.
- High temperature, especially long day cause bolting, thus reduces its market value.
- Higher yields are obtained under short day and mild temperature.
- Succulence and tenderness of leaves are increased under high atmospheric humidity.
- Can be grown throughout the year under mild temperature conditions.

SOIL CONDITIONS

- Spinach beet can be grown on a wide range of soils.
- It thrives best in well drained loamy soil.
- pH should be in the range of 6-6.5.
- Low soil pH is harmful for growth and development of crop.

VARIETIES

/

HYBRIDS

On the basis of pigmentation of midrib and leaf veins, palak cultivars can be divided into two groups:

1. Reddish midrib and leaf veins.
2. Green midrib and leaf veins.

All Green:

- This is an early variety suitable for growing in September.
- Leaves are green, uniform, tender with entire leaf margins.
- Plant produces seed stalks in 75days after sowing.
- Average yield is 125q/ha of green leaves.

Arka Anupama:

- It has been developed through hybridization of IIHR-10 and IIHR-8 followed by pedigree method of selection and released from IIHR, Bangalore.
- Leaves are medium large, dark green, wrinkled and attractive.
- It is late bolting variety and regenerates at fast rate.
- Leaves are ready for first harvesting in 30 days after sowing.
- It gives about 410 q/ha fresh green leaves in four cuttings.

Banerjee Gaint:

- It is very popular variety developed in West Bengal through hybridization between Local Palak x Sugar beet.
- It produces large thick and succulent leaves with very succulent stem and fleshy roots.
- It yields 150-200q/ha of green leaves.

Jobner Green:

- Evolved through spontaneous mutation and selection made from a local collection (5-5).
- Leaves are long, thick, and succulent with strong flavour.
- Can be successfully grown on alkaline soils having pH of 7.0-10.5.
- It produces tender leaves and strong flavour having entire margin.
- Taste is comparable to cultivar All Green.
- Prolific yielder with average yield of 300q/ha.

HS-23:

- It is quick growing and heavy yielding cultivar, gives first cutting in 30 days after sowing and a total of 6-8 cuttings at 15 days intervals.
- Evolved through mass selection
- Leaves are long, dark, thick and succulent

Pusa Jyoti:

- It gives 6-8 cuttings and yields 290q/ha.
- It is a polyploid, evolved through selection among colchicine treated progenies of All Green.
- It is a giant leaved type with succulent and crisp leaves.
- It yields 490q/ha with 6-7 cuttings.
- It is rich in K, Ca, Na, Fe, and ascorbic acid and can be grown throughout the year.

Palak No. 51-16:

- It produces green leaves, gives several cuttings and yields about 160q/ha.
- Released by the Maharashtra State Department Of Agriculture.
- It is a late bolting cultivar.

Pusa Palak:

- It produces uniform green leaves without any purple pigmentation.
- Developed by hybridization between Swiss Chard x Local Palak
- It is a late bolting cultivar.

Ooty-1:

- It is tasty green leafy vegetable.
- It yields 150q/ha of leaves.
- Leaves are rich in vitamins.
- It also contains higher carotene content.
- It can be grown throughout the year and can withstand frost.

Pusa Harit:

- Suitable for cultivation in the hills throughout the year,
- Plants are upright, vigorous growing with uniformly thick green, slightly crinkled and giant sized leaves,
- Heavy yielder with remarkable ability for rejuvenation.
- It has late bolting habit and wide range of adaptability to varying climates,
- Average yield 150-200q/ha.

Punjab Green:

- Foliage is shining dark green, thick, long, sweet, succulent and free from sourness.
- There is light purple pigment on the stem.
- Slow bolter and has low oxalic acid content which is a desirable character in greens.
- Average yield is 315q/ha.

Punjab Selection:

- Leaves are light green, long, thin, narrow and smooth with slightly sour taste.
- Stem is covered with purple pigment.
- It yields 275 q/ha green leaves.

Pant Composite-1:

- It is released from GBPUAT, Pantnagar.
- It is a heavy yielder and tolerant to *Cercospora* leaf spot.

Pusa Bharati:

- Leaves are long, succulent and flavoured.
- It yields 500q of green leaves per hectare.

SOWING TIME

- In plains of India, it 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.
- It can be grown throughout the year in places where mild climate exist.
- In hills, it is generally sown in March-May

SEED RATE

- Summer crop : 25-30 kg/ha
- Winter crop : 10-15kg/ha
- Seeds are soaked in water overnight before sowing to improve germination

SPACING

- Keep planting distance of 25-30cm between rows and plants should be spaced at 5-10cm after thinning.

NUTRIENT MANAGEMENT

- For good crop, add 250-300q/ha of Farm Yard Manure per hectare and mix it well during field preparation.
- Besides Farm Yard Manure, 80-100kg nitrogen, 60 kg phosphorus and 60kg potash should be applied per hectare in the form of inorganic fertilizers.
- The entire quantities of P and K along with one fourth quantity of nitrogen are applied at the time of planting.
- The remaining amount of nitrogen is top dressed into three split doses each @ 20-25kg/ha after each cutting.

USE OF PLANT GROWTH REGULATORS

- In Spinach beet, application of GA at 10ml/L in combination with 1 per cent urea has been reported to give higher yield.

IRRIGATION

- There should be sufficient soil moisture for proper seed germination and growth.
- If soil moisture is not sufficient at the time of sowing, pre sowing irrigation is advisable.
- Irrigation should be done after sowing.
- In summers, water is applied at 4-5 days interval and in winters at 8-10 days interval.
- However, the rainy season crop does not require any irrigation except during the long dry spell.

INTERCULTURAL PRACTICES

- Thinning is essential which should be done to provide proper space for accommodation and development of large uniform plants.
- Shallow hoeing is essential because the spinach beet plant cannot compete well with the weeds.
- To keep away the weeds from the field and to loosen the soil for proper aeration, 2-3 hoeings cum weedings are required.
- Application of Pyrazone @ 2.4-2.8 kg/ha as pre-emergence application is also found effective
- Harvesting is made more difficult where weeds are present.
- Avoid weedicides for controlling weeds in palak.

HARVESTING

- Spinach beet leaves become ready for harvesting in 25-30 days after sowing, the leaves are cut with the help of a sharp knife/sickle.
- The successive cuttings may be done at 15-20 days interval. In 4-6 cuttings, the crop is over.
- Winter crop gives more cutting than spring-summer crop.
- Varieties of broad leaves are usually high yielding than those of a short leaved.
- The yield and quality of leaves are affected adversely, if harvesting is not done at regular intervals.
- Palak is highly perishable vegetable, so immediately after harvesting, it should be sent to the market.
- The attractive appearance of leaves and their turgidity is lost within 24 hours of harvesting along with rotting of leaves.
- Palak cannot be stored at room temperature, but at low temperature (0°C) with high relative humidity (90-95 per cent) leaves can be stored for about 10 to 14 days.

YIELD

- On an average, green leaves yield varies from 100-150 q/ha (winter) and 80-100 q/ha (Spring-summer).

DISEASES

Fungal

Diseases

Damping off : (*Pythium spp.*)

- Seedlings are attacked by the fungus before or after germination and killed.

Control measures

- Avoid thick sowing of seeds.
- Treat seeds before sowing with any one of the fungicides like carbendazim or captan @2.5g/kg of seed.
- This disease can be controlled by drenching the infected seedlings with a mixture of mancozeb (0.25%) and carbendazim (0.05%).

Downy mildew : (*Peronospora spinaciae*)

- Affected plants show similar symptoms as that of downy mildew of peas.
- The causal organism can survive in soil as oospores, in seed as dormant mycelium, on the seed as contaminating oospores, or on perennial spinach beet.

Control measures

- Use clean seed.
- Remove crop debris and destroy it.

- Follow a three year crop rotation and spray zineb at 0.2 per cent.

Leaf spot : (*Cladosporium variabile and Stemphylium botryosum*)

- It is a seed borne disease.
- Older leaves show dirty white, water soaked circular spots.

Control measures

- Seed treatment with hot water or with fungicides like carbendazim. (0.05%) is recommended to check the disease.
- The pathogen can be eradicated by 1.2 per cent chlorine treatment for 10 minutes.

Anthracnose : (*Colletotrichum dematium*)

- Affected leaves show water-soaked spots, which later on coalesce and cause drying of the leaves.
- On seed stalk, elongated spots are formed.
- Black dots are also seen on seed.

Control measures

- Reduce leaf moisture by avoiding sprinkler irrigation, if possible.
- Spinach fields should be adequately fertilized.
- Use resistant varieties.
- Apply copper oxychloride (0.3%) as a protectant spray at 10–14 day interval.

Bacterial

Diseases

Bacterial soft rot: (*Erwinia carotovora*)

- It is a post harvest diseases, the disease appears on leaves in transit.
- Water soaked areas develops and rotting occurs in the packed leaves due to lack of aeration and cleanliness.

Control measures

- Follow rotation with maize, beans, small grains and grasses.
- Care should be taken at harvesting and handling to avoid bruising.
- A storage temperature just above freezing (0°C) and a relative humidity below 90 per cent does much to reduce soft rot losses.
- Storage rooms dump tanks and boxes should be disinfected each season with copper sulfate.

Viral

Diseases

Spinach mosaic

- This disease is characterized by light to dark green patches and mosaic symptoms on infected leaves.
- The leaves are reduced in size, distorted and invariably show chlorotic sectors which are almost white.
- This infected disease is caused by a strain of cucumber mosaic virus (CMV).
- This virus is easily transmitted by sap inoculation.
- The virus is also transmitted by insect vector *Myzus persicae* in a non-persistent manner.

Control measures

- Removal and destruction of affected plants, control of aphids with malathion @ 0.05 per cent, and growing of improved varieties are recommended.

Pests

Aphids

- These are small in size.
- Both adults and nymphs suck sap from plant tissues due to which, the plant becomes weak.

Control measures:

- Spray malathion (0.05 %) or oxy-demeton methyl (0.025 %).

Leaf eating caterpillar: (*Laphygma exiqua*)

- Caterpillars feed on leaves and make holes.

Control measures

- Spray malathion (0.05%) for effective control.

SEED

PRODUCTION

Land Requirements

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

Climatic Requirement

- Palak is a cool season crop, but has a much wider range of adaptability to climatic conditions.

Isolation

- Palak is cross-pollinated by wind.
- Air current may carry the pollen to considerable distances.

- Seed fields must be isolated from fields of other varieties of palak and fields of same variety not conforming to varietal purity requirement for certification and from swiss chard, sugar-beet and garden beet, at least by 1600 meters for foundation seed production and 1000 meters for certified seed production.

Roguing

- Careful roguing for off-types, early bolters and pigweed is necessary.
- The first roguing may be done at pre flowering stage to remove off type on the basis of foliage characters.
- Subsequently early bolters, off-types plants and pigweed may be removed immediately, as and when they are noticed again.

Time of Sowing

- For seed crop, sowing should be done in October and November.

Preparation of Field

- Prepare the field to fine tilth by ploughing.
- Three to four harrowing, followed by leveling are necessary.

Method of Sowing

- Sow the seed in rows 45 cm apart. Place the seeds close to each other at the depth of about 2 cm.
- Later on the plants can be thinned to 15 cm.
- Sufficient soil moisture is required for good germination.

Harvesting

- Harvesting should be done when most of the seeds are firm before they shatter and the crop is cut by hand and allowed to dry in the field.
- Crop bolts after 75 days of sowing and harvesting is done after 150-180 days.
- The seeds do not shed, so harvesting is done after full ripening.
- After drying the seed can be threshed by beating them with sticks.
- After cleaning, the seeds must be dried to 9 per cent moisture before storage.

Yield:

- Seed yield-vary from 10-15q/ha.

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SEED PRODUCTION

SEED CERTIFICATION STANDARDS

Field Inspection

- A minimum of two inspections shall be made, the first before flowering and the second during flowering stage

A. Field standards

a. General Requirements

Isolation

Seed fields should be isolated from the contaminants as shown below:

Contaminants	Minimum distances (meters)	
	Foundation Seed	Certified Seed
Fields of other varieties	1600	1000
Fields of same variety not conforming to varieties purity requirements for certification	1600	1000
Fields of the swiss chard (chard, sea kale beet, silver beet), sugar beet and garden beet	1600	1000

b. Specific Requirements

Factors	Standards permitted (%)*	
	Foundation Seed	Certified Seed
Off types	0.10	0.20

* Maximum permitted limit at and after flowering.

B. Seed Standards

Factors	Standards for each class	
	Foundation	Certified
Pure seed (minimum) %	96	96

Inert matter (maximum) %	4	4
Other crop seeds (maximum) Number/ kg	5	10
Weed seeds (maximum) Number/ kg	5	10
Germination (minimum) %	60	60
Moisture (maximum) %	9	9
For vapour proof containers (maximum)%	8	8

SPINACH

Objectives: Spinach or English Spinach or Vilayati Palak is the most important potherb or leafy vegetable grown in winter season. The word spinach actually comes from Spanish word Hispania. The shape of the leaves is quite different from that of Palak. The edible parts consist of the compact rosette of leaves prior to the elongation of central bud in flower stalk formation. It is purely a cool season plant and is dioecious in nature. It is having two types of varieties viz. prickly seeded and round seeded. The present chapter will make the students understand with its importance, production technology, seed production practices and plant protection measures.

SCIENTIFIC NAME	<i>(Spinacia oleracea L.)</i>
COMMON NAME	Vilayati palak, Angreji Palak
CHROMOSOME NUMBER	2n=2x=12
FAMILY	Chenopodiaceae
CENTRE OF ORIGIN	Iran

NUTRITIVE VALUE (per 100g of edible portion)

Energy (kcal)	26	Riboflavin (mg)	0.2
Moisture (%)	90.7	Niacin (mg)	0.6
Protein (g)	3.2	Ascorbic acid (mg)	51
Fat (g)	0.3	Calcium (mg)	93

Carbohydrate (g)	4.3	Phosphorus (mg)	51
Vitamin-A (IU)	9300	Iron (g)	3.1
Thiamin (mg)	0.1	Oxalic acid	658 mg

USES:

- Traditionally spinach or vilayati palak is classified as a pot herb.
- The edible part of spinach is a compact rosette which is normally consumed as a cooked vegetable.
- Sometimes, it is also used as salad along with lettuce and other vegetables.
- Spinach is highly suitable for hydroponics.
- Spinach is also processed, primarily canned and fried.
- Leaves of spinach are rich in vitamin-A (9300 IU) and contain considerable amount of iron and calcium.
- Spinach produces a seed stalk easily in response to low day and night temperature.
- Spacing and environmental conditions influence leaf number and size.
- The margins are smooth or wavy, surface is also variable ranging from smooth to heavily of savoy.
- The blistered appearance of savoy tissue results from differential growth of parenchyma tissues between the leaf veins.
- Spinach is classified as a dioecious plant, however, rarely some monoecious plants may develop in certain cultivars.

There are 4 sex forms in spinach.

Extreme males:

- These produce only staminate flowers with minimum foliage.
- Small with very little vegetative development and tend to bolt quickly.
- This plant type flowers early and die soon after flowering.
- Eliminate the extreme males from commercial strains by selection.

Vegetative males:

- These produce only staminate flowers, more foliage and flower later than extreme males.

Female plants:

- These produce only pistillate flowers and have well developed foliage with very late tendency to flower.
- Gibberellic acid plays an important role in sex expression of spinach.
- Female and vegetative male plants are preferred because they are larger, slower bolting and higher yielding.
- Pollination is mostly by wind.
- Fruits usually an achene, the fertilized ovary form a one seeded fruit called utricle. Parthenocarpic fruits also occur in spinach.

Vegetative males and females are slower to flower and produce considerably more foliage, making them the preferred plants type for commercial cultivation.

Monoecious plant:

- These produce staminate and pistillate flowers, well developed foliage and are slow to flower.

There are two types of seeds:

1. Smooth round seeded types (considered as summer type)
2. Irregularly prickly shape (considered as winter type)

CULTIVARS AND HYBRIDS

CULTIVARS

Cultivars may be either smooth seeded or prickly seeded and smooth leaved or Savoy leaved.

Cultivars

A.

**may
Leaves**

AND

be

heavily

classified

HYBRIDS

as:

savoyed

i) **Plants** **late** **seeding**
 a) Leaves blue-green
 b) Leaves dark green
 ii) **Plants** **not** **late** **seeding**
 a) Plants very late seeding
 b) Plants medium early seeding
B. Leaves not savoyed (or slightly savoyed in cool weather)

i) Plants early seeding

a) Seeds prickly
 b) Seeds not prickly

ii) Plants not early seeding

a) Seeds prickly
 b) Seeds not prickly

I. Leaves blue green
II. Leaves medium green

Cultivars may be classified into 3 groups as:

A. Round-seeded

1. Smooth-leaved (or slightly savoyed in cool weather)
 i) Early bolting or not long-standing
 ii) Slow bolting or long-standing

2. Savoy-leaved

i) Early bolting or not long-standing
 (a) Mosaic resistant
 (b) Not mosaic resistant

ii) Slow bolting or long-standing

B. Prickly seeded

1. Smooth-leaved (or slightly savoyed in cool weather)
 i) Early bolting or not long-standing
 (a) Mosaic resistant
 (b) Not mosaic resistant

ii) Slow bolting or long-standing

2. Savoy-leaved

i) Early bolting or not long-standing
 (a) Mosaic resistant
 (b) Not mosaic resistant

ii) Slow bolting or long-standing

Cultivars may also be classified into 3 groups on the basis of leaf type as:

i) Savoy
 ii) Semi-savoy
 iii) Smooth

- Prickly seeded cultivars are suitable for winter autumn sowing in hills while smooth leaved are suited for spring summer cultivation in hills and autumn sowing in plains.

- Round leaved cultivars are seeded in hills in summers and autumn sowing is done in plains.
- Round seeded varieties perform well in the plains whereas, prickly seeded grow better in hills.

Spinach varieties commonly grown in India are:
Virginia Savoy

- Prickly seeded cultivar having blistered large dark green leaves with round tips.
- Plants are upright and vigorous in growth, average yield 100-125 q/ha

Early Smooth Leaf

- Smooth leaf type and smooth or round seeded.
- Leaves are small light green with a pointed apex.

Long Standing

- Dark green thick leaves triangular in shape with a pointed apex.
- Slow in growth, average yield 100-125 q/ha

CLIMATE

- Spinach is strictly a cool season vegetable.
- It does not grow well during hot weather.
- Spinach growth is best at temperature of about 18-20°C.
- Spinach is a short day plant and the growth is slow at 10°C.
- Acclimated plants can tolerate freezing temperature up to -10°C.

SOIL AND FIELD PREPARATION

- It can be grown on a wide range of soil types however soil having high moisture holding capacity and good drainage are preferred.
- Plants have some tolerance of salinity and favorable pH range is 6.5 to 7.0.
- Soil should be ploughed thoroughly two or three times followed by harrowing.
- Planting should be done to ensure uniform irrigation.

SOWING, SEED RATE AND SPACING

- Spinach can be sown round the year in different agro-climate conditions of the country.
- The different sowing times are as follows:
 - In plains : September-October
 - In low hills : July-November, February-March
 - In high Hills : March-June and September
- In spinach, 50 per cent of the plants turn out to be male with poor growth and such plants cannot be removed till the time of blooming.
- Hence a higher seed rate of 37-45kg/ha is required.
- Seeds are either broadcasted or line sown.
- However, line sowing is preferred for the convenience in intercultural operations.
- Row to row spacing is maintained at 30 cm and plant to plant at 10-12cm.

NUTRIENT MANAGEMENT

- Apply 100q/ha well rotted Farm Yard Manure/compost during field preparation.
- An application of 75 kg N, 55 kg P and 30 kg K/ha gives best yield.
- Nitrogen should be applied in 2 splits, first half prior to sowing along with full quantity of Farm Yard Manure, P and K and other half 1 month after seed germination.

IRRIGATION

- Spinach is a quick growing shallow rooted crop that is not tolerant to water stress.
- Adequate moisture should be maintained by frequent irrigation when necessary.
- Irrigation practice that splash soil into the leaves is damaging and should be avoided.
- About 12-13 inch water may be sufficient during the entire crop season.
- Moisture requirement is not very high since rate of transpiration is low during cool season.
- Water logging of the field should be prevented.

WEED CONTROL

- Weed control is very important because spinach plant cannot compete well with the weeds.
- For weed control, one to two shallow hoeings are needed. Herbicides can also be used to control the weeds effectively.

- Asulam (6 or 8l/ha) has been reported to give good weed control in spring-summer and autumn crop without any harmful effects.

HARVESTING

- Harvesting should not be done early in the morning because leaves are crisp and break easily.
- The crop is ready for harvest 4-6 weeks after sowing.
- Cutting is done with a sharp knife/ sickle.
- About 3-4 cuttings may be obtained throughout the season.
- Product should be hydro or vacuum cooled immediately after harvest.

YIELD

- About 50-60 q/ha green leaves can be obtained from one hectare..

STORAGE

- Spinach can be stored at 0°C and at 95-100 per cent RH.
- It can be stored only for 10-14 days.
- Temperature should be as close to 0°C as possible because spinach deteriorates rapidly at higher temperature.

DISEASES AND PESTS

- Diseases and Pests of Spinach are same as that of spin

SEED PRODUCTION

SEED

Climatic requirements

- Spinach is a cool season crop, but it has a much wider range of adaptability to climatic conditions.
- It produces seed freely in the north Indian plains.
- Long day plant with critical day length ranging from 12-15 hours

PRODUCTION

Land requirements

- Land to be used for seed production should be free of volunteer plants.
- The soil of selected field should be rich in organic matter.

Isolation distance

- Foundation seed : 1600 m
- Certified seed : 1000 m

Cultural Practices: Almost similar to that of leaf crop
Time of sowing

- For seed production purpose, seed sowing should be done in October- November

Methods of sowing

- Sow the seeds in rows 45 cm apart.
- Place the seeds close to each other at the depth of about 2cm. The seedlings after emergence can be thinned to provide a spacing of 15 cm within a line. .
- Sufficient soil moisture is required for good germination.

Nutrient management

- Well rotten Farm Yard Manure @ 350-400 q/ha should be applied at the time of preparation of land.
- Besides this, N, P and K @ 150:100:100kg/ha, respectively should also be applied.
- Nitrogen should be applied in 2 splits, first half prior to sowing along with full quantity of Farm Yard Manure, P and K and other half 1 month after first application.
- More nitrogen is required because high nitrogen increased the yield and dry matter content of the tops.

Irrigation

- Frequent irrigation according to season is required to obtain good yield.

Intercultural operation

- The field should be kept free of weeds especially in the early stages of crop growth..
- The field should be completely clean of pigweed plants after the crop has been left for seed.

Cutting

- Not more than 2-3 cuttings should be taken from the seed crops.

Rouging

- Careful rouging for off-types, early bolters and pigweed plants is necessary.
- The rouging may be done at pre-flowering stage to remove off-types on the basis of foliage characters.
- Subsequently early bolters, off-types plants and pigweed plants may be removed immediately as and when they are noticed.

Harvesting:

- Harvesting should be done when most of seeds are formed before shattering.
- The crop is cut by hand and allowed to dry in the field.
- After drying the seeds can be threshed by beating them with sticks.
- After cleaning, the seed must be dried to 9 per cent moisture before storage.

Seed Yield:

- Seed yield varies from 1000-1500 kg/ha.

SEED Field

CERTIFICATION

STANDARDS Inspection

Minimum of two inspections shall be made first before flowering and second during flowering stage.

A.

Field

standard

a) General requirements

Contaminants	Minimum distance (Meter)	
	Foundation Seed	Certified Seed
Field of other variety	1600	1000
Field of same variety not confirming to varietal purity	1600	1000
Field of swiss chard	1600	1000

b) Specific requirements

Factor	Maximum permitted (per cent)	
	Foundation Seed	Certified Seed
Off-type	0.10	0.20

B. Seed standards

Factor	Standards for each class	
	Foundation	Certified
Pure seed (minimum) %	96	96

Insert mater (maximum) %	4	4
Other crop seed (maximum) Number/ kg	5	10
Weed seed (maximum) Number/ kg	5	10
Germination (minimum) %	60	60
Moisture (maximum) %	9	9
For vapour proof containers (maximum) %	8	8

LETTUCE

BOTANICAL : *Lactuca sativa* L.

FAMILY : Compositae

CHROMOSOME NUMBER: $2n=2x=18$

ORIGIN : Asia Minor, Iran and Turkistan

AREA AND PRODUCTION

- Lettuce is one of the most important vegetable crops in temperate countries.
- However, it occupies an important position for its cultivation in tropical and subtropical countries also.
- In the world, the largest consumer and producer is USA.
- Large areas of lettuce are also grown in South Eastern Australia, Japan, China, Israel, Northern Mexico, Chile, Argentina, Brazil and Peru.
- Area under lettuce is 0.12 million hectares with a production of 0.79 million tonnes (FAO, 2009).

ORIGIN AND HISTORY

- Lettuce is originated in Mediterranean region, Probable ancestors of Lettuce is *Lactuca serriola* L.
- Lettuce is cultivated about 4500 B.C.
- The crop was spread throughout the Mediterranean region during Greek and Roman eras and from there to rest of Europe.
- It was recorded as being grown in new world long back in 1494.

NUTRITIVE VALUE (per 100g of edible portion)

Energy (kcal)	14	Vitamin-A (IU)	900
Moisture (%)	95.1	Thiamine (mg)	0.06
Protein (g)	1.2	Riboflavin (mg)	0.06
Fat (g)	0.2	Niacin (mg)	0.3
CHO (R)	2.5	Ascorbic acid (mg)	8

USES

- Lettuce is rich in vitamin A and minerals like Ca and Fe.
- Its tender leaves are chopped and used as salad with salt and vinegar.
- Lettuce is known to be sedative, diuretic and expectorant.

SOIL

- It grows well in light, well manured, well drained soils with adequate moisture.
- It is slightly tolerant to acid soil (pH 6.0 -6.8) but highly susceptible to acidic soil.

CLIMATE

- It requires cool temperature.
- It thrives best at higher altitude in tropics and sub tropics.
- The seed germinate quickly at 21-24°C.
- But lower and higher temperature is harmful for germination.
- Temperature above 22°C promotes bolting causing bitterness in leaves and accelerates the development of tip burn and rot.
- Seeds become dormant and fail to germinate when the soil temperature is above 22-30°C.

VARIETIES / HYBRIDS

- Varieties are grouped on the basis of morphological characters.

Head

type:

1. Crisp Head:

- Under this group the cultivars are heading types with wrinkled non wrapper leaves, round, large head (up to 1kg), brittle textured and tightly folded, with green outer and white or yellowish inner leaves.
- Examples are New York 515, Imperial 44,152,456,615 and 847.
- Great Lakes and Pennlake are commercial cultivars.

2. Butter Head:

- The cultivars form relatively small, loose heads with broad oily, crumbled, soft textured leaves.
- Both crisp and butter head belongs to head lettuce i.e. *var. capitata*
- Examples are Borough Wonder, Cobham Green and Avondefiance

Non-heading

type:

1. Cos or Romaine (*var. longifolia*):

- The cultivars have elongated leaves forming a loaf shaped head.
- Outer leaves are dark with heavy nobs, inner leaves are finer and lighter in colour coarse in appearance but eating quality is quite good.
- Examples are Eiffel Tower, Paris Island and Paris White

2. Leaf or Bunching (*var. crispa*):

- The cultivars are non-heading or leaf type. Colour, heat sensitivity and quality vary but all produce a rosette of leaves.
- Best example is Black-seeded Simpson, Prizehead, Australian and Salad Bowl for outdoor and Grand Rapids for greenhouse production

3. Asparagus or Stem (*var asparagina*):

- Also known as celery lettuce
- The cultivars have thick stem which is peeled and eaten raw e.g. Celtuce
- The leaves are also edible but inferior in quality than other types.eg Lettuce

Latin:

- It resembles butter head in forming loose head but the leaves are elongated and similar to Cos.
- Grown in Mediterranean countries.
- The cultivar Gallega, Criolla, Verde, Criolla Blanca and Madrilene are best examples.

Some of the important varieties are
Punjab Lettuce No.1:

- Released from Punjab Agricultural University, Ludhiana
- Leaves light green, shiny and crisp.
- It is a non-heading variety with loose leaves, takes about 45 days from sowing to first harvest.
- Average yield is 88q/ha.

Great Lakes:

- Recommended by IARI, New Delhi, crisp head type having large firm heads with green leaves, outer leaves are blistered, resistant to tip burn but susceptible to powdery mildew.

Alamo-1:

- It is a head type variety released from Dr Y S Parmar University of Horticulture and Forestry, Solan.
- Leaves are crisp, cup shaped, bending and dark green in colour.
- Heads solid, weighing from 500-800gram
- Ready for harvesting in 80-90days.
- Average yield 235q/ha.
- Few other varieties are Slowbolt (Leaf type), Chinese Yellow (Leaf type), Imperial 859 (Crisp Head type), White Boston (Butter Head type), Dark Green (Cos type), Alamo 1 (Head type), Simpson Black Seeded (Leafy type), Eves Wonder (Heading type) and Ruby (Leafy & purple coloured).

Recently developed Lettuce cultivars:

- Cultivars 9547 and 9542, Salma, Svetlana (Nathasha), Impact, Magnum, Marksman, Diamond, Elisa and Florida Buttercrisps,

SOWING TIME

- In the plains, the seeds are sown in the nursery beds in September to October.
- At high altitude, the sowing is done from March-June/July.

SOWING METHODS

- It can be sown directly in the field or by raising the nursery beds.
- In the nursery beds, the seedlings are transplanted after 4-6 weeks of sowing.

SEED RATE

- About 400 to 500 gram seed is required for one hectare area.

SPACING

- Seedlings are transplanted at a spacing of 45×45, 45 ×30 or 30 ×30cm depending on soil type and cultivars.

NUTRIENT MANAGEMENT

- For getting good yield, 100-150q of well rotten Farm Yard Manure should be incorporated during land preparation.
- Besides this apply 50 kg each of N and K₂O and 90 kg of P₂O₅.
- Entire quantity of Farm Yard Manure, P K and half nitrogen is applied in the field at the time of field preparation. The remaining nitrogen is top dressed one month after first application at the time of hoeing/earthing up.

IRRIGATION

- When sufficient moisture is not present in soil, a pre-sowing irrigation is done for seed germination in directly sown crops.
- Soon after transplanting, the lettuce crop should be irrigated.
- Subsequent irrigation is done at 8-12 days interval.

INTERCULTURAL OPERATIONS

- Shallow hoeing and weedings are essential to keep the field free from weeds and 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.
- Herbicides like Propyzamide @ 1.5 kg/ha when applied as pre-planting proved effective for the control of weeds.

USE OF GROWTH REGULATORS

- The plant fresh weight increase with IBA and NAA at 50 to 100 ppm, the use of GA₃ @ 10 mg/l stimulate respiration in lettuce seedling when applied at active stage of growth and development.

HARVESTING

- Harvesting depends upon the type and the purpose for which it is grown.
- Head lettuce for market is allowed to develop a solid head.
- The leafy variety become ready for harvesting within 50-60 days of sowing and harvested when the leaves attain full size but remain tender.
- Head type variety takes 60-70 days to harvest. Heads are harvested when they attain a good size and become solid.
- For home consumption the lettuce leaves can be harvested at any time, but for market it is allowed to develop a full size.

YIELD

- Green yield varies from 100-140 quintals/ha.

STORAGE

- Lettuce can be stored for about 3 to 4 weeks at 0°C with 90 to 95 % relative humidity and the freshness of lettuce is maintained by the pre harvest spray of butaric acid at 5 to 10 ppm.

DISEASES

Fungal Diseases

Damping off: Same as cabbage

Root rot

- This disease is characterized by severe stunting and rosetting followed by wilting and death of the plant.
- Lateral roots and cortical tissues of the tap root are severely rotted.

Control measures:

- Removal and destruction of affected crop and follow crop rotation.

Downy Mildew

- Light green to yellow areas develop on the leaves which later become brown.
- Excess moisture enhances this disease.
- Cos and butter head cultivars are more susceptible than crisp head and leaf types.

Control measures:

- Spraying of 0.2 per cent zineb can control this disease.

VIRAL DISEASES

Big Vein of Lettuce

- Yellow discoloration of veins is the primary symptom of big vein.
- Later, entire leaves become thickened and crinkled.
- Plants remain stunted and do not form heads.

Control measures:

- Avoid moist condition of soil and planting susceptible cultivars.
- Fumigation of the soil with chloropicrin checks this disease.

PESTS

Cabbage Semilooper

- It prefers lettuce for oviposition and prefers young plants.

Control measures:

- Apply malathion (0.05 %) and repeat after 10 days.

Aphids

- These are small in size.
- Both adults and nymphs suck sap from plant tissues due to which, the plant become weak.

Control measures:

- Spray malathion (0.05%) or oxy-demeton methyl (0.025 %).

PHYSIOLOGICAL DISORDER**Tip burn**

- The disorder may be caused due to the prevalence of high temperature, light intensity and long duration, excess of nitrogen, deficiency of Ca and B, antigenic age of plant, high Mn and soil moisture content and high endogenous level of IAA.
- It is characterized by the appearance of tip burning of lateral margins of inner leaves of mature heads.

Correction:

- Increase the dark period and relative humidity.
- Spray the crop with CaCl_2 @ 0.5 per cent on the standing crop.

SEED PRODUCTION**Climatic requirement**

- Lettuce is an annual cool season crop.
- It does well in cool growing season with a monthly average of 12-15°C.
- Its leaves become tough and bitter in hot dry weather.

Land requirement

- Land to be used for seed production should be free of volunteer plants.
- The soil of selected field should be rich in organic matter.

Isolation requirement

- Lettuce is highly self-pollinated, but 1-6 per cent cross pollination due to insects also occurs.
- At least 50 meters isolation distance for foundation seed production and 25 meters for certified seed production should be maintained.

Time of sowing

- For seed crops, sowing should be done in October.

Method of sowing

- The seeds may be sown in raised nursery beds in rows 3-4cm apart, and seedlings later transplanted at a distance of 45 × 30-45cm, when they are 5-6 weeks old.

Nutrient management

- Apply well-rotten farmyard manure @ 200-250 quintals, 60 kg phosphorus and 50 kg potash per hectare at the time of preparation of land.
- Nitrogen @ 60kg per hectare is to be applied in three splits. First part is applied at the time of field preparation and remaining two parts are applied each at six weeks interval.

Irrigation

- Irrigation should be given as and when needed to maintain uniform soil moisture conditions in the soil.

Rouging

- Off types plants at vegetative growth stage,
- During flowering for early and late bolters.

Harvesting and threshing

- Lettuce seeds ripen unevenly and fully mature seed shatter readily.
- It is advisable to harvest when 30-50 per cent of the seed in the heads show white pappus.
- The plants are cut by hand and left to dry on the ground for a few days.
- Latter, the seeds are collected by gently shaking them.

Seed Yield

- The leafy types usually produce 5 to 6 quintals seeds per hectare.
- However, the heading type varieties like Great lakes produce only 1.0-1.25 quintals seed yield per hectare.

SEED PRODUCTION

SEED

CERTIFICATION

STANDARDS

Field Inspection

- A minimum of three inspections should be made.
 - The first before heads are formed in heading types, and before full grown stage of non-heading types.
 - The second inspection when heads have formed in heading types and at full grown stage of non-heading types
 - The third one should be at flowering stage.

A.**a.****Field
General****standards
requirement****Isolation distance**

Contaminants	Minimum distance (m)	
	Foundation Seed	Certified Seed
Fields of other varieties	50	25
Fields of same variety not confirming to varietal purity requirements and wild type	50	25

b. Specific requirements

Factor	Maximum permitted percentage	
	Foundation Seed	Certified Seed
Off-type	0.10	0.20
Plants affected by seed borne diseases	0.10	0.50
Objectionable weed plants	0.10	0.20

B. Seed Standards

Factors	Standards for each class	
	Foundation Seed	Certified Seed
Pure seed (minimum %)	98	98
Inert matter (maximum)%	2	2
Other crop	-	-

seeds (maximum)%		
Total Weed seed (maximum)Number/ kg	5	10
Objectionable weed seeds (maximum) Number/ kg	2	5
Other distinguishable varieties (maximum) Number/ kg	10	2
Germination (minimum) %	70	70
Moisture (maximum) %	8	8
For vapour proof containers (maximum) %	6	6

ONION

SCIENTIFIC NAME : *Allium cepa* L.

COMMON NAME : Pyaz

FAMILY : Alliaceae

CHROMOSOME NUMBER : 2n=16

ORIGIN : South East Asia

IMPORTANCE AND USES

- The green leaves and immature and mature bulbs are eaten raw
- Used in preparation of sauces, soups and seasoning of food on account 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.
- Relieves heat sensation.
- Bulb juice is used as smelling on hysterical fits in faintness.
- Used to relive insect bites and sour throat.
- Results of investigation suggested that onions in the diet may play a part in preventing heart diseases and other ailments.

- Onions are given in jaundice, spleen enlargement and dyspeptic after cooping in vinegar.
- In malarial fever, they are eaten twice a day.
- Roasted onion 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.
- Reduces blood sugar & has lipid lowering effect.

NUTRITIVE VALUE (per 100 g of edible portion)

Particulars	Green	Bulb	Particulars	Green	Bulb
Moisture (%)	87.6	86.6	P (mg)	-	50
Protein (g)	0.9	1.2	Fe (mg)	7.5	0.7
Fat (g)	0.2	0.1	Vitamin-A (IU)	992	0
Carbohydrates(g)	8.9	11.1	Thiamine (mg)	0	0.08
Energy (kcal)	41	50	Riboflavin (mg)	0.01	0.01
Ca (mg)	50	47	Vitamin-C (mg)	17	11

- Pungency in onion is due to an enzymatic reaction only when tissues are damaged.
- It is due to the presence of sulphur bearing compound known as allyl-propyl-disulphide.
- There are 4 classes of colour of bulbs i.e. White, Yellow, Red and Brown.
- Red colour is due to anthocyanin pigment and yellow is due to quercetin pigment

AREA AND PRODUCTION

- The area under this crop in India was 1064 thousand ha having a production 15118 thousand tonnes with a productivity of 14.2 MT/ha (NHB, 2011).

CLIMATE

Role of temperature

- Onion does best under mild climate without extreme of heat and cold. It does not perform well in excessive rainfall.
- Before bulbing, temperature between 12.8-23°C is required whereas 20 to 25°C for at least 10 hours per day is required later for proper bulb development.
- About 70 per cent relative humidity is good for this crop.
- Very low temperatures in the beginning result in bolting while sudden rise in temperature favours early maturity of the crop resulting into small sized bulbs.
- Onion bulbs more quickly under warm temperature than at cool temperature.

- Temperature is more important in seed production than the day length. While photoperiod is more important than temperature for bulb formation.

Role of photoperiod

- Photoperiod requirement in onion is a quantitative character and each cultivar needs a minimum day length for bulb formation which is known as critical value.
- This critical value in combination with temperature influences bulb initiation.
- The so called short day cultivars when passed the critical value limit will initiate bulb formation and development is continued under long day conditions.
- Conversely, a long day cultivar will not be able to initiate bulb formation unless its longer critical value of photoperiod is reached.
- If onion plants are kept under short day conditions they continue to grow for over 3 years without bulbing.
- Short day cultivars form bulbs under long day conditions but long day can not form bulb under short day conditions.
- Almost all varieties grown in the plains are short-day cultivars.
- Kharif onion varieties require a day length of 10-11 hours where as rabi varieties require relatively higher temperature and 12-13 hours of day length.
- Brown Spanish is a long day variety (day length of more than 14 hours and a low temperature is required for proper development of bulbs).

SOIL

- Onion grows well on light loam, sandy loam or clay loam, deep friable and fertile soil rich in organic matter.
- The soil should be well drained.
- The optimum soil pH should be 5.8 to 6.5.

CULTIVARS

- The onion varieties have been classified on the basis of size and skin colour.
- Further, onion has been classified as common and multiplier onion.

A. Common Big Onion (Rabi):

1. Red Coloured: Agrifound Dark Red, Agrifound Light Red, Arka Niketan, Arka Pragati, Hisar-II, Kalyanpur Red Round, N-2-4-1, Punjab Red Round, Punjab Selection, Pusa Madhavi (Good Storage), Pusa Ratnar (Fair in storage), Pusa Red, Udaipur 101, Udaipur 103, VL-3

2. Kharif Onion: Arka Kalyan, Arka Pragati, Baswant-780, N-53, Arka Niketan (can also be grown in late kharif in Maharastra)

3. White skinned varieties: Pusa White Flat, Pusa White Round, N-257-9-1, 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)

B. Multiplier Onion:

Agrifound Red, CO-1, CO-2 (resistant to purple blotch), CO-3 (resistant to thrips), CO-4 (moderately resistant to thrips), MDU-1

C. Small Onion:

Agrifound Rose (pickling type, suitable for export), Arka Bindu

Varietal characteristics of some of the important varieties are given as under:

RED SKINNED CULTIVARS

Agrifound Dark Red:

- Recommended for cultivation in summer season in hills and dry temperate zone of Himachal Pradesh.
- Bulbs are dark red, globular in shape with tight skin, moderately pungent.
- Matures in 100-110 days for maturity, excellent in keeping quality.
- Average yield 200-250q/ha.

Agrifound Light Red:

- Bulbs globular, 4-6 cm in size, matures in 160-165 days after sowing.
- Average yield is 300 q/ha.
- Recommended for winter (rabi) season and good for storage.

Agrifound Rose:

- A pickling type cultivar, bulbs 2.5-3.5 cm in size, matures in 95-110 days after sowing.
- Average yield is 190-200q/ha.
- Suitable for export.

Arka Bindu:

- Bulb size 2.5-3.5cm, mature in 100 days after transplanting.
- Average yield is 250q/ha in winter season and recommended for export

Arka Niketen:

- Bulbs globular, 4-6 cm across, mature in 145 days after transplanting.
- Average yield is 330q/ha.
- Good for storage and recommended for winter season (rabi).

Pusa Red:

- Bulbs medium sized, flat to globular, matures in 140-145 days after transplanting.

- Average yield is 250-300q/ha.
- Recommended for rabi season.
- Very good for storage.

Punjab Red Round:

- Medium to large sized bulbs, early maturing, yields on an average 300q/ha.
- Recommended for rabi season.

Punjab Selection:

- Bulbs of 5-5.5 cm in diameter, weighing about 50-70 g; average yield is 200q/ha.
- Recommended for rabi season.

WHITE SKINNED CULTIVARS

Pusa White Flat:

- Medium to large bulbs, TSS content is 12-14%, drying ratio is 9:1 matures in 20-130 days after sowing, average yield is 330-350q/ha.
- Recommended for rabi season.
- Suitable for dehydration purposes, very good for green onions and storage.

Pusa White Round:

- Matures in 125-130 days, TSS 12-13%, drying ratio is 8:1 and average yield is 300-330q/ha.
- Recommended for rabi season.
- Suitable for dehydration purposes and green onions.
- Very good in storage.

Punjab 48 (S-48):

- Average yield is 300q/ha, matures in 140 days after sowing.
- Suitable for dehydration purposes.

Udaipur 102:

- Bulbs 4.5-6.5 cm in size, mature in 120 days after transplanting, average yield is 300-350 q/ha.
- Suitable for rabi season and dehydration.

Palam Lohit:

- High yielding, attractive deep purple round
- Bulbs with narrow neck.
- Early in maturity than Patna Red

- Average bulb yield 450 q/ha.
- Moderately resistant to downy mildew.

YELLOW SKINNED VARIETIES

Brown Spanish:

- It is a medium long day type variety suitable for low hills.
- bulbs are thick skinned, bulbs are round and globular, brownish red coloured, less pungent, excellent storability, average yield 250-300q/ha

Early Grano:

- Bulbs 7-8 cm in size, mature in 95-110 days after transplanting, average yield is 500-600 q/ha.
- Good for salad.
- Suitable for green onions and better storage.

KHARIF

ONION

VARIETIES

Arka Kalyan:

- Bulbs 4-6 cm across, maturity 100-110DAT.
- Average yield 336 q/ha.
- Recommended for rainy (Kharif) season

Arka Pragati:

- Maturity 140-145 DAT.
- Recommended for winter (Rabi) and rainy (Kharif) season.
- Average yield 200 q/ha.

Baswant 780:

- Matures in 110-110 DAT.

- Average yield 200-250q/ha.
- Recommended for rainy (Kharif) season
- Good for storage.

N-53:

- Bulbs are globe shaped medium sized, very attractive, purplish red at harvesting and moderately pungent.
- Bulbs mature in 150-165 days, neck of the bulbs become thin at the time of maturity and leaves remain green.
- Most suitable for kharif season, average yield 150-180q/ha.

Arka Niketan:

- Bulbs globular, 4-6 cm across.
- Matures in 145 DAT.
- Average yield 340 q/ha.
- Recommended for winter season. Good for storage

SOWING TIME

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

SEED RATE

Propagation Method	Seed Rate/ha
Rabi	8-10 kg
Kharif	12-15 kg
Dibbling Method	20-25 kg

SPACING

- Follow a spacing of 15 cm between rows and 5-8cm between plant to plant
- Transplanting on ridges is ideal for kharif onion crop.
- Partial pruning of top is done in over-aged tall seedlings to augment the stand of the crop.
- It also provides convenience in planting.

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

NUTRITIONAL REQUIREMENTS

- Apply well rotted Farm Yard Manure @200-300q, nitrogen @ 60-150kg, phosphorus@ 35-150 kg and Potassium@ 25-120kg per hectare depending on the soil test, cultivar and growing season.
- FYM is applied at the time of field preparation. Apply 50 per cent nitrogen and entire quantity of phosphorus and potash before transplanting or bulb sowing.
- Remaining half nitrogen is top dressed 5-6 weeks after transplanting.

IRRIGATION

- Just after transplanting and subsequently irrigation is given as per need of the crop and critical stages.
- Irrigation should be stopped 15-20 days before uprooting the bulb or before commencement of maturity.
- 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 is to be applied at an interval of 10-15 days in cool weather and at a week interval during hot weather.
- Bulb formation and bulb enlargement stages (70-100 days after transplanting) are the critical for water requirement.
- Insufficient moisture tends to slow down bulb growth while over supply causes rotting. A dry spell may cause splitting of the outer scales.
- Generally, 10-12 irrigations are given in rabi season.
- Stop irrigation when the tops mature and start falling down.

INTER CULTURAL PRACTICES

- Onion is a closely planted and a shallow rooted crop and hence hand weeding is difficult 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.
- Apply Trifluralin @ 0.75-1.0 kg/ha or Alachlor (Lasso) @ 2 litres/ha or Pendimetalin (Stomp) @ 3 litres/ha as pre-transplant application in 750 litres of water.
- Soil incorporation of nitrofen @ 1.2-2.0 Kg/ha as post plant application is recommended at 25-30 days after transplanting.
- Three weedings are sufficient to harvest economic crop if performed at 30, 50 and 75 days after transplanting.

Growing kharif onions by sets:

- Onion sets are small bulbs (around 0.25-1.0 inch in diameter) grown in the previous year.
- These sets are used as the propagating material for the production of dry bulbs and bunching onions.
- Variety recommended for this crop is N-53.
- 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 diameter and disease free are selected and stored till July.
- About 10 quintals 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.

Production technology of rainy season (kharif) onion in northern India

- Onion is usually grown in winter (Rabi) season in Northern India, but it is grown both in Rabi and rainy season (Kharif) season in Central, Western and Northern India.
- Research work carried out in IARI has helped to standardize production technology to obtain successful Kharif crop.
- NHRDF has taken up this technology on large scale at farmer's fields in Rajasthan, Punjab, Haryana, Eastern Uttar Pradesh and Bihar.
- For successful Kharif crop, seed should be sown by end of May and June and transplanted in August.
- Harvesting is done in December-January. Suitable varieties for Kharif crop are N-53, Agrifound Dark Red, Baswant 780 and Arka Kalyan.
- About 150-200 q/ha of yield can be obtained.

Production technology of long day types in hills

- Use Brown Spanish variety.
- Seed sowing should be done in September-November.
- Transplanting should be done by March
- Harvesting should start in the month of August.
- Plants can be stored up to March-April

HARVESTING

- Onions are ready for dry bulbs harvesting when the tops get dried (or 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 from the time they reach pencil size up until bulbing begins.
- To hasten the maturity process, the tops can be rolled down with a light weight roller when about 10 per cent of the tops have fallen naturally.
- 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 loss.

Onion for green production

- Plants are pulled when bulbs just start formation

Immature bulb purpose

- As per need i.e. either for home consumption or supply to market, pull along with the tops.

Mature bulb purpose

- Picked when the top starts drooping just above the bulb point, it is also known as Neck-fall stage.

YIELD

Rabi Season:

- Average yield varies from 300-350 q/ha

Kharif Season:

- Average yield varies from 250-300 q/ha

DRYING AND CURING

- In northern India, for kharif season, curing is required for 2-3 weeks along with the tops.
- In rabi, bulbs are cured in field for 3-5 days in window method, tops are cut, leaving 2-2.5cm above the bulbs and then bulbs are again cured in shade for 7-10 days to remove the field heat.
- Curing for 10-12 days in shade helps in the development of more number of skin and also their retention for longer period.

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.

GRADING

- Onions are graded into big, medium and small size as per market demand.
- Thicknecked, bolted, doubles, injured and decayed bulbs are picked out and rest are graded into different size.

STORAGE

- At all temperatures, there is a gradual loss in weight of onion.
- The onion bulbs can be stored at temperatures of 23.9-29.4°C or higher for 5-6 months without sprouting and without excessive loss in weight.
- A temperature of 0°C and a relative humidity of 65-70 per cent has been recommended for successful storage

DISEASES

Fungal

Diseases

Downy mildew: (*Peronospora destructor*)

- The first sign of the disease is the formation of elongated patches on leaves varying in size.
- These areas become covered with white to purplish fruiting bodies.
- Often, leaves fold over the affected area and the leaf tips wither away.
- Bulbs do not attain full growth and are often soft and immature.
- Cool temperature and presence of water is required for disease initiation.

Control measures

- Before sowing, treat the bulbs with mancozeb (0.25 %) followed by spray with the same fungicide at the same concentration.
- Regular sprays of metalaxyl + mancozeb (0.25%) checks this disease.

Onion smut : (*Urocystis cepulae*)

- This disease is more prevalent in temperate regions.
- The fungus survives in the soil.
- Dark brown streaks are seen on the leaves and stem.
- The bending and twisting of earlier infected leaves also occur.
- The linear black lesions most commonly appear near the base of the bulb and grow up to the fourth scale deep.

Control measures:

- Seed treatment with thiram or captan (3g/kg seed) checks seed borne infection.
- Also treat the soil with formaldehyde (1:7) before sowing.

Purple blotch : (*Alternaria porri*)

- It is very destructive under favourable conditions.

- The first spot usually appears on the oldest leaves.
- In the beginning they are small, elongated, sunken and whitish, generally with purple centre.
- These blotches later on enlarge, coalesce and are covered with the black fruiting bodies.

Control measures

- Seed treatments with captan or thiram (2.5g/kg seed), proper crop rotation, adequate drainage in the fields and fungicidal application of mancozeb (0.25%) have been found very effective.

Black mould: (*Aspergillus niger*)

- The infection starts from the top or any other injured portion.
- The affected tissue becomes water soaked and at first a white mould develops between the scales.
- This follows development of black spores on the stalk which can be seen with naked eyes and the mass remains on exterior of the scales and can easily be rubbed off.

Control measures

- Avoid bulb injury during various operations and sort out any bulb showing wound, green and thick neck, doubles etc.
- Allow only perfect bulbs for storage.
- Also clean the stores properly and check for sufficient ventilation, and temperature should be below 15°C.

Stemphylium leaf spot: (*Stemphylium vesicarium*)

- Purple coloured long spots appear on stems and leaves.

Control measures

- Spray of metalaxyl + mancozeb (0.25%) as soon as the symptoms appear.
- Repeat after 15-20 days if needed

Bacterial

diseases

Soft rot: (*Erwinia carotovora* pv. *carotovora*)

- The disease is characterized by water soaked soft rot on inner scales of bulbs.
- Sometimes bulb appears healthy from outside but if cut open, 1-2 scales are found infected.

Control measures

- The disease can be managed by applying streptomycin (200 ppm), and the use of resistant varieties.

Viral

disease

Onion yellow dwarf virus

- Short yellow streaks appear at the base of the first leaf emerging through the neck of the bulb.
- The leaves fall over and present an abnormal appearance.
- Flower stalks of the infected plant show yellow streaks extending upwards from the base.
- Later the streaks coalesce.
- The stalk becomes yellow throughout, and get twisted and curled in a characteristic manner.
- The leaves turn yellow, become crinkled and drop underdeveloped, although they are usually well shaped.

Control measures

- Indexing of virus free material, production of virus free stock of bulbs in areas where disease is absent and roguing out infected and volunteer onion plants will control the disease.

Pests

Onion thrips: (*Thrips tabaci*)

- Affected leaves show silvery white blotches which later become brownish.
- Spring summer crop is affected much by thrips.
- A long spell of dry weather is favourable for its rapid multiplication.

Control measures

- Collect the debris, affected leaves, weeds and destroy them.
- Follow crop rotation.
- Grow resistant varieties like Nasik Red and Spanish White.
- Apply malathion (0.05%) or phorate 10 G (1 kg /ha).

Borer: (*Helicoverpa armigera*)

- Larvae attack leaves, flower and flower stalks.

Control measures

- Collect and destroy affected flower and flower stalk and apply deltamethrin (0.0025 %).

Onion maggots: (*Hylemyia antiqua*)

- It attacks the tender portion of the bulb.
- They remain hiding in the base of the plants or in the cracks of the soil, where they also lay eggs.

- Affected plants become yellow to brown.

Control measures

- Soil application of phorate 10G (25 kg/ha) and spray of malathion (0.05 %) can be done.
- Follow crop rotation.

Mites

- These are very small pests and remain mostly on the under surface of the leaves.
- Affected plants become pale yellow.
- Crop infested with mites gives sickly appearance.

Control measures

- Expose infected bulbs to sun for about two days and dust the crop with malathion dust (20-25 kg/ha).

Bulb or stem nematode: (*Ditylenchus dipsaci*)

- It is one of the important seed borne nematodes.
- Seedlings become pale white, twisted and stunted in growth.
- Leaves become thick and swell, resulting in splitting of the epidermis.
- Bulbs also carry nematodes.
- Tips of the leaves become necrotic.
- Cracks appear in the bulb.

Control measures

- Provide good drainage, obtain and use healthy seeds, follow long crop rotation and sow resistant varieties.

PHYSIOLOGICAL

DISORDERS

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
- Restricted or poor vegetative growth also leads to bolting.
- Sharp fluctuations in temperatures at bulb initiation stage.
- Low temperature (10-12°C) for prolonged period.

- Poor supply of nitrogen in nursery and field.

Correction

- Time of planting should be adjusted in such a way that the crop may expose to moderate temperature at bulbing.
- Sowing of nursery at proper time
- Transplant healthy and 6-7 weeks old seedlings.
- Supply recommended dose of nitrogen.

Sprouting

- An important disorder in storage of onion and garlic and results in huge losses.
- It is associated with excessive moisture at maturity and supply of nitrogen.

Correction:

- 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.

SEED PRODUCTION

SEED PRODUCTION

- Onion seed is usually produced in the temperate and subtropical countries and in regions where high temperature prevails throughout the year especially during seed ripening.
- Only the early bolting type of onion requires relatively little low temperature exposure to produce seed.
- Onion is a biennial crop for the purpose of seed production.
- In one season, bulbs are produced from seed and in the second season bulbs are replanted to produce seed.
- Onion seeds are poor in keeping quality and loose viability within a year.
- Therefore, it is essential to produce seeds freshly and use the same for bulb production.
- It is highly cross-pollinated crop which is facilitated by protandrous nature of flowers.
- Cross pollination is carried out by honeybees.

Methods of Seed Production

- There are two methods of seed production.
- Most commonly used method of seed production is bulb-to-seed method.
- Another method is seed-to-seed method.
- In the first year, the crop is raised in the same manner as raised for table purpose (first year)

Bulb-to-seed method

- The bulbs produced in the previous season are lifted, selected, stored and replanted to produce seed in the second year.
- Mostly the bulb to seed method is used for seed production because of following advantage over the seed method.
- It permits selection of true to type and healthy bulbs for seed production.
- Seed yields are comparatively high.
- The seed to seed method, however, can be practised for varieties having a poor keeping quality.

First season

All the package of practices are same for raising bulb crop as followed for table crop.

Planting of bulbs and seed production (second year)

Selection of Bulbs

- For seed production, bulbs harvested during warm weather should be selected and stored carefully till middle of October.
- Temperature ranging from 4.5-14°C with an optimum of 12°C is the best for storage of mother bulbs which are to be planted for seed production.
- The roots of the bulbs should be left intact after harvest.
- Bulbs selected for replanting should be free from disease infection.
- Double and long necked bulbs are discarded and only true to type are selected.

Time of planting bulbs

- The best time of planting of bulbs is the second fortnight of October

Preparation of land

- Prepare the field to good tilth by one deep ploughing, followed by three to four harrowing and land leveling.

Seed rate

- The seed yield is affected by the size of bulbs.
- The bigger sized bulbs give high seed yield.
- However, a very large size bulb of 2.5-3.0 cm diameter is used for planting.
- Approximately 15 quintals of bulbs per hectare are required.
- If the bulb diameter is 3-4 cm, it will need three times more seed bulb.

Method of planting and spacing

- Selected bulbs are planted 8-10 cm deep in the soil at a distance of 30-45 × 30-45 cm, the size of beds depend upon the source of irrigation.
- In certain species, the upper half portion should be removed, leaving the disc like stem and roots intact, the removal of upper tops hasten sprouting.

- To avoid rotting due to fungal infection of bulbs in the field, carbendazim @ 0.2 per cent is used for dipping the bulbs before planting.
- The treated bulbs are planted along one side of the ridge.

Irrigation

- Fortnightly irrigation is given during winters and weekly irrigation is given during the hot weather.
- Discontinuing irrigation when the seeds reach the milk stage gave high yields, good quality seeds with economy of labour and water.

Nutrient management

- The doses and methods of application are same as for the first year.

Interculture

- Same as in first year
- Higher seed yield is obtained if planting is done in the first fortnight of October.
- Mulching practices record higher yield.
- Herbicide treatment (pendimethalin and fluchlorlin at 2.5 l/acre) and fungicide sprays (0.3% mancozeb) at 10 days intervals to control purple blotch also increase seed yield and quality.

Seed-to-seed method of seed production

- In this method, the first season crop is left to over winter in the field, so as to produce seed in the following season.
- Bulb-seed method of seed production not only takes two years for seed production but it is more expensive as large quantities of bulbs are to be stored for planting in the second year and losses in storage may also be considerable.
- In this method more seed yields are expected and the time to ensure 100 per cent bolting is also eliminated.
- Seed yield from this method is much higher but seed quality may be poor as rouging process of bulbs is not practised.

Rouging of seed crop

First year

- It is desirable to begin rouging in the field before bulbs are harvested.
- Any plant having different foliage colour, or plant type, or maturing bulbs should be rogued out from the field.
- After harvesting, the bulb should be carefully rogued for colour and off types such as thick-necks, doubles, bottlenecks, as well as many other types, which don't confirm to varietal type.

Second year

- Plant only true to type bulbs and remove plants not confirming to varietal characters before flowering.

Methods of Seed Production

There are two methods of seed production

Flowering

- Inflorescence in the form of umbels with small flowers, a single spathe which split into segments, young flowers emerges having a superior ovary above the six stamens and petals like perianth.
- Flowers are borne in simple umbels at the apex of flowering stem.
- Flowers may number from 50 to 2000 depending on cultivars.
- It is protandrous.
- The anthers of inner whorls dehisce first and usually it occurs between 9.00 am and 5.00 pm.
- Style becomes receptive when it elongates to a length of 5 mm.

Pollination

- It is a cross-pollinated crop.
- It is pollinated chiefly by honeybees, which visit the nectarines.
- Though cross-pollinated, selfing also takes place as insect visit many flower in a single umbels of the same plant before leaving for another plant.

Isolation requirement

- Onion is basically cross-pollinated crop, but some self-pollination does occur.
- It is chiefly pollinated by honeybees.
- For pure seed production, the seed field must be isolated from fields of other varieties of onion, and fields of same variety not confirming to varietal purity requirements for certification, at least by 1000 meters for foundation seed production and 500 for certified seed production.

Harvesting and threshing

- Seed is ready for harvest when first formed seed in the heads get blackened.
- Two to three pickings are necessary to harvest the heads at just the right stage.
- Seed heads are cut, or snapped off, keeping a small portion of the stalk attached.
- Seed heads, after harvest, should be thoroughly dried.
- Air circulation is important while drying seed heads.
- Hence, the tray or canvases should be filled only to a depth of 15 cm.
- Heads can be threshed when seeds separate easily from them.
- Much of the seed falls from the capsule during drying.

- The seeds can be cleaned by immersing them in clean water for 5-10 minutes and then drying in the sun or artificially.
- Before storage, the seeds must be dried for 6-8 per cent moisture.

Seed yield

- The average seed yield varies from 8.5-10 q /ha.

Factor influencing seed yield

Seed yield is influenced by many factors, among them important are:

- Cultivars
- Bulb weight
- Soil and climate
- Spacing
- Fertilizer application
- Seed stalks per bulb

SEED CERTIFICATION STANDARDS

SEED CERTIFICATION STANDARDS

Field Inspection

a. Mother bulb production stage: A minimum of two inspections should be done as follows:

- The first inspection should be done after transplanting of seedlings in order to determine isolation, volunteer plants, off-types including bolters and other relevant factors
- The second inspection should be done after the bulbs have been lifted to verify the true characteristics of bulb.

b. Seed production stage: A minimum of four inspections shall be made as follows

- The first inspection should be done before flowering in order to determine isolation, volunteer plants, off- types including bolters and other relevant factors
- The second and third inspection should be during flowering to check isolation, off types and other relevant factors.
- The fourth inspection should be at maturity to verify the true nature of the plant and other relevant factors.

A. Fields Standards

a. General requirements

Isolation: Onion seed fields shall be isolated from the contaminants as shown in the table:

Contaminants	Minimum Distance (meter)	
	Mother bulb production stage	Seed production stage

	Foundation	Certified	Foundation	Certified
Fields of other varieties	5	5	1000	500
Fields of the same variety not confirming to varietal purity requirements for certification	5	5	1000	500

b. Specific requirements

Factors	Maximum permitted (%)	
	Foundation	Certified
Bulbs not confirming to the varietal characteristic	0.10	0.20
Off types	0.10	0.20

B. Seed Standards

Factors	Standards For Each Class	
	Foundation	Certified
Pure seed (minimum) %	98	98
Inert matter (maximum) %	2	2
Other crop seeds (maximum) Number/ kg	5	10
Weed seeds (maximum) Number/ kg	5	10
Germination (minimum) %	70	70

Moisture (maximum) %	8	8
For vapour-proof containers (maximum) %	6	6

LEEK

AIM: Leek is a non-bulb forming member of the onion family and is grown for its blanched stem and leaves. It is eaten raw alone or mixed in salads and cooked as flavouring in soups and stews. It is not grown in India on commercial scale but is a favourite vegetable in a kitchen garden. The climatic and soil requirements are the same as those for onion. The present chapter will make the students understand with its importance, production technology, seed production practices and plant protection measures.

BOTANICAL NAME	<i>Allium ampeloprasum</i> var. <i>porrum</i> L. Syn. <i>Allium porrum</i> L
CHROMOSOME NUMBER	2n=2x=32
COMMON NAME	Leek
FAMILY	Alliaceae

INTRODUCTION

- Leek is a non bulb forming tetraploid plant of onion family.
- Except large size it looks like green onion.
- Its cultivation is not commercial in India and grown only in kitchen garden.
- Leek is cultivated for blanched stems and leaves.
- It is a biennial plant, consumed as salad and used in flavouring the soups.

ORIGIN

- The *Allium* species are not evenly distributed with in the northern hemisphere, since most of them occur in old world.
- Leek is thought to have been derived from the sand leek (*A. ampeloprasum*) which grows wild in southern Europe, North Africa and the Middle East.

NUTRITIVE VALUE (per 100 g of edible portion)

Energy (kcal)	77	Vitamin-	30
---------------	----	----------	----

		A(IU)	
Moisture (g)	78.9	Thiamine(mg)	0.23
Protein (g)	1.8	Calcium(mg)	50
Fat (g)	0.1	Iron(mg)	2.3
Carbohydrates(g)	17.2		

ADAPTABILITY

- Leeks grow best in a cool to moderate climate.
- The Willamette Valley and Oregon Coast are ideal.
- They can be grown all the year round.

SOIL

- A well aerated soil with both good drainage and good moisture retention capacity with a pH of 6.5-7 is best, which should not be subjected to flooding at any time.
- Deep ploughing is recommended so that a longer shaft can be developed.
- They can be grown successfully on mineral soils but in heavy clay soils, harvesting should be held up and the removal of surplus soil from roots may require more labour.

VARIETIES

Main fall varieties (August to October):

- American Flag, Jolant, Kilima, King Richard, Primor.

Late fall - winter (October to December):

- Derrick, Electra, Goldina, Goliath, Kilima, Tivi, Wintereuzen.

Overwinter (spring harvest):

- Carina, Conqueror (moderate bulbing), Eskimo and Siberia.

These varieties mature in 80-120 days.

Characteristics of few varieties is given here under PPL-1

- It is a selection from exotic germplasm.
- The whole plant is consumed.
- Leaves light green, swollen stem and do not form bulb.
- Ready in 150-160 days and good replacement for green onion.

Palam Paushtik:

- An alternative of green onion, suitable for salad, soup and cooking.
- Matures in about 140-150 days with average yield of 300-350q/ha.

SOWING TIME

- August – October is the ideal time of sowing in plains and seedlings are planted when they are 15cm height. In hills, it is sown in March-April.
- Leek withstands heat and cold better than onions.
- Temperature is more important than day length in seed stalk development.
- It thrives well in higher altitude.

- Seeds are produced in India at higher altitude.

SEED AND SEED TREATMENT

- About 5-7 kg of leek seeds is required to be sown per hectare, but leeks are not commonly direct seeded.
- Use treated high quality seed for transplant production.
- Leek seed, like other *Alliums* has very limited useful viability (less than 2 years) unless stored under ideal conditions.

Seeding and Transplanting

- Direct field seeding is possible but not recommended due to the lack of registered herbicides and length of time needed to harvest from direct-seeded plantings (8-12 months or longer).
- Leeks are normally transplanted.
- They should be seeded under protection early in the season (February to March) or in outdoor seedbeds (April to May).
- Leeks for harvesting in August-September should be sown from mid-February to mid-March.
- For harvesting in early winter sow the crop from mid-March to mid-April.
- For spring harvest, seed may be sown from April to mid-May.
- The right varieties (above) must be used for each harvest season.
- At transplanting, leek seedlings should be placed in furrows 15 cm deep.
- Furrows are filled in during cultivation and as the plants develop, the rows should be hilled up.
- Leeks should have a white shaft that reaches almost to the base of the leaves.
- Care must be taken not to allow soil between leaves as it will penetrate the shaft.
- Another method of transplanting is to drop each seedling into an individual hole, 15 cm deep, pressed into the ground.
- This procedure eliminates the need for filling of furrows but ridging should still be done.
- Seedlings are spaced at a spacing of 40 x 10 cm.

NUTRITIONAL REQUIREMENTS

- A soil test is necessary to determine phosphate and potash requirement.
- Apply 200-250q well rotten Farm Yard Manure or compost along with 80-100kg N, 60 kg P₂O₅ and 80 kg k₂O/ha.
- Entire quantity of FYM, P₂O₅, k₂O and half N should be thoroughly mixed in the soil at the time of planting. Remaining N is side dressed one month after.

USE OF GROWTH REGULATORS
For proper growth and development

- Ethephon @ 50mg/l as foliar spray should be applied 20-25 days after sowing.

- NAA @50mg/l should be applied at 60 and 90 days after planting.

IRRIGATION

- Irrigate uniformly to maintain vigorous, uniform growth and tender stalks.
- A total of 12-15 inches of water may be required depending on planting date, seasonal variation and variety.
- Soil type does not affect the amount of total water needed, but does decide frequency of water application.
- Lighter soils need more frequent water applications, but less water applied per application.

WEED CONTROL

- Same as that of onion.

BLANCHING

- Blanching is important in leek cultivation.
- It is done by covering the plants to a certain height so as to bleach them, which improves the quality of the crop.
- For this purpose, plants are put in up to their center leaves in trenches or pits which are heavily manured and to earth up soil as they grow.
- Care should be taken not to earth up soil too early when the plants are young.

HARVESTING AND HANDLING

- Leeks do not bulb or go dormant in the fall but continue to grow slowly.
- The time of harvest is, therefore, very flexible, depending on the time of planting, market conditions and variety of leek planted.
- Small leeks can be sold starting in early August and varieties that have frost tolerance may be harvested throughout the fall and winter months.
- Machine harvest of leeks is now possible, but most leeks are lifted or dug by machine and then harvested, cleaned and packed by hand.
- Single or multiple row harvesters can be used effectively.

YIELD

- Leek yields approximately 925q green bulbs per hectare.

STORAGE

- Store leek seed at 0°C and 95 to 100 per cent relative humidity.
- Leeks, if properly handled, should be kept satisfactorily for 2 to 3 months at 0°C.

- Leeks should be cooled promptly after harvest to near 0°C by hydro cooling, crushed ice or vacuum cooling and they should be kept at this temperature with high relative humidity throughout storage.
- Yellowing and decay develop rapidly at warmer storage temperatures.
- High relative humidity is essential to prevent wilting.
- The use of polyethylene film crate liners and of crushed ice can aid in preventing moisture loss.
- Good refrigeration will retard the elongation and curvature that develops in leeks at 10°C or 21.1°C.
- Respiration or heat evolution of leeks is about eight times faster at 21.1°C than at 0°C.
- Storage for 4-5 months at 0°C is possible by using a controlled atmosphere (CA), although there will be some loss in quality.
- The best CA contains from 1-3 per cent oxygen and from 5-10 per cent carbon dioxide.
- This CA retards yellowing and decay.
- Atmospheres containing 15-20 per cent carbon dioxide cause tissue injury.
- Cultivar, pre harvest and post harvest conditions, degree of trimming and method of packing will all influence the storage life of leeks.

PACKAGING

- Leeks are commonly trimmed to 12 inch length, bunched depending on diameter and often placed in polyethylene film bags.
- They are usually packaged in 5 kg cartons or wire bound crates, holding 10 film bags, each 500 g
- Other crates may be packaged with 18-24 bunches with a net weight up to 15 kg.

DISEASES

- Diseases of leek are same as that of onion

PESTS & SEED PRODUCTION

PESTS

Onion maggot : (*Hylemya antique*)

- It is similar in appearance to a housefly, though smaller.
- Larvae feed on the plant tissue.
- They may kill smaller plants.
- Feeding wounds act as entry point for secondary plant pests.

Control measures

- Spray malathion (0.05%) or deltamethrin (0.0025%)

Onion Thrips : (*Thrips tabaci*)

- Affected leaves show silvery white blotches which later become brownish.
- Spring- summer crop is affected more by thrips.
- A long spell of dry weather is favourable for its rapid multiplication.

Control measures

- Collect the debris, affected leaves, weeds and destroy them.
- Follow crop rotation.
- Grow resistant varieties like 'Nasik Red' and 'Spanish White'.
- Apply malathion (0.05 %) or phorate 10 G (1 kg /ha).

SEED PRODUCTION

- Leek does not usually seed in the plains as the mature plants should be expose to low temperatures for a period before they form flowering stalks.
- The seed is produced at higher altitudes in the hills.

Methods of Seed Production

Seed to seed method

- In this method, the first season bulb crop is left to over winter in the field, so as to produce seed in following season.

Bulb to seed method

- Bulbs stored in previous season are lifted, selected and replanted to produce seed in 2nd year.

Mostly bulb to seed method is followed because

- It permits selections of true to type and healthy bulbs for seed production.
- Seed yields are comparatively high.

Production and storage of bulbs (1st year) Sowing time

- Sowing of over wintered bulbs is done from Middle of October to middle of November

Nutritional Requirements

- Apply 200q/ ha of FYM, 60 kg each of N and P and 80 kg of K per hectare.
- Method of application is the same as for bulb crop.

Spacing

- Depends upon variety and bulb size, a spacing of 40 x 10 – 15 cm is followed.

Irrigation

- Fortnightly irrigation during winters and weekly irrigation during hot weather/summers is required..

Interculture

- Same as that of onion
 - **SEED CERTIFICATION STANDARDS**
- **A. Field Standards**
- **a. General requirement**
- **Isolation**
-

Contaminants	Mother bulb production stage (meter)	
	Foundation Seed	Certified Seed
Field of other varieties	5	5
Field of same variety	5	5

-
- **b. Specific requirements**

Factors	Maximum permitted limits (%)	
	Foundation Seed	Certified Seed
Bulbs not confirming to varietal characters	0.10	0.20
Off types	0.10	0.20

-
- **B. Seed Standards**

Factors	Standards	
	Foundation Seed	Certified Seed
Pure seed (minimum) %	98	98
Inert Matter (maximum) %	2	2
Weed seeds (maximum) Number/ kg	5	10
Germination (minimum) %	70	70
Moisture (maximum) %	8	8
For vapour Proof containers (maximum) %	6	6

ASPARAGUS

BOTANICAL NAME	<i>Asparagus officinalis</i> L.
CHROMOSOME NUMBER	2n=2x=20
COMMON NAME	Satavari
FAMILY	Liliaceae

INTRODUCTION

- Asparagus is an herbaceous perennial and is grown in large areas in countries like USA, Germany, Spain and France, while India's contribution is meager.
- The tender shoots called 'spears' are used as vegetable and in preparation of soup.
- It is also eaten as salad.
- The canned and frozen spears are also used as processed foods.
- The tender shoots contain a white crystalline substance, asparagine, which is used in medicine as diuretic in cardiac dropsy and chronic gout.
- It has good potential as fresh vegetable.

ORIGIN

- Asparagus has been grown for many years.
- The Ancient Greeks and Romans relished this crop.
- It originated in Asia Minor and is a member of the lily family.
- California, Michigan, and Washington are the major producing states, but there is some commercial production in many of the northern and western states.
- Warm regions such as Northern Mexico and Southern California also grow it.
- Recent research has shown that asparagus can be grown at a profit in India too.

NUTRITIVE VALUE (per 100 g of edible portion)

Moisture (%)	91.7	Fat (g)	0.2
Thiamine (mg)	0.12	Calcium (mg)	15.8
Carbohydrates (g)	2.9	Energy (Kcal)	20
Vit. B ₂ (mg)	0.13	Fe (mg)	0.7
Protein (g)	1.7	Vitamin A(IU)	762
Vitamin C (mg)	25	P (mg)	46.9

CLIMATE

- Asparagus is grown in temperate and sub-tropical regions.
- Mean day temperature of 25-30°C and 15-20°C at night are ideal.

SOILS AND SOIL PREPARATION

- Well drained soils are must for successful production, and sandy soils are also preferred.
- Good drainage is important to control crown rot disease.
- Commercial plantings of asparagus should not be made in soil that is heavier than a sandy loam.
- Avoid sites which retain standing water for more than 8 hours after a heavy rain.
- The optimum pH is 6.5-7.5.

VARIETIES

- Many new asparagus varieties are now available.
- Varieties are broadly divided into two groups,
 1. With green coloured spears : more popular and mainly used in fresh market
 2. With white or light green coloured asparagus - mainly used for processing.
- All available male hybrids are more productive and do not produce seed which sprouts to become a weed.
- Jersey Gem, Jersey Giant and Greenwich produce superior yields in North Carolina.

- Jersey Gem has the added benefit of having tolerance to the disease *Cercospora* leaf spot.
- The increased yields of hybrids make them worth the extra seed cost.

Perfection:

- Recommended by IARI, New Delhi.
- It is an early, uniform, productive variety, delicious with high food value.
- The spears are large, green, succulent and light tipped.
- Average yield is 80-100 q/ha.

Selection-841:

- Bush type, medium, uniform plants and productive.
- The spears are 15-20 cm long, succulent, tender, green with better flavour and suitable for soup preparation.
- Yield is 90-110q green spears/ha.
- Despite these varieties, UC-72, UC-66 and Sel-831 are also grown in Kashmir, India.

SEASON/SOWING TIME

- In hills : March-May
- In plains : July-November

SEED RATE

- Asparagus can be propagated through seeds, seedlings and crowns but most commonly followed practice is through seeds only.
- It requires about 3-4 kg seed for cultivation in one hectare.

NUTRIENT MANAGEMENT

- Apply chicken manure @75-125 quintals per hectare or Farm Yard Manure@150 to 250 quintals per hectare as basal dose.
- In addition, during succeeding years, apply 80-120kg of nitrogen, 80-100kg of phosphorus and 60-80kg of potassium per hectare twice in a year.
- Make one application of N, P and K just before first appearance of spears in the spring in early March.
- Apply the same amount of fertilizer at the conclusion of the harvest season in mid-May.
- Apply the fertilizer to the top of the soil or with very shallow incorporation.

PLANTING

There are three methods of planting
a) Crown planting

- Use only certified crowns for planting as they may carry several diseases

- Plant asparagus crowns (roots plus plant buds) so that the top of the crown is 15 cm below the soil level.
- Depth of planting is critical, if planted too shallow, asparagus will produce a large number of small spears that are not commercially salable.
- If planted too deep, spears will be very large, but will be few in number.
- Plant crowns 30 cm apart in the row with the buds upright, and 150 cm between rows to have 21,750 crowns per hectare.
- Cover crowns with 5-7.5 cm of soil after planting.
- As plants grow, gradually fill in the rest of the furrow with 2.5-5 cm of soil in 3-5 cultivations, but do not completely cover plants.
- The furrow should be completely filled by July of the first year.
- Plant before the buds begins to appear in the spring.
- Both direct seeded and transplanted asparagus can be planted in single or double rows with 5 foot spacing between beds.
- Single rows should be planted on top of "W" shaped beds (Fig.15.1).
- The "W" shaped rows are formed with a wide furrow opener followed by a beds shaper.
- Double rows of direct seeded or transplanted asparagus should be planted on shelved beds (Fig. 15.2).
- Transplants can also be planted on the side of an angle-shaped furrow (Fig. 15.3). The "V" shape in the middle of the row is important since it provides a place for soil washed from the side of the beds during rains (Fig. 15.4).

b) Direct seeding methods

- Seeds should be placed 5 cm apart in the row, 2 to 2.5 cm deep.
- Single row seedlings require 2.5-3.4kg of seed per hectare and double row seeding require 4.5 to 6.8 kg seeds per hectare.
- Asparagus seeds germinate best at 24°C.
- Direct seeding is preferred when the soil temperature is at least 16°C.

c) Seedling transplant method

- Asparagus seedlings can be grown successfully in peat pots, plastic pots, trays, peat pellets or seedling type trays.
- Seedling growth and survival are usually better with larger cells up to 5x5 cm seedling cells.
- Most of the artificial soil media produce a good transplant.
- Good growth above the crown and good root system development require planting the seed not more than 1.25 cm deep.
- Transplanting of seedling is preferred after the threat of frost but before temperatures get above 32°C.
- Favourable conditions usually occur in April and May.

DIRECT SEEDING AND TRANSPLANTING

- Direct seeding have the following advantages over crown planting:
 1. Reduced costs, mechanization of planting, freedom from disease and increased yields are few advantages of this method.
 2. But these methods require more care, closer attention, irrigation and better management than crown planting.

USE OF PLANT GROWTH REGULATORS

- Abscissic acid appears to promote sink strength or encourage phloem uploading.
- Gibberellic Acid promotes growth of asparagus buds.
- Butyric Acid supports spear emergence.

IRRIGATION

- Adequate moisture should be maintained for good germination and early seedling growth.
- Do not let asparagus plants become dry while they are establishing a root system during the first two months.
- Water stress during this early stage can reduce yields.
- After the root system is established, irrigation is needed only during extreme drought.

WEED MANAGEMENT

- Weed control in asparagus production is very important.
- Timely cultivation is a critical part of any asparagus weed control program, especially during the first two years.
- The first year asparagus should be cultivated at least once in a month until September or 6 times.
- The number of cultivations may be reduced by using herbicides.
- Remove all weeds that are present after harvest.
- Use only very shallow disking (2.5 to 5 cm) to remove these weeds.
- Deeper disking will damage crowns and can drastically reduce yield.

HARVESTING

- Asparagus can be harvested on limited basis (2 to 3 weeks, or 8 spears per plant) during the first year after planting.
- Harvesting should be limited during the second year as it results in slight reduction in spear size which is as an indication of when to stop.
- It takes a long time for asparagus to develop a large root system.
- A large root system is necessary for a healthy bed of asparagus to produce for many years.
- Do not harvest too much in early years because bed life can be shortened and total yield and profit drastically reduced.
- Harvest 6 to 8 weeks during the third year of growth, generally until mid-May.
- Allow spears to reach 20 cm tall and then cut with a knife or hand snap at the soil surface.
- Spears should not be allowed to get taller than 22.5 cm.
- The decision on when to harvest is based on having an average of one harvestable size spear per foot of row.
- When temperature exceeds 27°C, it may be necessary to harvest daily.

BLANCHING

- Mounding the soil to a height of 25-30 cm over the rows is practiced to blanch the young spears and get 'white asparagus' for canning.
- After harvest, the spears should be held in a cool shaded place and sprinkled with water to prevent shriveling and wilting.
- A single irrigation sprinkler over the boxes works well. Asparagus should be hydro cooled before packing.

MARKETING

- When preparing asparagus for market, spears should be uniform in length.
- Tie in bunches of 500-1000g or pack loose in a carton.
- Asparagus loses edible quality rapidly and should be cooled as soon as possible.
- After bunching, place the butts of the spears in damp peat moss or blotter paper in a crate or carton.
- Pack 6.8 or 13.6 kg in special pyramid-shaped crates.

YIELD

- Male plants give the higher total yield while female plants produce larger individual spears.
- Yield varies with varieties, region, climate, and sex form.
- On an average, 25-40 q spears are produced in one hectare

STORAGE

- Asparagus can be stored for 2-3 weeks at 95 per cent relative humidity and at 0-2°C.
- Spears stored in wet tissue paper looked fresh and firm after 13 or 16 days of storage.

DISEASES & PESTS

Crown rot and root rot

- Asparagus is affected by two *Fusarium* species.
- The first is *Fusarium oxysporum* pv. *asparagi* which causes crown rot; and the second one is *Fusarium moniliforme* which causes root rot.
- The crown rot fungus is found in most soils but at very low levels.
- If asparagus crowns are planted that have crown rot they will not produce spears for more than 4 to 7 years, and this is not profitable.

Control measures

- Do not plant asparagus in soil in which asparagus has been grown in the last 5 years.
- Do not purchase crowns grown in soil where asparagus was grown in the last 5 years.
- Purchase only certified crowns, keep asparagus growing rapidly to reduce crown rot disease by following the recommended management practices.
- The root rot pathogen may be spread through asparagus seed. Make sure to treat seeds for producing crown.

Cercospora blight : (*Cercospora asparagi*)

- Symptoms include small, oval and grey to tan lesions (spots) with reddish brown borders on the needles and small branches.
- It causes the needles to fall from the mature fern.
- It can be identified by the browning of needles.
- The disease occurs when the humidity and temperature are very high.

Control measures

- An integrated approach of several cultural practices will help provide partial control.
- Schedule overhead irrigations to allow thorough drying of the foliage before nightfall, or use drip or furrow irrigation to keep foliage dry.
- Wider row spacing will increase the air movement to dry foliage and delay canopy closure.
- Rows should also be planted in a north-south direction to take advantage of prevailing southerly winds in drying foliage burning.
- Disposal of infested residue in the spring delays blight appearance by about one week.
- There are no known asparagus varieties resistant to *Cercospora* blight.

Soft rot: (*Erwinia spp.*)

- Harvested asparagus is susceptible to bacterial soft rot.

Control measures

- Management is based on avoiding injuries and immediately cooling harvested spears.
- Wash water and water used for hydrocooling should contain chlorine.

Rust : (*Puccinia asparagi*)

- It is not a common disease.
- Rust causes small brown rusty pustules on spears and fern branches.

Control measures

- The most effective way to control asparagus rust is to plant resistant varieties.

PESTS

Asparagus beetle

- Asparagus beetles and their larvae attack on spears and ferns.

Control measures

- Spray carbaryl (0.1%) to control this insect.

Army worms

- Army worms can be especially bad on young ferns.

Control measures

- These can be controlled by deltamethrin (0.0025%) or carbaryl (0.1%).

European asparagus aphid

- It can be a problem occasionally.
- The blue-green aphid forms colonies in August or September.
- When the aphid forms colonies, it causes "Christmas tree" or bonsai effect.
- The new fern becomes shortened or stunted and new needles look like they are clustered.
- The entire plant takes on a blue green colour.

Control measures

- It can be controlled with a spray of malathion (0.05 %) or oxy-demeton methyl (0.025 %).

Follow the following important rules for producing asparagus seeds

- Do not harvest the spears because it reduces stored reserves for maximum stalk growth and seed production.
- Keep honey bees in the field to ensure good pollination.
- Control the asparagus beetles otherwise they will eat the seed.
- Since low germination is a common problem with asparagus seed, so harvest only red ripe berries for seed as compared to seed from less matured bronze coloured berries.

SEED

CERTIFICATION

A. Field Standards

General

a.

Isolation

Contaminants	Minimum distance (m)	
	Foundation Seed	Certified Seed
Field of other Varieties	500	300
Field of same variety not confirming to varietal purity	500	300

b. Specific Requirements

Factor	Standards permitted (%)	
	Foundation Seed	Certified Seed
Off types	0.10	0.20

B. SEED STANDARDS

Factors	Standards For each class	
	Foundation Seed	Certified Seed
Pure seed (minimum) %	96.0	96.0
Inert matter (maximum) %	4.0	4.0
Other crop seeds (maximum) Number/ kg	5.0	10.0
Weed seeds (maximum) Number/ kg	5.0	10.0
Germination (minimum) %	70	70
Moisture (maximum) %	8	8
For vapour proof containers (maximum) %	6	6

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GLOBE ARTICHOKE

AIM: Globe Artichoke commonly known as Artichoke is a perennial crop grown for its flower buds. It has thistle like plants. The above ground portion dies each year during winters and again emerges in spring. It is generally propagated by means of suckers or off shoots from the old root stocks and also by dividing the old crown into pieces with a portion of the stem. The buds are harvested before they become loose and fibrous. It is very nutritious as it contains appreciable quantities of proteins, carbohydrates and minerals. The present chapter will make the students understand with its importance, production technology, seed production practices and plant protection measures.

SCIENTIFIC NAME	<i>Cynara scolymus L.</i>
CENTRE OF ORIGIN	Mediterranean region
FAMILY	Compositae
VERNACULAR NAME	Hathichik
CHROMOSOME NO	$2n=2x=34$

- Globe artichoke commonly known as artichoke is an herbaceous perennial in which the globular immature flower heads or buds are used as vegetable.
- The cultivation of artichoke is done on a limited scale in India.
- However, it is an important vegetable crop in European countries.
- The small heads are eaten raw or cooked, white large heads are eaten only after cooking.
- The thick receptacle known as heart is used for canning.
- The flower heads are considered useful in the dietary of diabetics.
- The leaves are bitter and considered to be useful in dropsy and rheumatism.

NUTRITIVE VALUE (per 100 g of edible portion)

Moisture (%)	84.94	Riboflavin (mg)	0.066
Carbohydrates (g)	10.51	Niacin (mg)	1.046
Proteins (g)	3.27	Ca (mg)	44
Fat (g)	0.15	P (mg)	90
Fibre (g)	5.4	K (mg)	370
Energy (kcal)	47	Na (mg)	94
Vitamin-C (mg)	11.7	Mg (mg)	60

CLIMATE

- It is a cool season crop and requires mild and frost free winter.
- Freezing temperature kills the plants.
- The crop can be grown successfully at a temperature of 12-18°C.
- The temperature above 22°C results in tough buds and tendency to spread.
- The roots can tolerate and survive freezing temperatures, while it is injurious to aerial portions.

SOIL

- Globe artichoke grows on many types of soil but deep, sandy, well drained soil having adequate amount of organic matter is ideal.
- The optimum soil pH is 6-7.5.

VARIETIES AND CULTURAL PRACTICES

VARIETIES

Green Globe:

- Cultivar is typical fresh market cultivar with long and slightly pointed buds.

Magnifico:

- Only one new cultivar which is developed in recent years and it is grown in relatively few acres.

Traditional Cultivars (propagated Vegetatively)

- **Green, big:** Camus de Bretagne and Castel (France), Green Globe (USA).
- **Green, medium-sized:** Blanca de Tudela (Spain), Argentina and Española (Chile), Blanc d'Oran (Algeria), Sakiz and Bayrampasha (Turkey).
- **Purple, big:** Romanesco and C3 (Italy).
- **Purple, medium-sized:** Violetto de Provenza (France), Brindisino, Catanese and Niscemese (Italy), Violet d'Algerie (Algeria), Baladi (Egypt).
- **Spined:** Spinosa Sarda (Italy), Criolla (Peru).
- **Cultivars Propagated By Seeds:**

1. **For industry:** Madrigal, Lorca, A-106 and Imperial Star
2. **Green:** Symphony Harmony
3. **Purple:** Concerto, Opal and Tempo

PROPAGATION AND PLANTING

- It is propagated by suckers or off-shoots from the old root stock and also by dividing the old crown into pieces with a portion of stem.
- Seeds are also used to propagate the crop but it produces highly variable plants and therefore not popular.
- The suckers or off-shoots are removed when they are 30-45cm high.
- For seed propagation, raised seed beds are prepared, and seedlings of 10-12.5cm height are used for planting.

SOWING TIME AND SPACING

- The sowing time is August-October for plains and March-May for hills.
- Spacing is maintained at 120×90cm at the time of transplanting.

FIELD PREPARATION, MANURING AND IRRIGATION

- The field is brought to fine tilth by repeated ploughings and beds or ridges are formed at a spacing of 2.4m. being a perennial crop, it requires abundant quantity of nutrients.
- Incorporate 200-30q Farm Yard Manure per hectare in the soil at the time of field preparation.
- Besides, add 120-140kg nitrogen, 80-100kg phosphorus and 300-400kg potash per hectare should be applied to harvest higher yields.
- The whole dose of farm yard manure, phosphorus and potash should be applied at the time of land preparation but nitrogen should be applied in three split doses during the season.
- Prior to planting the soil must be ploughed deeply, working in substantial amount of organic matter.
- Liming should be done if the pH falls below 6.5.
- About three to five irrigations are sufficient to raise the crop.
- Avoid water logging conditions.
- After each irrigation, inter spaces between the rows are hoed for weed control.
- Since the crop stands in the field for 6-7 years, after each harvest the leaves and stems are cut off below the ground level and allowed to decompose in the soil.

WEED CONTROL

- Weeds are controlled with diuron or simazine applied prior to weed emergence and by cultivation.
- An application of Trifluralin (1.2kg/ha) + diuron (1.5kg/ha) before planting successfully control the broad leaved grassy weeds.

HARVESTING

- The sowing of crop through suckers or off-shoots is very popular and yields (in 6-7 months after planting) earlier than seed crop (about 8 months).
- The harvest season starts from September-October.
- A native plant produces 12 or more stems and 40-50 edible buds and harvest continues throughout the winter.
- Average yield is 100-120q/ha.

POST HARVEST HANDLING

- Each bud is cut along with 2-2.5cm long stem.
- The buds can be stored at 0°C with 90-95 percent relative humidity for a period of 3-4 weeks.
- Pre cooling of buds at 5°C is practiced to achieve lesser weight loss, discoloration and incidence of decay than buds that are not pre cooled.

• DISEASES AND PESTS

• DISEASES

• 1. Curly dwarf

- Curly dwarf is caused by virus.
- It includes leaf curl, dwarfing of the plants and reduced production of the buds and many of them misshapen.
- This virus is transplanted easily during the replanting process from propagating material if infected stumps are not culled carefully.
- Insect transmission of the disease may also occur.
- Buds may become misshapen and remain small.

• Control

measures

- Improved cultural practices including planting of garlic and onions will repel aphids, a prevalent enemy of artichokes.
- Avoid planting infected propagating material.
- Control of the insect vector that transmits the disease by repeated sprays of malathion @ 0.05 per cent is also recommended.

• 2. Botrytis blight : (*Botrytis cinerea*)

- It appears as a fungal growth and decay on tissue damaged by insect or frost, when the weather becomes warm and moist.
- Although it infects both the plant and the flower bud, economic damage is usually limited to the harvested artichokes.

Control

measures

- Best control for *botrytis* blight is low humidity and good air circulation and factors that do not enhance the infection.
- Removal of infected buds in the packing shed and storing and shipping at low temperature will control the disease.

• PESTS

• 1. Artichoke plume moth : (*Platyptilia carduidactyla*)

- It is the most common pest of artichoke.
- It is a brown buff moth with narrow wing.
- The yellowish larvae with black head feed on leaves, stem and developing buds.

Control**measures**

- Spray deltamethrin (0.0025 %) for effective control
- **2. Aphids: (*Myzus braggii*)**
- Several species of aphids feed on artichoke.
- The artichoke aphid is yellowish green while where as *Myzus fabae* is black in colour.
- Both cause serious damage by sucking sap from the underside of leaves.

Control**measures**

- These aphids can be controlled with a spray of malathion (0.05%) or oxy-demeton methyl (0.025%).

POTATO

BOTANICAL NAME	<i>Solanum tuberosum L.</i>
FAMILY	Solanaceae
CHROMOSOME NO	2n=48
COMMON NAME	Alu, Aloo, Aaloo

ORIGIN AND HISTORY

- The probable centre of origin of potato is in South America in the central Andean region.
- The first mention of potato in India occurs in Terry's account of a banquet at Ajmer given by Asaph Khan to Sir Thomas Ro in 1615.
- Cultivation of potato begun first in the Nilgiri hills in the 1822.

USES

- Potato 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 vitamins (B₁, B₂, B₆ and C), minerals (Ca, P and Fe) and protein.
- It contains all the dietary substances except fat. It is used as staple diet in many of the countries especially in the west.
- Raw potato should not be consumed as they result in cramps in stomach.

AREA AND PRODUCTION

- The area under this crop in India was 1863 thousand ha having a production 42339 thousand tonnes with a productivity of 22.7 MT/ha (NHB, 2011).

NUTRITIVE VALUE (per 100g of edible portion)

Energy (kcal)	97	Vitamin-B ₆ (mg)	0.26
Carbohydrate (g)	22.6	Vitamin-C (mg)	17
Starch (g)	15	Calcium (mg)	10

Fibre (g)	2.2	Iron (mg)	0.7
Fat (g)	0.1	Magnesium (mg)	3.8
Protein (g)	1.6	Phosphorus (mg)	40
Thiamine (mg)	0.10	Sodium (mg)	6
Riboflavin (mg)	0.01	Potassium (mg)	421

VARIETIES

Cultivars recommended in different parts of India:

Early Varieties (ready in 70-80 days)	Main season varieties (ready in 90-95 days)	Late Varieties
Kufri Ashoka	Kufri Jyoti	K. Jeevan
K. Chandermukhi	K. Sutlej	K. Neelamani
Kufri Jawahar	K. Pukhraj, K. Megha	K. Khasigaro
Kufri Lauvkar	K. Badshah, Kufri Anand	K. Naveen
	Kufri Bahar, K. Sadabahar	
	K. Deva, K. Sherpa, K. Swarna	
	Red coloured: Kufri Sindhuri, Kufri Lalima	

FOR PROCESSING: Kufri Chipsona 1, Kufri Chipsona 2, Kufri Chipsona 3, Kufri Himsona.

Descriptions of the important commercial varieties of potatoes are given here under:

Kufri Alankar:

- A very early (75 days) photo insensitive variety capable of giving high yields, suitable for cultivation in the plains of northern India.
- This variety, by virtue of its earliness, can be included in the multiple cropping patterns which are coming into vogue with the introduction of the short-duration dwarf, high-yielding varieties of rice and wheat.

Kufri Badshah:

- Medium maturing with large size and round oval shape.
- Other tuber characters are: skin white, eyes flat, flesh dull white, tubers develop light purple colour on exposure to light.
- It is resistant to late blight. It is suitable for cultivation in Punjab, Haryana, Rajasthan, Uttar Pradesh, Bihar and West Bengal.

Kufri Bahar:

- Tuber characters of this variety are: size large and shape round to oval, skin white, eyes medium deep and flesh white.
- It is medium maturing and susceptible to all major diseases.
- It is suitable for cultivation in northern plains of India.

Kufri Chandramukhi:

- Early maturing (matures 10 days earlier than Up to Date) with attractive oval white tubers.
- It degenerates slowly and keeps well in storage.
- It gives high yields (higher than Up to Date), cooks easily and does not degenerate rapidly in the plains.

Kufri Chamatkar:

- An early bulking variety (110-120 days) with uniform sized, shining and smooth tubers suitable for cultivation in Punjab, Haryana, Uttar Pradesh and Madhya Pradesh.

Kufri Deva:

- It is recommended for growing in the Tarai area of western Uttar Pradesh.
- The tubers are oval round with white yellow flesh and takes about 130 days for harvest in the plains and 150-160 days in the hills.

Kufri Jeewan:

- A late maturing high yielding variety, possessing high degree of field resistance to late blight, resistance to the wart and *Cercospora* leaf spot disease.
- It is recommended for cultivation in Himachal Pradesh.

Kufri Jyoti:

- Tubers of this variety are large oval, flattened, white skinned, eyes flat and flesh dull white.
- A widely adaptable and fertilizers responsive variety, possessing a high degree of field resistance to late blight disease in the foliage and also a good degree of tuber resistance to the same disease.
- This variety is also resistant to the wart and moderately resistant to *Cercospora* leaf spot.

- It is recommended for Himachal Pradesh and Kumaun hills of Uttarakhand.

Kufri Kumar:

- A late maturing (41/2 to 51/2 months) variety, with large, white, and oblong tubers.
- It is a good yielder both in the hills and in the plains and possesses a high degree of field resistance to late blight.
- It has, therefore, been recommended for the hills, particularly where late blight is a problem.

Kufri Kuber:

- It is a variety evolved at the Potato Breeding Station, Shimla in 1943 (Now CPRI).
- It is an early variety, particularly suited for the plains.
- It is extremely quick growing in habit and covers the ground very rapidly.
- As an early crop in the plains, it can be harvested in about 21/2 months after planting. Its tubers are of uniform medium size.

Kufri Kundan:

- It is a hybrid derived from a cross between Ekishirazy and Katahdin and is released by the Central Potato Research Institute, Shimla.
- It is particularly promising in the hills where it yields assured crops, especially in years of late blight epidemics, as it shows considerable degree of field resistance to blight.
- Its tubers are white attractive and of a good size.
- One of the chief merits of this variety is that it is preferred for cultivation in clay soils.
- It is not suitable for the plains where it does not yield assured crops.
- It is moderately resistant to late blight but susceptible to other disease including virus diseases.

Kufri Kisan:

- This is a late maturing variety which gives heavy yields in the plains.
- It is particularly suitable for Uttar Pradesh, Madhya Pradesh, Delhi and the Punjab.
- The tubers are medium in size, with a smooth surface, deep eyes, white skin and round shape.
- It has a very good keeping quality.

Kufri Khasi-Garo:

- An early maturing variety possessing a good degree of field resistance to late blight and moderate resistance to early blight and viruses.
- It is fit for growing in the regions of Assam.

Kufri Lalima:

- Tuber is medium in size, shape round, skin red, eyes medium deep and white flesh.
- It is medium maturing and moderate resistant to early blight.
- It is suitable for cultivation in entire area of north Indian plains and is gradually replacing 'Kufri Sindhuri'.

Kufri Lavkar :

- It is an early maturing variety (matures in 70 days in plateau and 100 days in the plains) with round white and light creamy firm flesh tubers.
- It is most suitable for growing in the Deccan plateau of Maharashtra.

Kufri Moti :

- It is suitable for growing in the Nilgiri hills where late blight poses problem for potato multiplication.
- The tubers are oval white and round, take 110-120 days to mature.
- It is field immune to race 1 of late blight.
- Resistance to wart and moderate resistance to *Cercospora* leaf spot and early blight, it resembles 'Great Scot' in maturity and tuber characteristics but gives comparatively 100 per cent more yield.
- It yields about 130 quintals per hectare.

Kufri Naveen:

- A fertilizers responsive variety for the Khasi Hill region of Assam; possess a high degree of field resistance to late blight, resistance to wart and moderate resistance to *Cercospora* leaf spot and early blight.

Kufri Neela:

- A late maturing (4 1/2 to 5 1/2 months) variety with round white tubers.
- It is a substitute for 'Great Scot' and has several virtues.
- It answers the trade needs and possess 'Great Scot' type of tubers. Besides, it yields about 70 per cent higher than 'Great Scot'.
- The greatest value of this variety is that it is resistant to late blight, which in recent years, has limited potato culture in the Nilgiri hills.

Kufri Neelmani :

- Suited for the Nilgiri hills in the South.
- It has given 100 per cent more yield than the variety 'Great Scot', which has long been popular in the Nilgiri area.
- The new variety can be grown in all the three potato crop season in that area.

Kufri Red:

- It is the selection from Darjeeling Red Round isolated and developed by the Central Potato Research Institute, Shimla.
- It is superior in yield and quality of tubers to Darjeeling Red Round.
- It has substituted Darjeeling Red Round on a large scale in Uttar Pradesh, Bihar and Punjab.

Kufri Safed :

- A new improved disease free clone of Phulwa and Kufri Safed has been developed by the Central Potato Research Institute, Shimla.
- The clone resembles Phulwa in most of its morphological features except that the leaves are slightly bigger.
- This variety yields on an average 25 per cent more than Phulwa.

Kufri Sindhuri :

- Medium maturing (31/2 to 41/2 months) with round, light red and medium sized tubers.
- It is suitable for cultivation as a main crop variety in the plains, as replacements to Kufri Red and other late varieties.

Kufri Sheetman :

- A frost resistant variety suitable especially for the Punjab, Rajasthan, Haryana, Uttar Pradesh, Madhya Pradesh and West Bengal.
- It can be planted late in the northern plains owing to its high degree of resistance to frost.

Up-to-Date:

- It is an early high yielding variety, having big sized tubers of oval shape and white colour.
- It has a white flesh which cooks readily and breaks if cooked for longer time than necessary.
- It is a very popular variety in the Shimla hills, Punjab and Uttar Pradesh.

Kufri Muthu:

- Developed by Central Potato Research Institute in 1971 through conventional hybridization.
- A medium maturing variety producing tall, erect, compact, vigorous plants with white flowers.
- The tubers are white, round-oval, large with medium deep eyes.
- The variety is moderately resistant to late blight and has been replaced by Kufri Jyoti. Suitable for cultivation in South Indian hills.

Kufri Sherpa:

- Developed by Central Potato Research Institute in 1983 through conventional hybridization.
- A medium maturing variety producing tall, erect, medium compact, vigorous plants with light red-purple flowers.
- The tubers are white, round flattened, medium with medium deep eyes.
- The variety is moderately resistant to early, immune to wart and was resistant to late blight but is not under cultivation at present.
- Suitable for cultivation in North Bengal hills and Sikkim

Kufri Swarna:

- Developed by Central Potato Research Institute in 1985 through conventional hybridization.
- A medium maturing (130-135 days in summer and 100-110 days in autumn) variety producing tall, erect, compact and vigorous plants with white flowers.
- The tubers are medium-large, white, round-oval with fleet eyes and unlike Kufri Jyoti do not show cracking.
- The variety is moderately resistant to late blight and cyst nematodes and heavy yielder (average yields 25-30 t/ha).
- Suitable for cultivation in South Indian hills.

Kufri Megha:

- Developed by Central Potato Research Institute in 1989 through conventional hybridization.
- A late maturing variety producing tall, erect, medium compact, vigorous plants with white flowers.
- The tubers are white, round-oval, medium with flat eyes.
- The variety is highly resistant to late blight and yields on an average 22-28 t/ha.
- Suitable for cultivation in North-eastern hills.

Kufri Jawahar:

- Developed by Central Potato Research Institute in 1996 through conventional hybridization.
- A medium-early maturing (80-90 days) variety producing short, erect, compact and vigorous plants with white flowers.
- The tubers are medium, white, round-oval with fleet eyes.
- The variety is moderately resistant to late blight and suitable for mechanized cultivation and gives average yields of 35-40 t/ha.
- Suitable for cultivation in North Indian plains and plateau region.

Kufri Sutlej:

- Developed by Central Potato Research Institute in 1996 through conventional

hybridization.

- A medium maturing (90-110 days) variety producing medium tall, erect, medium compact and vigorous plants with white flowers.
- Tubers are attractive, large, white, oval with fleet eyes.
- The variety is moderately resistant to late blight having average yields of 35-40 t/ha.
- Suitable for cultivation in North Indian plains.

Kufri Ashoka:

- Developed by Central Potato Research Institute in 1996 through conventional hybridization.
- An early maturing (60-80 days) variety producing medium tall, erect, medium compact and vigorous plants with light red-purple flowers.
- Tubers are medium-large, white, oval-long with medium-deep eyes.
- The variety is susceptible to major potato diseases and yields on an average 28-35 t/ha.
- Suitable for cultivation in North Indian plains.

Kufri Pukhraj:

- Developed by Central Potato Research Institute in 1998 through conventional hybridization.
- An early maturing (70-90 days) variety producing tall, semi-erect, medium compact and vigorous plants with white flowers.
- Tubers are large, white, oval, slightly tapered with fleet eyes and develop faint purple colour on exposure to sun.
- The variety is resistant to early blight and moderately resistant to late blight and on an average yields of 40-50 t/ha.
- Suitable for cultivation in North Indian plains and plateau region.

Kufri Giriraj:

- Developed by Central Potato Research Institute in 1998 through conventional hybridization.
- A medium maturing (130-135 days) variety producing medium tall, semi-erect, medium compact and vigorous plants with light-purple flowers.
- Tubers are medium to large, white, oval, with fleet eyes.
- The variety is field resistant to late blight with average yields of 25-30 t/ha. Suitable for cultivation in North Indian hills.

Kufri Anand:

- Developed by Central Potato Research Institute in 1999 through conventional hybridization.
- A medium maturing (100-110 days) variety producing tall, erect, open and vigorous plants with light purple flowers.
- Tubers are large, oval-oblong, white skinned with fleet eyes.

- The variety is resistant to late blight and gives average yields of 40-45 t/ha.
- Suitable for cultivation in North Indian plains.

Kufri Kanchan:

- Developed by Central Potato Research Institute in 1999 through conventional hybridization.
- A medium maturing (110-135 in summers and 90-100 days in winter) variety producing medium tall, semi-erect, medium compact, vigorous plants with red purple flowers.
- Tubers are medium-large, oval-oblong and red with fleet eyes.
- The variety is field resistant to late blight, resistant to wart and slow rate of degeneration.
- It on an average yields 25-28 t/ha. Suitable for cultivation in North Bengal hills.

Kufri Arun:

- Developed by Central Potato Research Institute in 2005 through conventional hybridization.
- A medium maturing (90-100 days) variety producing tall, erect, vigorous, medium-compact plants with light red-purple flowers.
- The tubers are medium, oval, red, medium deep eyes with creamy flesh.
- The variety is field resistant to late blight and on an average yields 25-30 t/ha.
- Suitable for cultivation in North Indian plains.

Kufri Pushkar:

- Developed by Central Potato Research Institute in 2005 through conventional hybridization.
- A medium maturing (90-100 days) variety producing medium-tall, erect, vigorous, compact plants with white flowers.
- The tubers are medium, round-oval, white, flat to medium deep eyes with light yellow flesh.
- The variety is resistant to late blight and early blight and on an average yields 35-38 t/ha.
- Suitable for cultivation in Indo-Gangetic plains and plateau region.

Kufri Shailja:

- Developed by Central Potato Research Institute in 2005 through conventional hybridization.
- A medium maturing (110-120 days) variety producing medium-tall, semi-erect, vigorous, semi-compact plants with light red-purple flowers.
- The tubers are medium, round-oval, white, smooth, shallow eyes with pale yellow flesh.
- The variety possesses field resistance to late blight both in foliage and tubers. The variety on an average yields 25-28 t/ha.
- Suitable for cultivation in North Indian hills.

Kufri Chipsona-1:

- Developed by Central Potato Research Institute in 1998 through conventional hybridization.
- A medium maturing (100-110 days) variety producing medium to tall, semi-erect, compact, vigorous plants with white flowers.
- The tubers are medium to large, oval, white with fleet eyes.
- The variety possesses resistance to late blight and is suitable both for preparation of chips and French fries and on an average yields 35-38 t/ha.
- Suitable for cultivation in North Indian plains.

Kufri Chipsona-2:

- Developed by Central Potato Research Institute in 1998 through conventional hybridization.
- A medium maturing (100-110 days) variety producing medium tall, erect, open, plants with white flowers.
- The tubers are medium to large, round, white with fleet eyes.
- The variety possesses resistance to late blight and tolerance to frost, suitable for preparation of chips and on an average yields 32-35 t/ha.
- Suitable for cultivation in North Indian plains.

Kufri Chipsona-3:

- Developed by Central Potato Research Institute in 2006 through conventional hybridization.
- A medium maturing (100-110 days) variety producing tall, erect, vigorous, semi-compact plants with white flowers.
- The tubers are round-oval, medium, white with fleet eyes.
- The variety possesses field resistance to late blight, moderate field resistance to phoma, early blight, mosaic, severe mosaic and leaf roll.
- The tubers have high dry matter, negligible glycoalkaloid content and comparatively good protein content, suitable for preparation of chips and on an average yields 32-35 t/ha.
- Suitable for cultivation in North Indian plains.

Kufri Surya:

- Developed by Central Potato Research Institute in 2006 through conventional hybridization.
- An early maturing (75-90 days) variety producing medium tall, erect, semi-compact, vigorous plants having light red purple flowers with shy flowering.
- The tubers are medium to large, oblong, white, smooth, shallow eyes with pale yellow flesh.
- This is a heat tolerant variety that can be grown in areas having night temperature above 20°C and is field resistant to hopper burn.
- This variety also possesses some resistance to mite damage and late blight.
- The variety on an average yields 35-40 t/ha.

- Suitable for cultivation in North Indian plains and Peninsular India.

Kufri Himalini:

- Developed by Central Potato Research Institute in 2006 through conventional hybridization.
- A medium maturing (110-120 days) variety producing medium-tall, semi-erect, vigorous, semi-compact plants with light purple flowers.
- The tubers are medium, oval-oblong, white, smooth, shallow eyes with pale yellow flesh.
- The variety possesses field resistance to late blight in foliage and moderate resistance in tubers.
- The variety on an average yields 27-30 t/ha. Suitable for cultivation in North western and north eastern hills.

Kufri Himsona:

- Developed by Central Potato Research Institute in 2007 through conventional hybridization.
- A medium maturing (120-140 days) variety producing open, medium, thin stems with flowers primarily purple/ intense purple with white tip on both sides.
- The tubers are medium, round-oval, white, smooth, shallow eyes with cream pale yellow flesh.
- It is the 1st high dry matter, low reducing sugar and late blight resistant potato variety for HP hills.
- The variety on an average yields 20-25 t/ha. Suitable for cultivation in North Indian hills.

Kufri Sadabahar:

- Developed by Central Potato Research Institute in 2007 through conventional hybridization.
- Medium maturing variety released as an apt replacement of K Bahar in UP and adjoining areas.
- The tubers are large, attractive, oblong, white with shallow eyes and flesh white.
- The variety possesses resistance to late blight, good keeping quality and dry matter (20%).
- The variety on an average yields 35-45 t/ha. Suitable for cultivation in Uttar Pradesh and adjoining areas.

Kufri Girdhari:

- Developed by Central Potato Research Institute in 2008 through conventional hybridization.
- A medium maturing (110-120 days) variety producing medium-tall, semi-erect, vigorous, semi-compact plants with white flowers.
- The tubers are medium, oval-oblong, white, smooth, shallow eyes with pale yellow flesh.
- The variety possesses high level of field resistance to late blight in foliage and tubers.
- The variety on an average yields 27-30 t/ha. Suitable for cultivation in hills.

Kufri Khyati:

- Developed by Central Potato Research Institute in 2008 through conventional hybridization.
- An early maturing variety with moderate resistance to late blight.
- The variety yields higher than existing early cultivars both at 60 and 75 days after planting.
- Suitable for cultivation in Indian plains.

TPS Population 92-PT- 27:

- Developed by Central Potato Research Institute in 2007. True potato seeds (botanical seeds) are produced through conventional hybridization.
- Uniform and high yielding TPS population with resistance to late blight.
- Both parents flower under short days in the plains.
- Suitable for cultivation in eastern region.

CLIMATE REQUIREMENTS

- Potato is a cool season crop.
- It grows well from sea level to snow line, where sufficient moisture and fertile soil are available.
- It is grown in winter in plains of India.
- However, in northern hills, it is grown as summer season crop.
- Potato is a long day plant but cultivated as short day plant.
- It required favourable environmental conditions such as low temperature and short day conditions at the time of tuberization.
- 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 when the night temperature is more than 23°C.
- Maximum tuberization is encountered at 20°C.
- Tuber formation stops completely at about 29-30°C.
- Planting is done in the hills when the maximum temperatures are about 20-22°C and minimum temperature are about 12-15°C

SOIL

- Potato can be produced on a wide range of soils, ranging from sandy loam, silt loam and clay soil.
- Soil for potato should be friable, well aerated, fairly well supplied with organic matter.
- Well drained sandy loam and medium loam soils are most suitable for potato cultivation.
- Light soil is preferred.
- Alkaline or saline soil is not suitable for potato cultivation. (pH 5.0-6.5)

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PLANNING & METHODS

PLANTING TIME

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

SEED RATE

- 25-35 q/ha

- Potato is traditionally propagated through tubers.
- The eyes on the tuber surface contain axillary buds and the tubers have a dormancy of nearly 8-10 weeks.
- The axillary buds start germinating when the dormancy is over and produces sprouts.
- Such sprouted tubers put up fast and vigorous growth when planted in the soil.
- Pre-sprouting of seed stocks, therefore, helps in increasing the number of main stems and consequently the yield by ensuring quick, uniform and full germination.

METHODS OF SOWING AND SPACING

Ridge and Furrow Method

- Ridge and furrow method is the most popular method carried out manually or mechanically
- In this method, the ridges are prepared.
- The lengths of the ridges depend on slope of the plot.
- Too long ridges and furrows are not supplied with irrigation water conveniently.
- The potato tubers are planted on ridges and irrigation water is let into the furrows.
- In hills, after placement of fertilizer in shallow furrows drawn with hand tools, tubers are placed and covered with soil to make ridges. Care should be taken that seed tubers should not come in direct contact of fertilizers.
- In mechanical method, furrows are made with the help of tractor drawn 2-4 row marker co fertilizer drills so as to apply fertilizer in one sequence. This is followed by planting of tubers with the help of 2-row planter cum ridger.

Flat Bed Method

- In these methods, the whole plot is divided into beds of convenient length and width.

- The shallow furrows are opened and potato tubers are planted at recommended distance.
- The tubers are covered with the original soil of furrows.
- When the germination is completed and plants become 10 to 12 cm height, earthing should be done.
- Suitable plant spacing in relating to potato seed grades are given in the below:

Diameter of tuber from longer axis	Planting distance (row x plant)
2.5-3.5cm	50 x 20 or 60 x 15 cm
3.5-5.0 cm	60 x 25 cm
5.0-6.0 cm	60 x 40 cm

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 40-50mm diameter at a spacing of 45-60cm between rows and 20-25cm between the tubers with in rows.
- Tubers are sold on weight basis; therefore, planting of large tubers is more expensive.
- These tubers are cut into pieces, each containing at least 1-2 eyes.
- Tuber cutting is not recommended specially when producing a seed crop because of danger of transmitting viruses and bacteria.
- Hence, special care is taken to avoid tuber decay when such cut tubers are used for plantation.

DORMANCY

- Hill tubers can not be used for autumn crop immediately because of dormancy period which remains for 2-3 months in tubers.
- Similarly, potato minitubers can not be planted immediately after harvest and during unknown period after that,
- Duration of dormancy in potato minitubers depends on cultivar, ripening time, growth condition, maintenance condition in store and the tuber size.
- Minitubers' dormancy period is longer than normal seed tubers.
- In these conditions, it is essential to break down the dormancy period.
- Thiourea solution (Sodium Potassium thiocynate) @ 1-2% which is used as a treatment to cut tubers for 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 acquous solution of thiourea for one hour followed by dipping in 2 ppm solution of GA for 10 seconds. Or

- Ethylene chlorohydrine used as a gas treatment. Six parts of water and 4 parts of chemical is mixed and the tubers are kept in this solution for 5 days in an air tight chamber and temperature should be kept at 70-80oF.
- 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.

Treatment of cut seed tubers

- Cut tubers should be treated with 0.2% 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 (Suberization/healing).
- Do not treat the tuber with any of the chemical if sprouts are coming out.
- Treat with aglal (0.5%) for 5-10 minutes to control scab disease.

REQUIREMENTS, MANAGEMENT, GRADING

NUTRITIONAL REQUIREMENTS AND THEIR MANAGEMENT

- Soil poor in organic matter content should be supplied with 250-500q/ha of Farm Yard Manure or compost during land preparation.
- When it is grown in medium type of soils, it needs 100-150 kg/ha nitrogen, 80-100 kg each of phosphorus and potash per hectare.
- Two-third to three fourth quantity of nitrogen along with whole quantity of phosphorus and potash is applied at the time of planting.
- Remaining one fourth to one third nitrogen is applied 30-35days after planting.

INTERCULTURAL OPERATIONS

- 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 are effectively controlled 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 pendimethalene@ 1.8 kg a.i. per ha or atrazine @ 1.0 kg a.i. per ha can effectively control the weeds.
- Post emergence application (5-10% 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.

- The use of weedicides in potato crop in general is not essential because earthing up operation destroys almost all weeds, if somehow, weed plants are growing on ridges, they may be pulled out by hands.
- Pre-emergence application of nitrofen @ 1.0 kg a.i. /ha or post emergence application of propanil @ 1.0 kg a.i. /ha may to be used in 800-1000 litre of water.

Water Management

- Before coming to the planting operation, it should be kept in mind that sufficient soil moisture is available for satisfactory sprouting.
- Pre-planting irrigation is advantageous for uniform germination.
- The rate of water is low till 30-35 days after planting.
- Further irrigation is done as and when crop needs.
- 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 crop.
- The total water requirement varies between 350-500mm depending upon soil type, climate and crop duration.
- Irrigation is stopped about 10 days before harvesting of crop to allow firming of tubers skin.

Harvesting and Yield

- The crop is harvested when it is fully matured which can be characterized by when haulms turn yellow 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.
- Harvested potatoes are heaped under shade for a couple of days, so that their skin becomes hard and soil adhering with them is also separated out.
- Under good crop management, 350-450q marketable potatoes of good quality can be produced from one hectare land.
 - Early varieties: 200 q/ha

- Late Varieties : 300 q/ha

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
- Over sized tubers are great in demand for chips making.
 - However, both the over sized and under sized are quite unsuitable for seed purpose.

Post harvest handling

- Nearly 20% of total potato production is used as planting material in the following season.
- Therefore, handling of seed stocks is particularly become very important.
- After harvesting, tubers are kept in heaps in cool places for drying and curing of skin i.e. for 10-15 days.
- Heaps 3-4 m long wide at the base and 1 m in the central height are the best.
- In hills, tubers are spread in well ventilated rooms for drying.
- After grading potato tubers meant for use as seed crop next year are treated with 3% boric acid solution for 30 minutes for protecting against soil borne pathogen before storing in the bags.
- In the plains, tubers after drying, curing and grading are stored in cold stores where temperature is maintained at 2-4°C with 75-80% RH.
- Low temperature checks sprouting and rotting and high RH reduces weight loss in tubers.
- Potatoes can be stored in the cold storage at the temperatures of 1.11-2.7°C and relative humidity of 90-95 per cent.

Marketing

The factors which make marketing of potato as 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 adequate only to store 35-40% of the total production.
- Functioning of CS many a time is not up to the mark and is marked by various mal practices.

- The markets in potato producing belts in NI plains are not properly integrated with major consuming markets of metropolitan cities.

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.

DISEASES & PESTS

Diseases

1. Early blight : (*Alternaria solani*)

- The infection appears on lower leaves with necrotic spots having concentric rings.
- This fungus survives in the soil in diseased plant debris.
- High moisture and low temperature is favourable for disease.

Control measures

- Follow crop rotation.
- Spray the crop with mancozeb @ 0.2 per cent, 30-35 days after planting and grow tolerant varieties such as Kufri Jeevan.

2. Late Blight : (*Phytophthora infestans*)

- The infection appears at the tips or edges of the lower leaves with circular or irregular water soaked spots.
- White downy fungus growth appears on the underside of the leaves around the spots.
- Cloudy weather is conducive for very fast spread of the disease.
- Later the disease may spread to tubers and initiate rotting.

Control measures

- Plant only healthy disease free seed tubers.
- Spray the crop with mancozeb @ 0.25 per cent well in advance.
- Avoid applying excess irrigation and nitrogen.

3. Black Leg / Soft Rot : (*Erwinia spp.*)

- The bases of shoots develop a blackened shrivelled cortex and its growth is stunted.

- Leaflets become reddish in colour at the tips.
- Branches become stiffened and more upright than normal.
- The affected haulms are jet black in colour at the soil level.
- The tubers become watery and upon rotting give off offensive sulphurous odour.

Control measures

- Obtain healthy tubers for planting.
- Collect and destroy affected plants.
- Wash the tubers with chlorinated water before storage and avoid planting too early.

4. Wart disease of potato: (*Synchytrium endobioticum*)

- Affected plants show warty growth protuberances on stems, stolons and tubers.
- The roots are not affected.
- The wart consists of distorted, proliferated, branched structures grown together into a mass of hypertrophied tissue.
- It is difficult to control once it has been established in a field.

Control measures

- Obtain disease free seed for planting.
- Soil treatment with 5 per cent Formalin is also effective.

Pests

1. Cut worms: (*Agrotis spp*)

- They feed only at night and cut the sprouts at ground level.
- They also attack tubers and make holes thereby reducing market prices.

Control measures

- Drench the plants with chlorpyrifos (0.04 %) where the damage is noticed.
- Use only well rotten Farm Yard Manure.

2. Leaf eating caterpillars : (*Spilosoma obliqua, Spodoptera exigua*)

- The caterpillars of both the species cause damage by feeding on potato leaves.

Control measures

- Spray the crop with deltamethrin (0.0025%).

3. Aphids : (*Myzus persicae*)

- Aphids suck the sap from leaves.
- Affected plants become weak, leaves become yellow and curl downwards.
- Aphid secretes honeydew, which gives rise to sooty mould and other fungal diseases.

Control measures

- Spray malathion (0.05%) or oxy-demeton methyl (0.025%).

4. Potato tuber moth: (*Phthorimaea operculella*)

- It is major pest of potato in storage.
- It can also attack in the field.
- It bores and makes tunnel into the potato tubers.

Control measures:

- Sow healthy insect free potato tubers.
- Use only well rotten Farm Yard Manure.
- Do earthing up carefully, so that the tubers are not exposed in the field to ovipositing female moths.
- Spray the crop with carbaryl (0.1 %).

PHYSIOLOGICAL DISORDERS

PHYSIOLOGICAL DISORDERS

1. Hollow Heart:

- It is caused by rapid growth of tubers.
- Tubers become oversized and remain empty with in 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

Management

- Maintain soil moisture conditions to the optimum level. Avoid over fertilization particularly N.
- Grow those varieties which are less prone to this defect.

2. Black Heart:

- It is caused by sub-oxidation conditions under potato tuber storage in piles as the air does not get into the centre.
- It occurs due to higher temperature and excessive moisture resulted in blackening of tissues in the centre.
- The appearance of the tuber affect the consumers otherwise there is no decay.

Management

- Provide proper ventilation. Keep potato tubers in layers. Do not store tubers in the heap.

3. Greening:

- There are various factors which increases the glycoalkaloid contents such as mechanical injury, premature harvest, and excessive application of fertilizers or exposure of tubers to sunlight which leads to solanin production which is slightly poisonous.

Management

- Proper earthing up of tubers as the tuberization 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 growth of some cells very fast resulting in knobbiness.

Management

- Frequent and optimum irrigation supply is the remedy

5. Cracking:

- It is due to boron deficiency or uneven water supply

Management:

- Application of Borax @ 20kg/ha. Frequent and optimum irrigation supply is the remedy

6. Sun Scalding:

- It occurs, generally, in the autumn crop when the temperature is high and sunshine is more.
- Emergence of sprout and leaflets is drastically effected at that time i.e. tip burn. It appears when temperature is more than 30°C.

Management

- Water should be passed through the furrows to lower the soil temperature.

7. Translucent End:

- It is related to environmental stress and occurs due to draught and heat.
- It is, generally, found at the proximal end of the tuber.
- Tubers show glossy appearance and are irregular in shape.
- This also results in decay in storage. These glossy areas are high in sugar and low in total soluble solids

Management:

- Avoid excessive nitrogen supply. Maintain 50% moisture in the field.

8. Black Spot:

- It means the internal browning of potato tubers.
- It occurs in vascular tissues with in 3 days of mechanical injury.
- Phenoles are related to black spot in potato tubers.

Management

- Genetic make up of the varieties. Provide proper storage and growing conditions.

9. 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 discolouration of the tissues and affect the vascular tissues at ring called ring necrosis.
- When fine elements or cells of vascular ring are affected, then it is called as net necrosis.
- This leads to unmarketable tubers. Tubers show more damage towards proximal end.

Management

- Avoid exposure of tubers to freezing temperature during storage or harvest.

10. Sprouting:

- It is often a serious problem in storage

Management

- It can be inhibited by spraying maleic hydrazide @ 1000-6000ppm about 2-3 weeks before harvesting.
- Chemicals like Chloro IPC (N-tetra chloro isopropyl carbonate)@ 0.5% and/or nomyl/amyol alcohol @0.05-0.12mg/ha also help in inhibiting sprouting

11. Swollen Lenticels:

- This disorder is caused by exposure of the tuber to very wet conditions in the field or in storage due to oxygen deprivation.
- Besides giving an unmarketable appearance to the tuber, the major problem is that an entrance to pathogenic organisms, bacterial soft rot, pink rot and leak, is created.

Management

- Avoid over-watering. Avoid harvesting low, swampy spots in the field. Pick fields with good drainage.
- Avoid condensation in storage. Keep storage well ventilated.

SEED PLOT TECHNIQUE

SEED PLOT TECHNIQUE

- Use of healthy seed in vegetative propagated crop like potato is very important.
- Continuous use of same seed stocks year after year without periodic replacement allows infiltration of diseases particularly widely prevalent viruses.
- These viruses readily spread through contact of foliage and roots in the field or through aphid vectors from far off fields or within fields.
- They have debilitating effect and are responsible for bringing down yield potential of infected tubers.
- The high hills were the traditional sources of healthy seed as population of aphids remain low due to low temperature.
- However, hills accounts for only 5% of the area under potato and this was not enough to meet the seed requirement of the plains.

- In 1962, Cockerham (Scotland) came to India to do some studies to increase the potato yield.
- On the basis of data on appearance and build up of aphids in different months, it was found that potato can successfully be grown for seed production in many parts of the plains under low or no aphid condition.
- This led to the development of “Seed Plot Technique” i.e. raising the healthy seed crop during low aphid population period available in northern plains.

Steps followed in seed plot technique:

- Planted before the commencement of 10th October.
- Sowing at closer spacing of 45cm x15 cm for smaller size potato tubers.
- Two inspections at least should be made to rogue out any diseased or off-type plants during growing season.
- Application of granular systemic insecticides at planting or earthing up.
- When the crop has tuberized well by the middle of December, restrict irrigation and later with hold it completely.
- At the end of December or first week of January, haulm should be cut down before the aphid population builds up to 20 aphids per 100 leaves.
- If the crop is still green destroy the haulms by spraying 2% solution of CuSO₄ or cut them.
- The harvesting of tubers is done in Mid February to end February

Modifications made

- Hot weather cultivation and green manuring.
- Crop rotation for 2-3 years.
- One or two sprays of systemic insecticides + spray of metalaxyl or mancozeb in December- January.
- Tubers dip treatment with 3% boric acid for 30 minutes after harvest and before storage of the produce.
- The use of this technique helps in meeting the large requirement of healthy seed in country.

SEED PRODUCTION

Seed Production

Following procedures should be followed for seed production:

- Potato plant is very sensitive to ecological factors such as temperature, rainfall, photo period etc.
- Optimum night temperature range from 15-20°C in pre-tuber initiation phase and 15°C in the post tuber initiation stage is required.
- The application of farmyard manure and gypsum/pyrites is needed for soils with pH more than 8.5 and conductivity less than 1 mmhos/cm² to make it suitable for potato production.

- Pre sprouting
 - Pre sprouting of seed tubers before planting seed crop is essential.
 - It ensures multiple, stout and healthy sprouts.
 - It helps in quick emergence and uniform stand and early maturity of the crop.
 - It also facilitates higher multiplication rate, more number of tubers and large production of seed sized tubers and pre-sprouting.
- Seed should be taken out from the cold store, 10-15 days before planting in the plains.
- The time of planting for seed crop in the plains varies with agro-climatic conditions of the regions.
- The optimum time of planting for western-central and eastern Indo-Gangetic plains is first week of October, second to third week of October and last week of October to first week of November, respectively.
- In the plains, optimum yield of seed potatoes can be obtained by green manuring of Sunhemp (*Crotalaria juncea*) or Dhaincha (*Sesbania aculeata*).
- The Dhaincha crop of 45-55 days adds 250-300 quintals of green biomass/ha.
- If green manuring is not done, 200-250 quintals of farmyard manure/ha is applied to improve the fertility and physical condition of the soil.
- Nitrogen, phosphorous and potash requirements should be based on soil test of the field.
- In general, a basal dose of 75 kg nitrogen, 60-80 kg phosphorous and 100-120 kg potash/ha may be applied at planting.
- Traditionally, seed of relatively small size (25-30g) is used for planting both in the hills and plains because of its better keeping quality, delayed sprouting in ordinary stores and lower seed rate.
- It has been observed the planting of 40 g seed tubers at 50 cm inter row and 20 cm intra-row spacing.
- It has been found best for seed production.
- Seed crop of potato can be planted with a tractor drawn potato planter or implements for all the operation viz. opening furrows, application of fertilizers, placement of tubers, ridging and spray of insecticides.
- Another method is that first ridges are formed after application of fertilizer and insecticides and then tubers are dibbled with Khurpa (a narrow blade tool) 5-7cm deep in the ridges manually.
- Care should be taken that tubers should not come in direct contact with the fertilizers and should remain 4-5 cm above or side of fertilizer done.
- Intercultural operations and weeding should commence at about 20-25 days after planting when plants attain height of about 10-15cm.
- Weeds compete for moisture and nutrients with potato crop mainly at two times during potato cultivation first before earthing up and second towards the maturity and harvesting of crop. Timely weed control either chemically or manually is essential otherwise potato yield is affected.
- During early stages of growth of potato plants, weeds may be controlled by a spray of paraquat dichloride (gramaxone @ 2.5 Kg a i/ha dissolved in 1000 l of water) at about 5 per cent emergence of plants.

- Sencor (metribuzin)@1.0 kg/ha as pre-emergence are effective herbicides.
- In the plains, potatoes are grown in winter season when seasonal rainfall is not sufficient to meet the entire water requirement of crop.
- Hence, frequent and light irrigation to potato crop at low moisture tension, except in river bed cultivation in Gujarat is essential for raising a successful seed crop.
- Water stress after planting delays emergence, whereas, water stress after emergence reduces the internodal length of stem and the size of leaflets.
- Tuber initiation stage is considered as critical stage for water stress, which reduces the tuber number and yield.
- Aphid, Myzus persicae is the most important virus vector for potato crop.
- Amongst potato viruses, leaf roll and virus Y are very serious, as due to their infection tuber yield is reported to be reduced by 25-80 per cent.
- The yield of plants infected with contageous viruses (Y, A and M) and leaf roll, is reduced by 10-15, 50-75 and 60-75 per cent, respectively.
- In the plains, three field inspections for roging of mosaics, leaf roll and off-type plants are recommended.
- The first inspection and rouging should be done after emergence of plants and before earthing up, second at 40-50 days after planting and third just before the dehauling to ensure better seed quality.
- Phorate 10G @10kg/ha should be applied at planting to control jassids, leaf hoppers and white flies in order to check the spread of vector transmitted viruses.
- An additional quantity of phorate 10G @7.5kg/ha should be applied at the time of earthing up to prevent the infection of aphid vector.
- For early blight and late blight, it is better, if one prophylactic spray with Dithane M-45@ 2kg/ha is given.
- This should be repeated at an interval of 10-14 days, depending upon the weather conditions.
- Harvesting may be done by either tractor or bullock drawn digger or manually with the help of a spade or Khurpa.
- Harvesting of seed crop in the Indo-Gangetic plains should be completed by 15th February and should not be delayed beyond the end of February to avoid tuber rotting due to soft rot and charcoal rot.
- Harvesting in the plains should be undertaken 10-15 days and in the hills about 15-20 days after dehauling, when skin is hard enough to withstand handling operation.
- After harvesting, potato tubers are required to be kept in heaps for about 15 days for curing of skin and shedding of soil.
- For better return in the market and to adjust seed rate according to size during planting, proper grading is essential.
- Grading of seed potatoes in four grades viz. small below 25g (25 mm), medium 25-60g (25-35 mm), large 60-100g (35-50 mm) and extra above 100 g (above 50 mm) tubers are important.
- Treated tubers should be dried in shade.
- Seed potatoes are packed in gunny bags of 80 kg each in the western and central plains, whereas in 50 kg each in the eastern areas of the country.
- The temperature in the cold should be maintained at 2-4°C during storage.

- The yield of seed crop ranges from 200 to 250 q/ha depending upon the duration of the crop.

SEED CERTIFICATION

I. General Seed Certificate Standards

- The general seed certification standards are basic together with the following specific standards constitute the standards of certification of seed potato.
- Classification of seed potato on the basis of production, there shall be two types of seed potatoes, namely the Hills and Plains grown and shall be designated as Hill Seed (HS) and Plain Seed (PS) respectively.
- Hill Seed (HS) shall be grown in the high hills, generally 2500 meter above the mean sea level. Plains Seed (PS) shall be grown in such areas where aphid infection is low during the crop growing season and which are technically suitable for seed production.

II. Land Requirements

- A crop of seed potato shall not be eligible for certification if grown on land infected with wart and cyst forming nematodes; brown or non-cyst forming nematodes within the previous three years common scab.

III.

Field

Inspection

A minimum of four inspections shall be made as follows:

- The first inspection should be done about 45 days after planting in the hills and about 35 days after planting in the plains to verify isolation, off-types and the extent of disease infection.
- The second inspection should be done about 60-65 days after planting for early varieties or at appropriate growth stage depending on the crop duration of the variety concerned.
- The third inspection should be done immediately after haulms cutting/destruction in order to verify that haulms have been cut / destroyed by the prescribed date and in proper manner.
- The fourth inspection should be done after 10 days' haulms cutting/destruction and before harvest in order to verify that no regrowth of haulms has taken place.

A. General requirements

Isolation

- The fields of potato should be isolated from the contaminants as shown below:

Contaminants	Minimum distance (meters)	
	Foundation	Certified
	Stage-I	Stage-

		II	
Fields of other varieties	5	5	5
Fields of the same variety not confirming to varietal purity requirements for certification	5	5	5

B. Specific requirements

Maximum permissible limits				
Factors	Stage	Foundation Seed		Certified Seed
		Stage-I	Stage-II	
Off types	I & II inspection	0.05 %	0.05 %	0.10 %
Plants showing symptoms of mild mosaic	I & II Inspection	1.0 %	2.0 %	3.0 %
Plants showing symptoms of severe mosaic, PLRV, PVY and yellows	I & II Inspection	0.50 %	0.75 %	1.0 %
*Total virus	-	1.0 %	2.0 %	3.0 %
**Plants infected by brown rot (Syn. Bacterial wilt)	I & II Inspection	None	3 plants per hectare	3 plants per hectare
PSTV	I & II Inspection	-	-	-
***Re-growth of plants after destruction of haulms	IV Inspection	0.50 %	0.50 %	0.50 %

Note:

- *Of the two inspection, the higher virus percentage will be considered for the purpose of the specified limits of tolerance.
- **The presence of brown rot infected plants within the specified limits of tolerance shall be permitted in the area known to be infected with this disease.
- ***Standards for re-growth after destruction of haulms shall be met at fourth inspection to be conducted about ten days after haulms cutting.

IV. Seed Standards

- Specification in respect of size and weight of seed material for foundation stage-1 foundation stage-II and certified class as detailed below:

Plains seed (PS)	Foundation Stage I and II	Certified class
Seed size	30-55 g	25-125 g
Large size	> 55 g	>125g
Hills seed (HS)		
Seed size	30-60 g	25-150 g
Large size	> 60 g	>150g

- Maximum tolerance limit of tuber showing visible symptoms caused by the diseases mentioned below will be as follows:

Diseases	Maximum permissible limits (by number)		
	Foundation		Certified
	Stage-1	Stage-II	
Late blight, dry rot or Charcoal rot (%)	1.0	1.0	1.0
Wet rot (%)	None	None	None
*Common scab (%)	3.0	3.0	5.0
**Black scurf (%)	5.0	5.0	5.0
*** Total diseases (%)	5.0	5.0	5.0

- *Even if a single tuber infected with common scab is detected in a seed lot, the entire seed lot shall be treated with approved fungicide before seed lot is declared fit for certification. Seed lots having infected tubers more than the prescribed limits will not be certified even after treatment.
 - A tuber carrying 10 per cent or above scurf will be considered as one infected unit.
 - Seed lots having black scurf infection more than the prescribed limits (>5%), could be certified after treatment with approved chemical/fungicide.
- ** The presence of brown rot infected plants within the specified limits of tolerance shall be permitted in the area known to be infected with this disease.
- *** For all diseases, the higher disease percentage will be considered for the purpose of the specified limits of tolerance.

TRUE POTATO SEED (TPS) TECHNOLOGY

TRUE POTATO SEED (TPS) TECHNOLOGY
 Cultivation through true potato seed is beneficial because:

- Seed material as potato tubers required to cultivate 1.32 m ha area is around 33 m q (seed rate 25 q/ha). Quality seed production, certification and storage of such a huge quantity is very difficult.
- Transportation of such a huge material is also difficult and costly and can be used as food material.
- True seed is free from viruses and many other diseases as their management is easy due to small area. Cost of cultivation is also less.

Methods of using true potato seed

- To raise seedlings and then transplanting
- Sowing of seed in nursery beds and then raising them for obtaining small sized potato tubers which are used for cultivation of the next crop. These seeds are sown in raised beds.

Problems associated with use of true potato seed

- Seed is very small and weak as compared to tomato, brinjal etc.
- It is not grown very deep and also low application of fertilizers is required.
- It very difficult to maintain optimum moisture conditions as it is sown very near to the surface.
- Poor germination and unhealthy and weak nursery seedlings of potato are creating problems to farmers.
- Therefore, farmers are not enthusiastic to take up this venture on large scale cultivation.

Refined technique for raising TPS

- Make nursery bed of size 2 m x 1m and then bricks are laid on these beds. Fine soil and FYM in equal proportion is put on these bricks making the surface 4-5 cm raised.
- Irrigation is given on the surface and the moisture is reaches to the surface through capillary action of the bricks.
- Sowing is done on this surface of the bricks. Seed is mixed with fine and well decomposed FYM and then put FYM on the raised surface for good germination or after broadcasting, the seed is covered with FYM.
- 3-4 small seeds are kept at equal spacing on one brick which is covered with FYM to raise small sized tubers. Irrigation is given up to the half level of bricks.

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TRUE POTATO SEED (TPS) TECHNOLOGY
 Cultivation through true potato seed is beneficial because:

- Seed material as potato tubers required to cultivate 1.32 m ha area is around 33 m q (seed rate 25 q/ha). Quality seed production, certification and storage of such a huge quantity is very difficult.
- Transportation of such a huge material is also difficult and costly and can be used as food material.
- True seed is free from viruses and many other diseases as their management is easy due to small area. Cost of cultivation is also less.

Methods of using true potato seed

- To raise seedlings and then transplanting
- Sowing of seed in nursery beds and then raising them for obtaining small sized potato tubers which are used for cultivation of the next crop. These seeds are sown in raised beds.

Problems associated with use of true potato seed

- Seed is very small and weak as compared to tomato, brinjal etc.
- It is not grown very deep and also low application of fertilizers is required.
- It very difficult to maintain optimum moisture conditions as it is sown very near to the surface.
- Poor germination and unhealthy and weak nursery seedlings of potato are creating problems to farmers.
- Therefore, farmers are not enthusiastic to take up this venture on large scale cultivation.

Refined technique for raising TPS

- Make nursery bed of size 2 m x 1m and then bricks are laid on these beds. Fine soil and FYM in equal proportion is put on these bricks making the surface 4-5 cm raised.
- Irrigation is given on the surface and the moisture is reaches to the surface through capillary action of the bricks.
- Sowing is done on this surface of the bricks. Seed is mixed with fine and well decomposed FYM and then put FYM on the raised surface for good germination or after broadcasting, the seed is covered with FYM.
- 3-4 small seeds are kept at equal spacing on one brick which is covered with FYM to raise small sized tubers. Irrigation is given up to the half level of bricks.

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BRUSSELS SPROUT

Two types of varieties exist on the basis of growth of the plant:

1. Dwarf
2. Tall

Hild's Ideal:

- Plant height varies from 60-65cm with 45-55 sprouts/plant and number of leaves varies from 45-55.
- Average diameter of sprouts is 7.0-8.0 cm and each sprout weighs about 7-8g.
- Sprouts are compact with good flavour.
- It takes about 115days for first picking after transplanting.
- Average yield per plant varies from 250-400g.

Jade Cross:

- It is an early hybrid which matures in 90days after transplanting.
 - Sprouts are firm, dark green, closely packed on long stems.
 - It can be grown under wide range of growing conditions.
- Some other important varieties are Improved Long Island, Danish Prize, Early Morn, Amager Market and Frontier Zuerg

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CAULIFLOWER

Varieties have been divided into four different maturity groups (I-IV) for northern Indian plains:

Maturity group	Nursery sowing time	Transplanting time	Opt. temp. range for curding	Varieties
Extra Early: May maturity (May-June)	End of February	March	24°C-30°C	Pusa Meghna, DC 23, Pusa Kartik Sankar
Early I (A) Sept. maturity (mid Sept.-mid Nov.)	Mid May	July beginning	20-25°C	Early Kunwari, Pusa Early Synthetic, Pant Gobhi-3, Pusa Meghna, Pusa Kartik Sankar
I (B) Oct. maturity (Mid Oct.-mid Nov.)	May end to Mid June	Mid July	20-25°C	Pusa Katki, Pusa Deepali, Pant Gobhi-2
Mid Early (II) Nov. maturity (Mid Nov.-mid Dec.)	July end	Sept. beginning	16-20°C	Improved Japanese, 12-C, Pusa hybrid-2, Pusa Sharad, Pant Gobhi-4
Mid late (III) Dec. maturity (mid Dec.-mid Jan.)	Aug. end	Sept. end	12-16°C	Pusa Synthetic, Pusa Subhra, Palam Uphar, KT-25, Pant Subhra, Pusa Him Jyoti, Pb. Giant 35, Pusa Paushja, Pusa Shukti
Late (IV)	Sept.	Oct. end-mid	10-16°C	Snowball 16,

Snowball (Jan.-March)	end to mid Oct.	Nov.		Pusa Snowball-I, Pusa Snowball K-1, Dania, Ooty-1
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Cauliflower cultivars grown in India can be classified in two broad groups:

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

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

The varieties can be grouped as early, mid early, mid late and late season varieties on the basis of maturity groups.

Early Varieties:

- Early kunwari
- Pusa Early Synthetic
- Pant Gobhi 3
- Pusa Deepali
- Pant Gobhi 2.

Mid Early Varieties:

- Improved Japanese
- Pusa Hybrid- 2

- Pusa Sharad
- Pant Gobhi- 4

Mid Late Varieties:

- Pusa Synthetic
- Pant Shubhra
- Pusa Shubhra
- Pusa Himjyoti
- Punjab Giant 35

Late Varieties:

- Pusa snowball-1
- Pusa snowball K-1
- Ooty-1

Description

Early Kunwari:

- It is an early variety suitable for growing in Punjab, Haryana, Himachal Pradesh and Delhi.
- It is released by Punjab Agricultural University, Ludhiana.
- The leaves are bluish green.
- Curds are semi-spherical with even surface and ready for harvesting from mid September to mid October.

Pant Gobhi-2:

- It is a composite variety released by GB Pant University of Agriculture and Technology, Pantnagar.
- Curds become ready for harvesting from October onwards.

Pusa Himjyoti:

- Curd is quite white, solid and round.
- It is early in maturity, having curds of 500-600g in weight.
- Yield of this variety is 160-180q/ha.
- The only variety which can be grown from April - July in the hills.

Pusa Hybrid-2:

- Plants are erect and medium tall with bluish green upright leaves.
- Curd is creamy-white and highly compact.
- The yield potential of this variety is 230-250q/ha.
- It is resistant to downy mildew.

Pusa Snowball:

- It is a late variety and suitable for cool season.
- Curds are very compact, medium in size and snow white in colour.

Pusa Snowball K-1:

- This is also developed at IARI, Regional Station, Katrain (Kullu Valley) and is tolerant to black rot.
- Amongst the snowball types, it has the best quality of snow white curds.

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