

# **DR. SUBHRAJYOTI CHATTERJEE**

**B.SC. (HORT.), M.SC. (HORT.) VEGETABLE SCIENCE, PH.D.**

**VEGETABLESCIENCE**

**RESEARCHGATE:**

<https://www.researchgate.net/profile/Subhrajyoti-Chatterjee-4>

**GOOGLE SCHOLAR:**

<https://scholar.google.com/citations?user=Fj1lUPoAAAAJ&hl=en&authuser=1>

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

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

(Hindi: Pyaz)

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

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

### Origin and taxonomy

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

The following types of onions are grown in India:

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



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



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



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





**Capsules**



**Walking onions**



**Walking onion flowers**



**Onion sets growing green stalks of their own**

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



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



### Botany

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

### Male sterility

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

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

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

### Climate

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

### Varieties

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

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

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

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

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

### Hybrid vigour

IIHR, Bangalore has developed F<sub>1</sub> hybrids like Arka Kirtiman, Arka Lalima and Arka Pitamber. A brief description of the above hybrids is given below :



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

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

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

### Soil

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



### Methods of planting

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

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

### Transplanting method

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

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

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

### **Planting of bulbs**

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

### **Broadcasting or drilling method**

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

### **Manures and fertilizers**

Onion is a heavy feeder of nitrogen and potash and a crop yielding 35 t/ha requires 120 kg N, 50 kg P<sub>2</sub>O<sub>5</sub> and 160 kg K<sub>2</sub>O, 15 kg Mg O and 20 kg sulphur. Apply 20-25 tones of farmyard manure at the time of first ploughing so that it may get mixed thoroughly during subsequent ploughings. Entire dose of P and K should be applied at the time of final land preparation. Nitrogen should be top-dressed in two equal splits, first half 3-4 weeks after transplanting and second half two months after transplanting.

### **Application of fertilizers in Tamil Nadu :**

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

### **Irrigation**

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

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

### **Weeding and inter-culture**

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

### **Harvesting and yield**

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

### **Rainy season onion cultivation**

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

### **Green onion or Spring onion**

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

### **Post-harvest handling**

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

### **Curing**

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

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

### **Storage**

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

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

### **Grading**

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

### **Marketing**

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

### **Export**

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

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

### **Dehydrated onion**

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

#### **Bulbs for dehydration should have the following characteristics:**

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

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

### **Seed Production**

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

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

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

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

### Multiplier Onion

(Syn : *Aggregatum* onion)

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

(Hindi : Cotta pyas)

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

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

#### Varieties

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

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

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

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

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

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

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

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

\*\*\*\*\*

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

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



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

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



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

**Nutritive Value of Garlic**

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

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

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

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

### Area, Production and Productivity

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

### VARIETIES

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

#### Agrifound White

The variety was notified by Govt. of India in 1989 vide notification no. 28(E) dated 13/4/1989. The variety was developed by mass selection from a local collection obtained from Biharsharif area in Bihar. The bulbs are compact, silvery white with creamy flesh. Bigger elongated cloves with 20-25 in numbers. Diameter 3.5 to 4.5 cm size index 12-15 cm<sup>2</sup>. The variety is susceptible to purple blotch and **stemphylium** blight which are common in the northern parts. TSS 41% dry matter 42.78% and good storer. The yield is 130 q/ha. It is recommended for cultivation in the areas where there is not much problem of purple blotch or **stemphylium** blight in rabi season.

#### YAMUNA SAFED (G-1)



This variety was notified by Govt. of India in the year 1991 vide notification no.527 (E) dated 16/8/1989. It was developed by mass selection from a local collection obtained from Delhi (Azadpur) market. The bulbs are compact, silvery white skin with creamy flesh. Diameter 4.0 cm to 4.5 cm. Sickle shaped cloves, 25-30 in number, size index of bulb 12-15 cm<sup>2</sup>, diameter of cloves 0.8 to 1.00 cm. The variety is tolerant to insect pests and diseases like purple blotch, stemphylium blight and onion thrips. TSS 38%, dry matter 39.5% and good storer. Yield 150-175 q/ha. It is recommended for cultivation all over the country.

### **YAMUNA SAFED-2 (G-50)**

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



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

### **YAMUNA SAFED-3 (G-282)**

The variety has done very well in Northern parts and also in Central parts of India. It was developed by mass selection technique from a local collection obtained from Dindigul (TN) in 1990. The leaves are wider than other varieties. Bulbs are creamy white and bigger sized (5-6cm dia). Size index 27-29cm<sup>2</sup>, diameter of cloves 1.2-1.5 cm. 15-16 number of cloves per bulb TSS 38.42%, dry matter 39-43%, medium storer. Average yield 175-200 q/ha. The variety is suitable for export. The variety was notified in the year 1999 vide notification no.1092 (E) dated 26/10/1999.



### **AGRIFOUND PARVATI**

This variety was developed in 1992 by selection from an exotic collection obtained from Hongkong market. The variety is long day type and as such is suitable for cultivation in mid and high hill of Northern states. Bulbs are of bigger size (5-6.5 cm), creamy white colour with pinkish tinge. Size index 16-72 cm<sup>2</sup>, diameter of cloves 1.5 to 1.8 cm, 10-16 cloves in number tolerant to common disease. Average yield 175-225 q/ha, medium storer. Suitable for export.

### **YAMUNA SAFED-4 (G-323)**

The variety has done very well in Zone VI. It was developed by mass selection technique from a local collection obtained from Jaunpur, Uttar Pradesh in 1988. Leaf wide, Bulb- compact, attractive creamy white colour, creamy flesh, bulb diameter 4-5 cm, size index 14-16 cm<sup>2</sup>, no. of cloves 18-23 per bulb, diameter of cloves 0.75-1.0 cm, cloves size index 1.8-2.0 cm<sup>2</sup>, Matures in 165-175 days.



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

### **MEDICINAL VALUE**

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

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

### **AGRO TECHNIQUES**

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

### **SOIL**

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

### **PLANTING**

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

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



## **MANURES AND FERTILIZERS**

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

## **IRRIGATION**

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

## **INTERCULTURE**

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

## **HARVESTING AND CURING**

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

## **YIELD**

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

## **SEED PRODUCTION**

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

## **POST- HARVEST MANAGEMENT**

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

### **DRYING AND CURING**

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

### **SORTING AND GRADING**

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

### **PACKAGING**

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

### **STORAGE**

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



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

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

## **PLANT PROTECTION**

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

### **DISEASES**

#### **PURPLE BLOTCH**

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

#### **STEMPHYLIUM BLIGHT**

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

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

### **CERCOSPORA LEAF BLIGHT**

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

### **POWDERY MILDEW**

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

### **MOSAIC DISEASE**

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

### **INSECT PESTS**

#### **THRIPS**

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

#### **STEM AND BULB NEMATODE**

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

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

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

### **MITES**

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

### **RHIZOGLYPHUS CALLAE AND GLYCOHAQUS DOMESTICUS**

These may attack on bulbs in storage. Fumigation of dry bulbs with methyl bromide after harvesting and before storage controls the mites. Application of methyl bromide @ 1kg/1000 cubic feet for 2 hours at 26°C is recommended.

### **PHYSIOLOGICAL DISORDERS**

Sprouting of bulbs in the field is noticed sometimes towards the start of maturity stage of bulbs particularly when there are winter rains or excessive soil moisture and nitrogen supply. This disorder is, however, not of permanent nature and varies from variety-to-variety. Early-planting also causes sprouting. Splitting is also noticed sometimes in some varieties, which is due to delayed harvesting or irrigation after long spell of drought. For past few years rubberification problem is noticed in Rajkot area and also Nilgiri hills of Tamil Nadu. It is increasing day-by-day. The actual cause for the disorder was since not identified, a trial was planned in collaboration with TNAU at HRS, Ooty, during 1995-96. The effects of insecticides, fungicides, micronutrients and growth regulator were studied. It was observed that rubberification was totally controlled by application of micronutrients i.e. zinc sulphate and ammonium molybdate. It was also controlled by neem cake insecticides and growth regulator like GA.

Further studies are required to eliminate this problem in different areas as the incidence is noticed variably in different areas.

The aerial bulbil formation is also quite common in garlic where lower temperature prevails for more periods or there is more temperature variation. It, however, does not affect much on yield or quality of bulbs and varietal variation is noticed where G-282 is seen more prone for this type of effect.

The rubberification and premature sprouting of bulbs are main physiological disorders in garlic. The reasons for these disorders are summarized as under for hill grown garlic in Tamil Nadu.

- Rubberification and premature sprouting of bulbs are noticed mostly in fields which are located in low-lying areas of watershed where there is heavy deposition of nutrients along with silt during heavy rains.
- These problems are severe in garlic fields which are more frequently irrigated than the normal requirements of garlic bulbs.
- With the application of higher levels of nitrogen, there is an increased level of pre-mature sprouting of bulbs which results in splitting and rubberification of bulbs.
- Rubberification incidence also increases when higher level of nitrogen is applied in the form of urea.
- Due to increased levels of nitrogen, in addition to the increased production of rubberized, there is an increased level of thrips incidence in leaves during the later stage of crop. The thrips lacerate leaves and cause severe damage to the crop. Through lacerated wounds by thrips, there is a severe incidence of blast disease, caused by *Botrytis allii*, when crops is 70-90 days old, which further deteriorates the quality of garlic bulbs.
- Short duration type of garlic (Mettupalayam type) is more susceptible than long duration type (Singapore type).
- Premature sprouting of bulbs is more in the crop (April-August) when there is high moisture level in soil at maturity of crop due to heavy rains.
- Delayed harvest during rainy season has increased premature sprouting and splitting of bulbs.
- Wider spacing of cloves at the time of planting increases uptake of nitrogen and water by the individual plants which increases premature sprouting and rubberification of garlic bulbs.

\*\*\*\*\*

1. Economic part of Garlic is \_\_\_\_\_  
a. bulb      b. root      c. umbels      d. cloves
2. \_\_\_\_\_ is a frost hardy bulbous perennial erect herb.

- a. Leek                      b. Onion                      c. Garlic                      d. Bunching onion
3. \_\_\_\_\_ is a crop that is grown only in rabi season
- a. Tomato      b. Brinjal      c. Onion      d. Garlic
4. The pungency in garlic is due to the presence of \_\_\_\_\_
5. In garlic \_\_\_\_\_ application at inflorescence stage enhance bulblet formation

## ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR POTATO

**Family: Solanaceae**

**Botanical Name: *Solanum tuberosum***

**Chromosome Number: 2n= 48**

### Origin and History

The probable centre of origin of potato is in South America in the central Andean region. Evidence indicates that potatoes were cultivated for centuries by South American Indians and the tubers were used as a common article of food. The Spaniards during invasion found this economic plant worthy of introduction into Europe. The Spanish people brought potato from Peru to Spain in 1565. Sir Francis Drake probably brought them to England about 1586. Following its introduction into European agriculture, potato became an important food crop of Italy, France, and Ireland. During the famine years, the potato crop became valuable food crop in Ireland. Potato was introduced to India from Europe in the beginning of the seventeenth century, probably by the Portuguese, who were the first to open trade routes to the east. The first mention of potato in India occurs in 'Terry's account of a banquet at Ajmer given by Asaph Khan to Sir Thomas Rao in 1615. Potato was grown in many gardens of Surat and Karnataka in about 1675. Cultivation of potato in northern hills started later than plains but became a cash crop much earlier. Cultivation of potato was beginning first in the Nilgiri hills in the 1822. The spread of potato is given in Figure 1.

### Nutritive value and uses

It is one of the important crops of the world. In India, it is used only as a vegetable. Sometimes it is also mixed with other vegetables. It is also used for making of chips, halwa, gulab jamun, rasgulla, murabba, kheer, guzlia and barfi etc. According to Aykroyd (1941), it contains 74.7 per cent water, 22.9 per cent sugar, .6 per cent protein, 0.1 per cent fat, 0.6 per cent mineral matters, 0.01 per cent calcium, 0.03 per cent phosphorus and 0.0007 per cent iron, while according to Macgillivray (1953), it contains 77.8 per cent water, and food value per 100g of edible portion is energy 85 calories, protein 2 g, calcium 13 mg, vitamin A 40 IU, ascorbic acid 12 mg, thiamine 0.11 mg, riboflavin 0.06 mg and niacin 1.18 mg and according to Chatfield (1949) raw potato also contains in 100 g, edible portion: Na 3 mg, K 410 mg, Ca 14 mg, Mg 27 mg, Fe 0.8 mg, Cu 0.16 mg, P 56mg, S 29 mg and Cl 35 mg. The potato tuber may contain an alkaloid (Solanine), if it is exposed to light. It is a poisonous compound but 70 per cent of it is removed when potatoes are peeled. This alkaloid may cause sickness or death both to live stock and the human beings. Nadkarni (1927) has reported the following medicinal uses of potatoes:

It is anti-scorbutic. Persons with neurotic and liver dyspepsia digest it well. It is also employed as an, diuretic and galactagogue, nervous sedative and stimulant in gout. The leaves in the form of extract are employed as an antispasmodic in chronic cough producing effects as those of optimum etc. potato grind into a paste is applied as plaster to burns caused by fire with good results. The juice of the potato is a dark colored liquid due to the presence of citric and succinic acids. Potatoes may be mealy or non-mealy. Mealy potatoes are those in which the cells, on cooking, separate from one another so that they may be piled up in loose flour with air between them instead of remaining in a solid mass with water in the small intercellular spaces. But this is absent in immature potatoes due to low quantity of starch. Mealiness and high starch are associated with high specific gravity. According to Covdon and Boussard (1897) disruption of potatoes in cooking is partly due to turgidity of tissues, the more turgid they are more easily do they fracture and permit the ready penetration of boiling water.

### **Area and Production**

In India out of total 5335447 ha of land under vegetables, potato occupies nearly 20.79 per cent area. The area (1109000 ha) under potato, during the year 1995-96 followed percentage change of -2.30, -10.56, -5.91 and 3.70 over 1991-92, 1992-93, 1993-94 and 1994-95, respectively. Production of potato was 18843300 MT during the year 1995-96, having 26.32 per cent share in the total vegetable production. Production increased by 3.56, 1.97, 8.34 and 8.29 per cent over 1991-92, 1992-93, 1993-94 and 1994-95 respectively. The productivity of potato was 16.99 MT/ha, whereas the highest 24.4 MT/ha was of West Bengal in the country (NHB, 1998) potato is grown in almost all the states of India. It is mainly grown in the states like Uttar Pradesh, West Bengal, Punjab, Karnataka, Assam and Madhya Pradesh. The major potato producing belts in India are as given below (NHB, 1998).

- **Himachal Pradesh:** Shimla, Lahul Spiti and Mandi.
- **Punjab:** Jalandhar, Hoshiyarpur, Ludhiana and Patiala.
- **Haryana:** Ambala, Kurukshetra, Hisar and Karnal.
- **Uttar Pradesh:** Farrukhabad, Etawah, Manpuri, barabanki, Allahabad, Badaun, Moradabad, Agra, Aligarh, Mathura and Faizabad.
- **Madhya Pradesh:** Sidhi, Satana, Rewa, Sagar, Rajgarh and Tikamgarh.
- **Chhattigarh:** Sarguja and Raipur.
- **Rajasthan**
- **Gujarat:** Khera, Dissa, Baransh katha, Jamnagar, Baroda, Mehsana.
- **Orisa:** Cuttack, Dhenkamal, Puri and Sambalpur.
- **West Bengal**

- **Maharashtra:** Pune, Satana, Kolhapur and Nasik.
- **Karnataka:** Belgaum and Dharwad , Hassan, Kolar.
- **Uttaranchal:** Almora, Pilibhit and Haldwani.
- **Andhra Pradesh:** Medak and Chittoor.
- **Tamil Nadu:** Dhinikulanna and the Nilgiris
- **Assam**

Apart from India, the other major producers of potato in world are China, Russian Federal, Poland, USA, Ukraine, Germany, Netherlands and UK (NHB, 1998)

**Classification, Botany and Floral Biology**

**Classification**

The potato was first domesticated in the high plateau region of the Peruvian and Bolivian Andes and has been grown for several millennia. A total of seven cultivated species were domesticated and they remain the most important crop in the high Andean, regions, where the greatest genetic diversity of cultivated potato is concentrated (Engel, 1970). The cultivated potatoes species are as given below:

**Table1. Classification and origin of the cultivated potatoes**

<b>Species</b>	<b>Distribution</b>	<b>Origin</b>
<i>Solanum tuberosum sub sp. tuberosum</i> (2n = 48) (2n =n48)	Cosmopolitan	By artificial selection in Europe, North America and Chile from introduced clones of group 2.
<i>S. tuberosum sub sp. andigena</i> (2n = 48)	Venezuela to northern Argentina; also sporadically in central America and Mexico	From group 4 and 5 by spontaneous doubling of the chromosome number.
<i>S.chaucha</i> (2n = 36) <i>S. phuerja</i> (2n = 24)	Central Peru to northern Bolivia Venezuela to northern Bolivia	By hybridization between group 2 and 4 and 5. by selection for short tuber dormancy from group 5.
<i>S.stentomum</i> (2n=24)	Southern Peru to northern Bolivia	By natural hybridization between wild species followed by artificial selection.



<i>S.juzepcsukii</i> (2n=36)	Central peru to southern Bolivia	From crosses of <i>S.acaule</i> with groups of 4 and 5
<i>S.curtilobum</i>	Central peru to southern Bolivia	Crosses of <i>S. juzepczukii</i> with group 2.

**The commercial potato generally belong to two species**

***Solanum andigenum***: it is not very common. Plants have thin and long stem, small and narrow leaflets. Flowers are produced more profusely. It has long stolons and mostly coloured deep-eyed tubers.

***Solanum tuberosum***: It is more common, plants have shorter and thicker stem larger and wider leaflets.

In addition to two species, there are also some important species, which shows resistant to biotic and abiotic. Theses species are given in Table 2.

**Table 2. Potato species resistant to biotic and abiotic**

Species	Utility
<i>Solanum demissum</i> lind (2n = 72)	Resistance to late blight, virus A, virus Y
<i>S. stoloniferum</i> (2n = 48)	Resistance to virus x, frost, Colorado beetle.
<i>S.vernei</i> Bitt et,. Wittm (2n = 24)	Resistant to two species of Heterodera nematode.
<i>S. multidissectum</i> Waek (2n=24)	Resistant to two species of Heterodera nematode.
<i>S.antipovczii</i> Bulk	Resistance to late blight
<i>S.curtilobum</i> jug. Et. Buk	Resistant to frost
<i>S. phureja</i> jug. Et. Buk	Non dormant type used inbreeding
<i>S. chacoense</i> bitter	Non dormant type used in breeding Tolerance to high temperature
<i>S . anomalocalyx</i> , <i>S. jamessi</i> Torr; <i>S. Saltense</i>	Resistance to early blight.

Potato can also be divided on the basis of origin and response to day length as given in Table 3.

**Table3. Classification on the Basis of origin and Response of Day Length:**

Distant characters	<i>S.tuberosum</i>	<i>S.andigenum</i>
Origin	Andean region	Chile region
Day length response	Long day plants	Short day plants
Ployploidy	Many types of polyploids	Tetraploids
Distinct varieties	'Up-to-date'      'Magnum'	All the desi varieties like

	Bonum' etc	'Darjeeling', 'Red Round', 'Phulwa' and 'Gola'
--	------------	---

Potato can be classified into early and late varieties. They are given below in Table 4.

**Table 4. Classification of potato on the Basis of Crop Duration**

Character	Early potato	Late potato
Stolon length	Short	Long
Stem	Hollow	Solid
Petioles	Broader	Narrow
Stolon number	Less number	More number
Tuber colour	White	Coloured
Photoperiodism	Long day for tuber development	Short day for tuber development
Varieties	'Satha', 'Gola', Great Scot', Kufri Chandramukhi'	'Phulwa', 'Kufri Kissan', 'Kufri Safed'

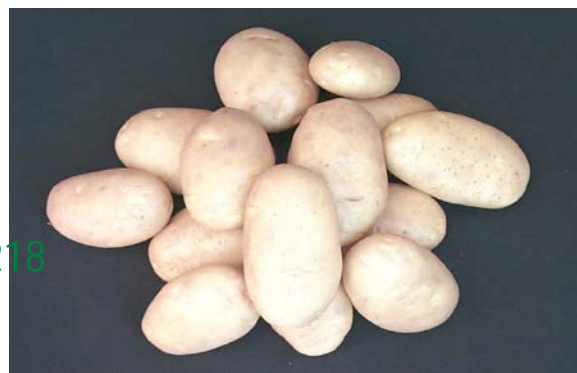
### Varieties/Hybrids

#### KUFRI ALANKAR

It is a derivatives of the cross (Kennebee x O.N .2090) x (Majestic x Ekishiraju), released in 1968 by Central Variety Release Committee for plains of Punjab, Haryana and Western Uttar Pradesh and specially suited for sandy soils. Plants are very tall, open and erect with thick and strong stem and RI) 2 colour uniformly distributed. Leaflets are rough and present in leaflets midrib of 2.3 top leaves but not in the stem base. Tubers are oblong, tapering towards and, flesh dull white eyes and medium deep to fleet. It shows slow rate of degeneration. Tubers develop crack if allowed to remain till full maturity. It is rapid bulking variety keeping quality not good. It matures 75 days in plains and 140 days in hills. The yield potential is 300 q/ha in plains and 100 a/ha in hills. This variety is having moderate field resistance to late blight with immunity to race 1 and '0' susceptible to common scab.

#### KUFRI ANAND

A derivative of PJ376 x PH/F 1430, released from CPRI, Shimla in 1999. plants are tall erect, vigorous, stems few, thick and



pigmented at the base. Foliage is grey-green, leaves intermediate and rachis green. Leaflets are ovate lanceolate, smooth, glossy surface with entire margin and occasionally terminal leaflets fused. Flowers are light purple in colour with moderate flowering. Anthers are orange yellow, well-developed and low pollen stain ability. Stigma is round and notched. Tubers are white, large oval long, flattened, smooth skin, fleet eyes, white flesh having red purple sprouts. It is a medium maturing variety (100-110 days) having a yield potential of 350-400 q/ha. This variety is adaptable to plains of Uttar Pradesh and neighboring states. This variety is resistant blight. The tubers are ideal in shape for French fries.

### **KUFRI ASHOKA**

It is a wider adaptable variety released from CPIU, Shimla in 1996. It is a derivative of (EMC-I 020 x Allerfi'uii lleste Gelbe). Plants are medium tall, erect, medium compact and vigorous. Stems are few, medium thick, lightly pigmented at base with poorly developed straight wings. Foliage is green. Leaves are intermediate having green rachis. Leaflets are ovate lanceolate, smooth glassy surface with entire margin, Flowers are light red purple. This variety has profuse flowering. Anthers are orange-yellow, well- developed and medium pollen stain ability. Stigma is round shaped. Tubers are white, large, oval long, smooth skin and fleet eyes with white flesh having purple sprouts. It is an early maturing (70-80 days) having yield potential of 400 q/ha, suited in Bihar, Haryana, Punjab, Uttar Pradesh and West Bengal for cultivation. It is susceptible to late blight and not suitable for processing.

### **KUFRI BADSHAH**

It is a cross of Kufri Jyoti and Kutri Alankar and released in 1980 by Central Sub Committee on release in varieties for Indo - gangetic plains of North India, including Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal, Madhya Pradesh and Plateau region. Plants are tall, haulms erect, 4-5 stems per plant with a tendency for branching, semi-solid, flexible, slightly



pubescent, red purple, well developed straight wings and short (about 7-8 cm) internodes. Leaves are green, medium long, prominent venation, rachis pigmented at base, disposition almost at right angles with the stem. Leaflets are broad, medium in size, slightly hairy, entire margin, ovate, glassy veins prominent, and petiole green, usually four pairs and one terminal leaflet. Tubers are mostly large to medium, oval, shining white, smooth, regular with shallow

eyes, flesh dull white, sprouts stout, thick, 1 bulbous white with light red pigmentation at the base. Stolen are thick, short and white. Flowers are scanty, white, and medium in size, fully stretching wings, pollen fertility 50-60 per cent and frequently set berries in the hills. This variety possesses medium dormancy. This variety has average keeping quality. It shows slow rate of degeneration. Tubers are tasty with good flavour. It contains 13.6 g/100 g starch and 18.6 per cent dry matter content. It matures in plains 90-100 days. It is tolerant to frost, resistant to late blight, early blight and potato virus 'X' but susceptible to soft.

### **KUFRI BAHAR**

It is a derivative of the cross Kufri Red x Ginek and released by Central Sub-Committee on Release of Varieties in 1980 for the plains of Haryana, Punjab and Western Uttar Pradesh. Plants are tall erect, medium compact and vigorous. Stem is thick, 4-5 stems per plant, succulent, semi-solid with moderately developed wings. Leaves are open, straight with 4-5 pairs of leaflets. Leaflets are grey green, medium, dull with entire margins. Foliage is of grey green colour. Tubers are large, white, round to oval, skin smooth with medium deep eyes, flesh white. Sprouts are bulbous and red. Stolens are medium long. This variety has moderate flowering, having white flowers, medium in size and sterile. Keeping quality is average with medium dormancy. It is mid maturity variety (90-100 days). Yield is 250-300 q/ha. Resistant to late blight, early blight and potato virus 'X', 'Y' and leaf roll. It is susceptible to insect pests, drought and frost.



### **KUFRI CHAMATKAR**

A derivative of the cross *Ekishiraju* x *Phulwa* and released in 1967 by Central Variety Released Committee for the plains of Uttar Pradesh, Madhya Pradesh, Haryana, Punjab, where one crop of long duration is raised. Plants are medium, spreading, short stolen, compact, dark green foliage, foliage prominent, very small internodes, more stems and small leaflets. Flowers are of white colour. Tubers are round and white, eyes medium deep, flesh yellow and red sprouts. Degeneration is slow and quick tuberization. It is late maturing variety, which matures 110-120 days in plains and 150 days in hills. The yield potential of this variety is 250 q/ha in plains and 75.00 q/ha in hills. It is resistant to early blight but susceptible to viruses, late blight, brown rot, charcoal rot, wilts and common scab.

### **KUFRI CHANDRAMUKHI**

It is a derivative of the cross S.4485 X Kufri Kuber and released in 1967 in Central Variety Release Committee for the plains of Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Rajasthan, Bihar, West Bengal and Maharashtra. It also grows well in Himachal Pradesh hills and Jammu regions. Plants are medium tall with open foliage habit and free from secondary growth. Foliage is grass green



and glossy. The small leaflets are not fully expanded especially on top, notched tip on one side of leaflets. Tubers are oval, white, flesh dull white, eye fleet, and sprouts light red and pubescent. The variety has slow rate of degeneration and early bulking. It possesses good keeping quality. It is mid season variety, matures 80-90 days in plains and 120 days in hills. An average yield is 200 q/ha in plains and 75 q/ha in hills. It is susceptible to common scab, late blight, brown rot, nematodes, charcoal rot and wilts.

#### **KUFRI CHIPSONA-1**

It is a cross of MEX.750826 x MS/78- 79 and released from CPRI, Shimla in 1998. Plants are medium tall, semi erect, compact and vigorous. Stems are few, thick, slightly pigmented with poorly developed straight wings. Foliage is green, leaves, open and rachis green. Leaflet is ovate, smooth, dull surface with entire margin. Flowers are white and profuse flowering. Anthers are orange-yellow, well developed, and stigma round pinhead. Tubers are white medium to large oval, smooth skin, fleet eyes, and dull white flesh having green sprouts. It is medium maturing variety (90-110 days) having 400q/ha. It is suitable for cultivation in Bihar and Uttar Pradesh. It is resistant to late blight. The variety is highly suitable for making chips and French fries.



It is a derivative of F-6 x QB/B-92-4 and released from CPRI, Shimla in 1998. Plants are medium tall, erect open and vigorous. Stem is few, medium thick slightly pigmented with straight wings. Foliage is dark green, leaves open, rachis green, leaflet ovate lanceolate, wrinkled dull surface with slightly wavy

#### **KUFRI CHIPSONA-2**

It is a derivative of F-6 x QB/B-92-4 and released from CPRI, Shimla in 1998. Plants are medium tall, erect open and vigorous. Stem is few, medium thick slightly pigmented with straight wings. Foliage is dark green, leaves open, rachis green, leaflet ovate lanceolate, wrinkled dull surface with slightly wavy



margin. Flowers are white and moderate in flowering. Anthers are yellow, well-developed and moderate pollen stability. Stigma is round notched. Tubers are white, medium, round oval, smooth skin, fleet eyes, and yellow flesh having reddish brown sprouts. It is medium maturing variety yielded 350 q/ha. This variety is resistant to late blight and tolerant to frost. Due to high dry matter content, low reducing sugars and low phenols, the variety is highly suitable for making chips and French Fries.

### **KUFRI DEWA**

It is a derivative of the cross Craig's Defiance x Phulwa and released by Central Sub-Committee on Release of Varieties in-1973 for Tarai area of Uttaranchal and Shimla agro climatic conditions. It is also suitable for Bihar and Orissa. Plants are very tall open, erect and very small internodes. Leaves are semi-compact, dark green and upright. Petioles are very long having 3-6 cm towards base and devoid of leaves. Tubers are erratic round with purple splashes, eye deep and pigmented and sprout light red with white flesh. Tubers develop brown spots after harvest. It is highly susceptible to late blight, possesses good resistance to frost and drought. It matures in 120 days in plains and 165 days in hills. An average yield is 250 q/ha.

### **KUFRI GIRIRAJ**

It is north and south India adaptable variety. It is a cross of SLB/1-132 x EX/A 680-16 and released from CPRI, Shimla in 1998. Plants are medium tall, semi-erect, medium compact and vigorous. Stems are many, medium thick, coloured at base with moderately developed straight wings. Foliage is green, leaves open and rachis green. Leaflets are ovate, smooth dull surface with entire margin. Flowers are light purple and shy flowering. Anthers are yellow, well-developed and low pollen stability. Stigma is round. Tubers are white, medium to large, oval smooth skin, fleet eyes, and white flesh and sprout light purple. The yield potential of this variety is 250 q/ha. This variety is resistant to late blight (both foliage and tubers). It is not suitable for processing.



### **KUFRI HIMALINI**

It is a derivative of cross SLB/H-140 x SLB/Z-389 (b) Recommended by 9th workshop of the All India Coordinated Potato Improvement Project for Hilly regions (hills of Northern India and Nilgiris in South) in the country. Plants are tall, vigorous, erect, semi-close, spreading tendency at the time of maturity. It possesses 4- 5 stems, stem solid, slightly hairy, colour red purple, spreading uniformly throughout the stem, wings moderately developed and straight. Leaves are semi-close, medium to long, placement medium and rachis of green colour. Leaflets

are grey green, flat, margin entire, petiole and mid rib green, medium in size and green and foliage grey green. Tubers are medium to large, oval, slightly flattened, skin white, eyes shallow to medium deep, flesh dull white and mealy texture. Sprouts are red purple and medium thick. Flowers are profuse, persistent white, light pinkish colour on the tips of corolla wings, pollens fertile and natural berries are formed. Tubers possess medium dormancy (2-2Y2 months). Keeping quality is good and does not show shrinkage on five months storage in hills. It is highly resistant to late blight but susceptible to early blight, phoma leaf spot, brown rot, and common scab and moderately susceptible to powdery scab and leaf blotch. Planting is done in March-April as summer crop in Nilgiris in northern hills, August- September for autumn crop in the southern hills. It matures 30-140 days after planting.

### **KUFRI JAWAHAR**

It is a derivative of Kufri Neelamani x Kufri jyoti and released from Central Potato Research Institute, Shimla in 1996. Plants are short, erect, compact and vigorous; stem few, thick, lightly pigmented at base with well-developed straight wings. Foliage is light green, leaves open, rachis green, terminal leaflet cordate, smooth dull surface with entire margin. Flowers are white moderately flowering. Anthers are orange yellow, well-developed and low pollen stability. Stigma is round and slightly notched. Tubers are creamy white, medium sized, round-oval smooth skin, eyes fleet, and pale yellow flesh having purple sprouts. It is an early maturing variety (80-90 days) yielded 400 q/ha. This variety is resistant to late blight. It is not suitable for processing. It is widely adaptable in Haryana and Punjab, plateau region of Gujarat, Karnataka and Madhya Pradesh. It is suitable for intensive cropping.

### **KUFRI JEEVAN**

It is a derivative of the cross M-109-3 x D 698 and adopted for northwest hills of Himachal Pradesh and Uttar Pradesh. Tubers are medium, white skin, oval shaped, eyes fleet, faint red picked, flesh waxy and pale yellow. It matures 150-160 days in hills and 120 days in plains. It is resistant to wart, highly resistant to late blight and in moderately resistant to early blight.

### **KUFRI JYOTI**

It is a derivative of the cross 3069d(4) x 2814 Q (1) and released in 1968 by the Central Variety Release Committee for Himachal Pradesh and Kumaon Hills of Uttranchal and also plains where late blight is a limiting factor. Plants are tall, compact and erect. Terminal leaflet is a cottony or





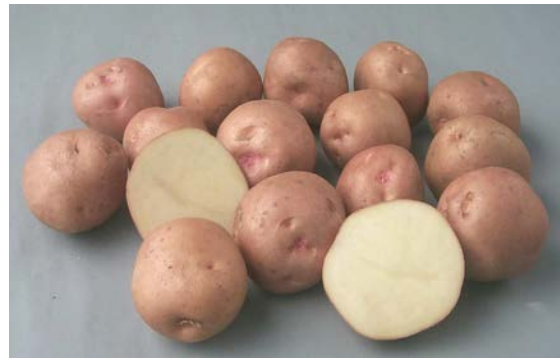
cordate and leaflet of top 2-3 leaves incurved at the base. Leaflets are broad and light green. Tubers are oval, white, eye fleet. Flesh is light white and waxy. Sprouts are blue purple and medium thick. It has good keeping quality if given proper post harvest treatment. It is field resistant to late blight with immunity to race. It is resistant to early blight and wart disease. It matures 100 days in plains and 120 days in hills. The yield potential is 200 and 150 q/ha in plains and hills, respectively.

### **KUFRI KHASHIGARO**

It is popular variety of hilly region and a derivative of the cross Taborky x SD 698 D. It is adapted to hilly regions of Assam. Tubers are medium, attractive white, round with deep eyes and waxy, pale yellow flesh and rapid bulking. It possesses short dormancy. It gave 160 q/ha tubers in 120 days crop duration.

### **KUFRI LALIMA**

It is a fast bulking variety and a derivative of the cross Kufri Red x CP 1362, which released in 1982 by Central Sub-Committee on Release of Varieties for the plains of Uttar Pradesh, Bihar, West Bengal, Orissa and Karnataka States. Plants are tall, vigorous, erect, compact and dark green. Stems are 4-5, stem red pigmented and prominent at internodes. Leaves are open, wide; rachis has red, pigmentation running on the central side.



Leaflets are smooth, glossy and ovate. Foliage is dark-green. Tuber is uniformly red, medium to large, round, regular, smooth with fleet to medium deep eyes. Flesh is white colour with mealy texture. Sprouts are medium thick with red colour. Mowers are numerous, persistent and blue purple coloured. Pollens are fertile, natural berry forms freely. It is susceptible to late blight wart, powdery, scab, leaf blotch, phoma leaf spot, brown rot, charcoal rot and common scab. It is susceptible to Virus 'Y'. It possesses slow rate of degeneration and medium dormancy (about 2Yz months).

### **KUFRI LAUVKAR**

It is a derivative of cross Serkoy x Adina released in 1973 by Central sub-committee on Release of Varieties for Decan Peninsula (Maharashtra). Plants are tall, erect and thick stems, large ovate lanceolate and incurving leaflets. Foliage is dark grey



green and glossy, foliage many, large and mostly borne on rachis. Tuber is round, white, and flesh white, sprouts beet root red colour, cooking and peeling easy. Cooked flesh is white and good in taste. It has slow rate of degeneration. It is susceptible to late blight, leaf blotch; potato virus 'Y' and leaf roll. This variety escapes attack to tuber moth. It is susceptible to early blight. It is an early variety, which yielded 250 q/ha tubers in 75-95 days crop duration.

#### **KUFRI MUTHU**

It is a derivative of the cross 3046(1) x M-109-C and released in 1971 by Central Sub Committee on release of Varieties for Nilgiri Hills for summer and autumn seasons. Plants are tall and vigorous: Leaves are dark green and short stolens. Tubers are large, white, roundish, oval, smooth eyes medium deep and flesh white. Sprouts are of blue purple colour. The yield potential of this variety is 135 q/ha in 100 days of crop duration. It is resistant to late blight but susceptible to early blight.

#### **KUFRI NAVEEN**

It is a derivative of the cross 0-692 x, 3070d (4) and adapted to northeast hills of Assam and high altitude of Himachal Pradesh. Tubers are medium, white and oval with fleet eyes. Flesh is waxy and pale yellow. It is susceptible to early blight and to resistant to wart. It possesses high degree of field resistant/immunity to race 0, 1 and 4 of late blight.

#### **KUFRI PUKHRAJ**

It is a wider adaptable variety and a cross of Craig's Defiance x JEX/B-687, which released in 1998 from CPRI, Shimla. Plants are tall, semi-erect, medium compact and vigorous. Stems are few, medium thick, green with moderately developed straight wings. Foliage is dark grey green. Leaves are closed with large sized foliage, rachis green. Leaflets are ovate to lanceolate, smooth glossy surface with entire margin. Flowers are white and moderate in flowering, anthers orange yellow, well-developed, high pollen stability and round stigma. Tubers are white, large, oval, slightly tapered, smooth skin, fleet eyes, and yellow flesh having blue purple sprouts. It is an early maturing variety (70- 90 days). The yield potential is 400 q/ha. It is resistant to early blight and moderately resistant to late blight. This variety is suitable in Bihar, Gujarat, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Punjab, Uttar Pradesh and West Bengal. It is not suitable for processing.



#### **KUFRI SHEETMAN**

It is a derivative of the cross Craig Defiance x Phulwa, released in 1968 by Central Variety Release Committee for plains, especially frost affected areas of Punjab, Rajasthan, Haryana and Western Uttar Pradesh. Plants are tall open erect and vigorous, stem thick, firm and erect. Leaflets are rough dull green with waxy margins. Tubers are oval and white with fleet eyes. It is resistant to frost and drought. It is susceptible to late blight and leaf roll.

#### **KUFRI SHERPA**

It is a derivative of the cross Ultimus x Adina and recommended for cultivation in the hills to West Bengal State by 9th Workshop of All India Coordinated Potato Improvement Project. Plants are tall, vigorous, erect, and semi-compact with spreading pasture under wet conditions. Stems are few, highly branched, semi-solid and slightly hairy. Leaflets are rough, hairy, oval, prominent venation, yellow green, petioles short; light green and medium in size. Foliage are small in size and usually 4- 7 pairs. Foliage is light green. Tubers are medium in size, round flattened, skin smooth, medium thick, white, eyes medium deep and flesh of pale yellow colour. Sprouts are conical, blue purple and medium thick, white, eyes medium deep and flesh of pale yellow colour. Flowers are scanty, persistent, and pink in colour, regular in shape with pollen fertility of 50-60 per cent. Tuber dormancy, is medium (2-2 ½ ) months with good keeping quality. It matures 135 and 100 days in hill and plains, respectively and yield is 225-250q/ha. It is susceptible to frost, brown rot and leaf roll and resistant to late blight (both in foliage and tubers) and phoma leaf spot but moderately resistant to early blight and highly immune to wart.

#### **KUFRI SINDHURI**

It is derivative of the cross Kufri Kundan x Kufri Red and released by Central Variety Release Committee in 1966 for plains of Punjab, Jammu, Orissa, Bihar, Haryana, Uttar Pradesh, Madhya Pradesh and West Bengal.

Plants are tall, erect, stems thick having pigment in most part of stem. Leaf rachis is pigmented and leaves open and stiff. Leaflets are dull, basal lobe unequal, petiole slightly pigmented but not midrib. Tubers are round, light red, with medium deep eyes. Flesh is dull white. Tubers are moderate in number, skin



firm, not prone to brushing, bigger tubers having tendency to develop hollow heart. Keeping quality is good. It is late variety and matures in 120 days in plains and 165 days in hills. In plains, it yields 300 q/ha. It is slightly resistance to frost. It is Tuber Crops susceptible to late

blight, common scab charcoal rot and wilts, moderately resistant to early blight and possesses field resistance to viral disease.

#### **KUFRI SUTLEJ**

It is a derivative of Kufri Bahar x Kufri Alankar and released in 1996 from CPRI, Shimla. Plants are medium compact and vigorous. Stem are few, thick, lightly pigmented at base with moderately developed wavy wings. Foliage is grey green. Leaves are ovate-lanceolate and rachis slightly pigmented. Leaflet is ovate, smooth dull surface with entire margin. Flowers are white moderate in flowering. Anthers are orange yellow, well-developed and high pollen stability. Stigma is round and slightly notched. Tubers are white, large, oval, smooth skin, fleet eyes, and white flesh and sprouts light red. It is medium maturing (90-100 days) variety yielded 400 q/ha. This variety is moderately resistant to late blight. It is recommended for cultivation in Bihar, Haryana, Madhya Pradesh, Punjab and Uttar Pradesh. This variety has good consumer quality because of easy to cook, waxy texture, and mild flavour and free from discolouration after cooking. It possesses medium dry matter. It is not suitable for processing.

### **KUFRI SWARNA**

It is a cross of Kufri Jyoti x (VIn) 2 (62.33.3) and released in the year of 1985 from CPRI, Shimla. Plants are tall, erect, compact and vigorous. Stem is few thick with prominent wings. Foliage is dark green, leaves open, rachis green leaflets ovate, moderately pubescent, entire margin and many follicles. Flowers are white, profuse flowering, anthers orange yellow, well-developed, low pollen stability and stigma round. Tubers are white, medium, round oval, smooth skin, fleet eyes, and white flesh having blue purple sprouts. This variety is widely adaptable for south India hills. It matures 130-135 days in summer, while 100-110 days in autumn. This variety is highly resistant to both the species of cyst (*Globodera rostochinensis* and *G. pallida*) and resistant to early and late blight. This variety is not suitable for processing.

### **Climatic Requirements**

Potato is basically cool season crop. It grows well from sea level to snow line, where sufficient moisture and fertile soil are available. It is grown in winter in plains of India. However, in northern hills, it is grown as summer season crop. Potato is a long day plant but cultivated as ~ day plant. It requires favourable environmental conditions such as low temperature and short day conditions at the time of tuberization for rapid bulking rate. About 20°C temperature is good for tuber formation and it reduces as the temperature increases. Tuberization is badly affected at about 30°C temperature. At higher temperature, the respiration rate increases and the carbohydrates produced by photosynthesis are consumed rather than stored in tuber. High temperatures at any part of growing period affect the size of leaflets, thereby reducing the tuber formation. It grows best under long day conditions sunshine along with cooler nights are essential for reducing the spread of diseases.

### **Soil Conditions**

Potato can be produced on a wide range of soils, ranging from sandy loam, silt loam, loam and clay soil. Soil for potato should be friable, well aerated, fairly deep and well supplied with organic matter. Well-drained sandy loam and medium loam soils are most suitable for potato cultivation. Soil structure and texture has a marked effect on the quality of the tuber. Light soil is preferred, because they tend to promote more uniform soil temperatures and make harvesting of the crop easier. Alkaline or saline soil is not suitable for potato cultivation. They are well suited to acidic soils (pH 5.0 to 6.5) as acidic conditions tend to limit scab diseases.

### **Planting Time**

#### **In Plains**

**Early Crop:** Third week of September to first week of October.

**Main crop:** First week of October to third week of October.

**Late Crop:** Third week of October to first week of November

**II. In Hills:** Potato is planted in hills from the third week of February to second week of April. In the southern hills near Ootacamund in Nilgiris, planting is done three times in a year, i.e. in the month of February, April and September. In the plateau regions of Maharashtra, Bihar Madhya Pradesh, potato is raised in rainy and winter seasons.. In the Mysore plateau, the summer and winter crop is planted in April-June and in October-December, respectively.

**Seed Rate, Methods of Sowing and Spacing**

The seed requirements for a hectare on the basis of seed size are given below:

Large size- 25-30 q/ha; Medium size- 15-20 q/ha; Small size- 10-15 q/ha; Out tubers- 8-12 q/h<sup>2</sup>:-' Potato is planted mainly by two methods:

**1. Ridge and Furrow Method:** In this method, the ridges are prepared. The length of the ridges depends on slope of the plot. Too long ridges and furrows are not supplied with irrigation water conveniently. The potato tubers are planted on is let into furrows.

**2. Flat Bed Method:** In this method, the whole plot is divided into beds of convenient length and width. The shallow furrows are opened and potato tubers are planted at recommended distance. The tubers are covered with the original soil of furrows. When the germination is completed and plants become 10 to 12 cm height, earthing should be done. Suitable plant spacing in relation to potato seed grades are given below:

Diameter of tuber from longer axis	Planting distance (row x seed)
2.5-3.5 cm	50 x 20 cm or 60 x 15 cm
3.5-5.0 cm	60 x 25 cm
5.0-6.0 cm	60 x 40 cm

**Nutritional Requirements and Their Management**

Soils poor in organic matter content should be supplied with 250 - 500 q/ha of farmyard manure or compost during land preparation, preferably a fortnight before planting. Potato plant is a heavy feeder. When it is grown in medium type of soils, it needs 100 to 150 kg nitrogen, 80 to 100 kg phosphorous and 80 to 100 kg potassium per hectare. Two - third to three fourth quantity of nitrogen along with whole quantity of phosphorus and potassium is applied at the time of planting. Remaining one fourth to one third nitrogen is applied 30 to 35 days after planting i.e. at the time of first earthing up or when plants become 25 to 30 cm in height either in the form of top dressing or as a foliar feeding. Spraying of essential micronutrients such as boron, zinc, copper, iron, manganese, molybdenum etc. is done when crop is showing deficiency symptoms.

### **Intercultural Operations**

In potato crop, both types of weeds are found i.e. broad-leaved weeds as well as narrow leaved weeds-The use of weedicides in potato crop in general is not essential because earthing up operation destroy almost all weeds, if some how, weed plants are growing on ridges, they may be pulled out by hands. Pre- emergence application of nitrogen @ 1.0 kg a.i./ha or alachlor @.2.0 kg a.i./ha or post emergence application of propanil @ 1.0 kg a.i./ha may be used ill solution fom1 (800-1000 litre/ha). Care should be taken while spraying of post- emergence herbicides that they should not come in the contact to potato plants. Proper development of tubers depends upon aeration, moisture availability and proper soil temperature. Therefore, proper earthing up is necessary. Earthing should be done when the plants are 15 to 22 cm ill height. Generally earthing is done at the time of top dressing of nitrogenous fertilizers. The ridges should be high enough to cover up tubers. If necessary, a second earthing may be done after two -week of the first one. A mould board plough or a ridger may be used for earthing up in large area.

### **Use of Plant Growth Regulators**

Soaking of potato seed tuber in CCC at 500 mg/l (Schedule and Pandita, 1986), sodium ascorbate at 100 mg/l (Murthy et al.. 1975) cytozyme at 5 per cent (Pandita and Hooda, 1979), Singh and Kaur, 1981) or foliar sprays with ethephon at 400 mg/l (Murthy and Banerjee, 1978, Pandita and Hooda, 1979 a, Sekhon and Singh, 1985), CCC at 25 mg/l or garlic acid at 10-100 mg/l(Kumar and Agarwal, 1978) increased tuber yield. Sidda Reddy (1988) also obtained higher tuber yield with foliar sprays of mixtallol at 1 or 2 mg/l.

### **Water Management**

Before coming to the planting operation. It should be kept in mind that the sufficient soil moisture is available for satisfactory sprouting. If not then light pre-irrigation or just after planting may be given. The rate of water use is low till 30-35 days after planting; it means that the first irrigation is essentially done within 30-35 days after planting. However, when soil moisture seems insufficient for sprouting, intervals of first irrigation should be reduced. Further, irrigation is done as and when crop needs. As regards method of irrigation in potato, the furrow method is commonly followed.

### **Harvesting, Yield and Storage**

Harvested potatoes are heaped under shade for a couple of days, so that their skin becomes hard and soil adhering with them is also separated out. Under good crop management, 350-450 quintals of marketable potatoes of good quality can be produced from one hectare land. The sorting operation is the most important, in that all cut tubers, bruised,

injured by insects-pest and disease are removed. Sorted healthy tubers are graded in to different grades based on diameter of the tubers reduce the prices in the market. Therefore, such tubers should be sorted and marked separately. Over sized tubers are great in demand for chips making. Very small sized tubers are also not remaining unsold. These tubers are purchased by poor people for making vegetable by partially Cushing them before cooking. However, both the over sized and under sized are quite unsuitable for seed purposes. Potatoes can be stored in the cold storage at the temperatures of 4 to 7°C and relative humidity.

## **Diseases and Pests**

### **Diseases**

#### **Non-Viral Diseases**

##### **Early Blight (*Alternaria solani*)**

The infection appears on lower leaves with necrotic spots having concentric rings. The fungus survives in the soil. In diseased plant debris. The collateral host is tomato. High moisture and low temperature are favourable for disease.

##### **Control Measures**

- (i) Follow crop rotation
- (ii) Collect and burn plant debris after harvesting
- (iii) Start sprays the crop Dithane M-45 at 0.2 per cent 30 to 35 days after planting and repeat 10 to 15 days interval
- (iv) Grow early blight tolerant varieties such as Kufri Naveen, Kufri Sindhuri and Kufri Jeevan.

##### **Late Blight (*Phytophthora infestans*)**

The infection appears at the tips or edges of the lower leaves with circular or irregular water soaked spots. White downy fungus growth appears on the underside of the leaves around the spots. Cloudy weather is conducive for very fast spread of the disease. In case of severe incidence all above ground parts may show rotting. Later the disease may spread to tubers and initiate rotting.

##### **Control Measures**

- (i) Plant only healthy disease free certified seed tubers.
- (ii) Spray the crop thoroughly with diathane M-45 (2.0 kg/ha) or diathane Z- 78 (2.5 kg/ha) or difolatan (2.5 kg/ha) well in advance to general appearance of disease. The spraying operations should remain continue at narrow interval of 5 to 6 days during cloudy weather.
- (iii) Dig out tubers when foliage is completely dry or cleaned. (iv) Grow late blight resistance varieties like Kufri Navaharl. (v) Avoid applying in excess nitrogen and irrigation.



### **Black Scurf (*Rhizoctonia solani*)**

The infected plants killed, stem canker may also be formed. Affected plants may form aerial tubers. On tubers, black sclerotial bodies are formed. It is a soil as well as tuber borne disease.

#### **Control Measures**

- (i) Always sow certified seeds
- (ii) Treat the seed tubers with any organo mercurial fungicides containing 6 per cent mercury {agallol, aretan, emisan etc.) for about 5 to 10 minutes before the planting and also seed tubers before keeping in the cold storage.
- (iii) Dip the tubers in 1.75 per cent solution of sulfuric acid for 20 minutes.
- (iv) Apply Brassicol at 30 kg per hectare in the soil at the time of sowing.
- (v) Apply sawdust at 25 q/ha with recommended doses of nitrogen at least 15 days before sowing.

### **Common Scab of Potato (*Streptomyces scabies*)**

It survives in soil years together and on infected tubers in cold storage. It may also spread through manure. Affected tubers show the superficial roughened areas of corky tissue, often slightly below the plane of healthy skin of tubers. Low soil moisture is favourable for proliferation of causal pathogen.

#### **Control Measures**

- (i) Obtain healthy, disease free seed tubers for planting.
- (ii) Disinfect the tubers by dipping in suspension of mercurial fungicide e.g. emisan-6 or agallol- 6 at 0.25 per cent concentration for 5 minutes,
- (iii) Plant the tubers shallow.
- (IV) Keep the soil wet during tuberization.
- (v) Follow crop rotation with non-host crops including beets, carrot etc.
- (VI) Maintain soil pH 5.0 to 5.3.

### **Black Leg or Soft Rot (*Erwinia spp.*)**

It is caused by different species of bacteria. The base of shoots develops a blackened shriveled cortex and its growth is stunted. Leaflets become reddish in colour at the tips, branches become stiffened and more upright than normal. The affected haulms are jet black in colour at the soil level. The tubers become watery and upon rotting give off offensive sulphurous odour.

#### **Control Measures:**

- (i) Obtain healthy seed tubers for planting.
- (ii) Avoid planting of cut seed potato.
- (iii) Avoid planting too early and too late in the season.
- (iv) Collect and destroy affected plants as and when seen in the field.

- (v) Avoid injury to tubers during harvesting, transit and storage.
- (vi) Wash the tubers with chlorinated water before storage.
- (vii) Keep the stores well ventilated, dry and cool.

**Bacterial Brown Rot or Wilt Disease (*Pseudomonas solanacearum*)**

Affected plants show dwarfing and bronze discolouration of the leaflets. When affected stem or tubers cut across, the browning of the xylem vessel is seen, and upon squeezing, the whitish bacterial ooze may come out.

**Control Measures**

- (i) Obtain healthy, disease free seed tubers for planting.
- (ii) Collect and destroy infected plants.
- (iii) Avoid flowing rain or irrigation water from diseased field to healthy one.
- (iv) Disinfect cutting knife with a suitable bactericide solution, whenever diseased tubers are cut.
- (v) Follow crop rotation with non-host crops such as maize, soybean and red top grass for at least three years in the field,
- (vi) Reduce the application of organic manure (it promotes activity of bacteria) but apply high doses of inorganic fertilizers (decrease the activity).
- (vii) Treat the seed tubers in 0.02 per cent streptomycin for 30 minutes after giving five mm deep cut.

**Charcoal Rot (*Macrophomina phaseoli*)**

The roots of the affected plants become brown in colour. The rotting starts on the stem portion. The skin of the stem becomes ash coloured. The dark lesions appear at the lenticels of the tubers and also round the stem end of tuber. Charcoal rot is common during the hot and dry months in late season crops.

**Control Measures**

- (i) Obtain disease free seed tubers for planting. Hill potatoes are nearly free from this pathogen.
- (ii) Grow early maturing varieties such as Kufri Alankar or Kufri Chandramukhi.
- (iii) Irrigate crop at regular intervals.
- (iv) Seed tubers may be treated with aguarol-6 or aretan at 0.25 per cent solution before storage. The treated tubers should not be eaten.

**Wart Disease of Potato (*Synchytrium endobioticum*)**

It is caused by the fungus. Affected plants show warty out growth protuberances on stems, stolons and tubers. The roots are not affected. The wart consists of distorted,

proliferated-branched structures grown together into a mass of hyper parasitic tissue. It is difficult to control once it has been established in a field.

**Control Measures**

- (i) Avoid growing potatoes in known wart-affected soil.
- (ii) Obtain disease free seed tubers for planting. (iii) Soil treatment with 5 per cent formalin is effective but very costly. (iv) Grow wart tolerance varieties like Kufri Sherpa, Kufri Jyoti, Kufri Jeevan and Kufri Muthu.

**Viral Diseases**

**Leaf Roll**

A virus known as potato leaf roll virus, potato virus 1, solanum virus 14 or Corium solani Holmes causes it. Transmission of virus in nature occurs through infected tubers and through insect, an aphid (*Myzus persicae*). Affected plants become dwarf, more upright than normal, the leaves are rolled, especially the lower one. They are thick and leathery.

**Mosaic Disease**

Potato crop is affected by mainly three types of mosaic.

Type of mosaic	Caused viruses
Mild mosaic	Potato Latent virus, Potato Virus X, Potato Mottle Virus, Solanum Virus-I
Rugose mosaic	Potato Virus X and Potato Virus Y
Cinkle of potato	Potato Virus X and Potato Virus A

**Control Measures of Potato Viral Diseases**

- (i) Plant only certified seed tubers
- (ii) Apply anyone of the systemic insecticides like thimet, temik or furadan in the furrow at 10 kg per hectare at the time of planting
- (iii) Uproot affected plants along with complete root system and mother tuber, and destroy them
- (iv) Spray the crop with metasystox at 0.1 per cent to control aphid population
- (v) Remove haulms in the first week of January, when aphid population build up is very fast.

**Phytoplasma Diseases**

**Potato Witches Broom**

Infected plants develop many axillary and basal shoots giving 'witches broom' appearance and develop small, pigmented tubers. These tubers sprout even attached to infected plants (Nagaich et al., 1974). The disease is transmitted by grafting and leafhopper

(*Orosius albicinctus*). Tuber transmission is also very high. The pathogen can infect tomato, brinjal, *Datura fastuosa*, *D. metel*, *Nicandra physaloides*, *Vinca rosea* and *Calendula officinalis*. This disease can be controlled by hot water treatment of 'witches broom' affected tubers at 50 °C for 10 minutes, causes degeneration of pathogen and plants developed from such tubers did not develop symptoms upto 6 to 7 weeks.

### **Purple Top of Potato**

The typical symptoms are purple pigmentation and rolling of basal parts of leaflets of young top leaves. The affected plants are stunted have many axillary shoots with aerial tubers. Root system is poorly developed (Nagaich and Giri, 1973). It causes phloem fluorescence. The disease is transmitted by grafting and leafhoppers (*Alebroides nigrocutellatus*, *Orosius albicinctus* (and *Serianthe equata*), Tuber transmission is also common but the extent varies with age of plants, the host range of pathogen includes tomato, tobacco, brinjal, clove, *Datura stramonium*, *Calendula officinalis*, *Cyphomandra betacea* etc, *Phyalis floridana*, *Vinca rosea*, Oxytetracycline, benlate, cycloheximide etc. are highly effective and causes 70 to 96 per cent remission of symptoms.

### **Marginal Falvescence of Potato**

Flavescence or chlorosis along the margins of leaflets of upper leaves and small, narrow leaflets are prominent symptoms, affected plants are stunted and produce clusters of small tubers, which have shorter dormancy and produce hairy sprouts. It causes phloem fluorescence (Nagaich and Giri, 1973). The disease is transmitted by grafting and hopper, *Seriana equata* the disease can infect other hosts like, tomato, tobacco, brinjal, *calendula officinalis*, *physalis floridana*, *vinca rosea*, and *cyphomandra betacea*. Treatment of affected plants with antiameobin + benlate or benlate + BP causes remission upto 80 per cent.

### **Potato Phyllody**

The disease is characterized by extreme hairiness and roughing of leaves and stems. Chlorotic leaves develop small leaflets but enlarged petioles. Infected plants develop several naked androecia as small yellow "rosettes" and axillary aerial tubers Phyllod flowers are enlarged and have cupped calyx and corolla (Khurana et al 1983). It has wide host range and includes *Dianthus barbatus*, *Pisum sativum*, *Lycopersicon chilense*, *Phyalis floridana*, *Solanum nigrum* and *Daucus carota*. The pathogen can be eliminated by subjecting infected tubers to hot water treatment at 50 °C for 10-15 minutes.

### **Pests**

#### **Cut Worms (*Agrotis* spp, *Euxoa* spp)**

They cut the sprouts at ground level. They feed only at night. They also attack tubers and make holes, thereby reducing market prices.

**Control Measures**

- (i) Spray the crop with dursban 20 EC at 2.5 ml per litre of water or drench the plants, where the damage is noticed.
- (ii) Apply phorate 10 G granules at 10 kg I per hectare on soil around the plants and rake the soil thereafter.
- (iii) Use only well rotten farmyard manure.

**Epilachna Beetle**

Both the adults and larvae of this beetle feed on skeletonization of leaves.

**Control Measures**

- (i) Pick up the eggs, larvae and adults by hands.
- (ii) Spray the crop with carbaryl at 0.1 per cent.
- (iii) Dust the crop with sevin dust at 30 kg per hectare.

**Leaf Eating Caterpillars (*Spilosoma obliqua*, *Spodoptera exigua*):**

Both the caterpillars cause damage by feeding potato leaves.

**Control Measures**

- (i) Spray the crop with thiodon 35 EC or endocel at 0.15 per cent
- (ii) Making border around the field with carbaryl dust would be effective control.

**Aphids (*Myzus persicae*)**

Aphids sucks the sap from leaves. Affected plants become weak, leaves become yellow and curl downwards. Aphid secretes honeydew, which gives rise to sooty mould and other fungal diseases.

**Control Measures**

- (i) Spray the crop with rogor or metasystox or nuvacron or monocil at 1 ml per liter of water, and repeat the spray 10 to 12 days interval
- (ii) Apply thimate 10 G granules at 10 kg per hectare in furrows at the time of planting.
- (iii) Cut the haulms in the first week of January to check the transmission of virus through seed potatoes.

**Jassids**

They are slender wedge shaped green hopping insects. They are diagonally. They suck sap from under surface of leaves causing yellowing, curling and later burning of leaves called 'hopper bums'

**Control Measures**

- (i) Spray the crop with metasystox at 0.1 per cent.
- (ii) Apply thimet 10 g granules at 10 kg per hectare in furrows at the time of planting.

**Potato Tuber Moth (*Phthorimaea operculella*)**

It is major pest of potato in storage. It can also attack in the field. It bores and makes tunnel into the potato tubers.

**Control Measures**

- (i) Sow healthy insect free potato tubers.
- (ii) Use only well rotten farmyard manure.
- (iii) Do earthing carefully, so that tuber is not exposed in the field to ovipositing female moths
- (iv) Spray the crop with carbaryl or nuvacron or monocil at 0.1 per cent.
- (v) Disinfect the go down with Malathion at 0.05 per cent before storing potatoes.
- (vi) Sort out all affected tubers before storage.

**Golden Nematode (*Globodera rostochiensis*, *Heterodera rostochiensis*)**

It is also known as potato root ell worm or potato cyst nematode. The infected plants produced additional rootlets near the soil surface. Later, outer leaves become prematurely yellow and die.

**Control Measures**

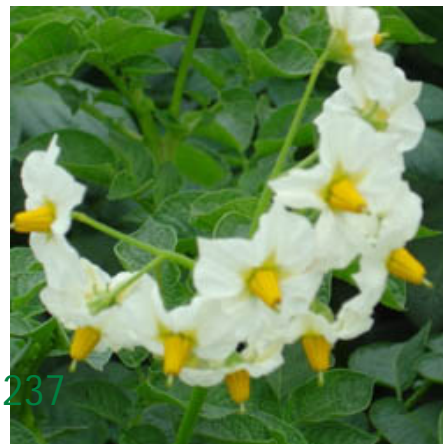
- (i) Keep the infested area in quarantine to prevent the spread
- (ii) Avoid growing tomato or brinjal in infested soil.
- (iii) Follow crop rotation excluding solanaceous crop.
- (iv) Treat the soil with DD at the rate of 90 gallons per hectare.
- (v) Avoid the soil seed tubers brought from infested area.

**Root Knot Nematodes (*Meloidogne incognita* and *M. javanica*)**

Affected plants are stunted, sickly and may show premature and sudden drying. Tiny galls are formed on tubers. The nematodes survive as egg masses in diseased root and tuber in soil.

**Control Measures**

Similar control measures as described in tomato.





\*\*\*\*\*

1. \_\_\_\_\_ is an example of an edible stolon
  - a. Potato
  - b. Carrot
  - c. Cut tuber
  - d. All the above
2. Which of the following is the order in which the potato tuber develop?
  - a. Initiation, tuberization and maturation
  - b. Tuberization, initiation and maturation
  - c. Initiation, maturation and tuberization
  - d. None
3. A vegetable that produces 'haulm' is
  - a. Groundnut
  - b. Potato
  - c. Sweet potato
  - d. Tapioca
4. Which of the following is the latest variety released which is suitable for chipping
  - a. Kufri Chandramuki
  - b. Kufri Chipsona 2
  - c. Kufri Chipsona 3
  - d. Kufri Dewa
5. Alkaloid present in potato
  - a. Tomatine
  - b. Solanin
  - c. Salosidine
  - d. Sinigrin

# **DR. SUBHRAJYOTI CHATTERJEE**

**B.SC. (HORT.), M.SC. (HORT.) VEGETABLE SCIENCE, PH.D.**

**VEGETABLESCIENCE**

**RESEARCHGATE:**

<https://www.researchgate.net/profile/Subhrajyoti-Chatterjee-4>

**GOOGLE SCHOLAR:**

<https://scholar.google.com/citations?user=Fj1lUPoAAAAJ&hl=en&authuser=1>



**Cabbage**

**Botanical Name:** *Brassica oleracea* var. *capitata* L.  
**Family:** Brassicaceae  
**Chromosome number** 2n=18  
**Origin :** *Mediterranean Region*

♥ **Cabbage was introduced much earlier than cauliflower in our country.**

♥ **Reported to be grown during the Mughal period though exact date is not available.**

♥ **Typically a cool season cole crop, grown for thickened main bud called head.**

♥ **The most popular vegetable around the world in respect of area, production and availability almost round the year.**

♥ **In India, ranks next to cauliflower in area and production.**

♥ **Traditionally, grown to a larger extent in the southern, eastern and coastal area of India**

♥ **With the development of hybrid and some tropical lines, it is produced almost round the year throughout the country.**

- ☉ Cabbage is one of the most important cash crop of mid and high hills of Kullu, Sirmour, Shimla and Mandi districts of Himachal Pradesh where ago-climatic conditions are favourable to grow it during off-season.

## Uses

- ☉ It is rich source of vitamin A, G & C and also contains P, K, Ca, Na & Fe in sufficient quantity.
- ☉ It is known to possess medicinal properties.
- ☉ It was used in ancient times against ailments like gout, diarrhea, stomach and cardiac troubles.
- ☉ It has anti-cancer property as it protects against bowel cancer due to presence of indole-3-carbinol.
- ☉ Cabbage Juice was used as a remedy against poisonous mushrooms and as a gargle against hoarseness.
- ☉ The leaves were used to cover wounds and ulcers.
- ☉ It is said to help digestion.

# Soils

- ♠ Cabbage can be grown in all types of soil with good fertility and good water regime.
- ♠ 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.
- ♠ On heavy soils, plant grows more slowly and the keeping quality is improved because of compactness.
- ♠ It prefers a soil reaction ranging from pH 6 to 6.5.
- ♠ Most cabbages are some what tolerant to salt.
- ♠ In saline soils, the plants show die back margins and dark foliage & become more susceptible to the diseases like black leg.
- ♠ C-index is a measure of salt content (i.e. g of NaCl per lt. of soil moisture). For Red Cabbage, the limit of salt tolerance is C-4 whereas for savoy and white cabbage it is C-6. At C-8 the crop may show reduction of 40% yield.

# CLIMATE

- ▶ It can withstand extreme cold and frost better than cauliflower.
- ▶ It thrives best in a relatively cool and moist climate,
- ▶ The optimum seed germination is obtained at 12.6-15.6 °C soil temperature.
- ▶ The optimum temperature for growth and head formation is 15-20 °C whereas above 25 °C, the growth is checked.
- ▶ The minimum temperature for its growth is just above 0 °C.
- ▶ Withstand temperature of 10-40 °C for a few days only.
- ▶ After cold treatment at 4-10 °C for 7-9 weeks, the plants bolt sooner with abundant flowers but plant should have passed juvenile phase.
- ▶ If the plants are not exposed to chilling temperature for required duration the cultivar remain vegetative.

😊 The cabbages are classified into three broad groups

- 😊 **White cabbage** – most commonly cultivated in India. Pointed, Round and Flat or Drumhead are the shapes
- 😊 **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.



# White cabbage cultivars are divided into 3 groups on the basis of maturity of heads after transplanting

<b>Early Group</b>	<b>Mid season Group</b>	<b>Late Group</b>
Takes 55-70 days	Cultivars fall under early and late	Takes 85-130 days
Golden Acre, Pride of India, Copenhagen Market, Pusa Ageti, Pusa Mukta, Pusa Sambandh (Synthetic variety)	Glory of Enkhuizen, September, Pusa Drum Head	Late Large Drum Head



# Hybrid varieties

- ▶ **BS 32 (Bejo shetal), Nath 401 and Sri Ganesh Gole (Maayco), Hari Rani Gole, Quisto, Bajrang, Kranti, Mitra are some with promise & identified through AICVIP.**

## Varieties of Red Cabbage

- ▶ **Red Acre**
- ▶ **Red Mammoth**

## Varieties of Savoy Cabbage

- ◉ **Perfection (Syn. Chieftain)**

# Cultivars suitable for growing in Himachal Pradesh

1.	Golden Acre	Suitable for cultivation in all areas of the state, heads are small and compact weigh around 1-1.5kg with few outer cup shaped leaves, early in maturity and gets ready in 60-70 days which is a week earlier to Pride of India, average yield 225-250q/ha
2.	Pusa Mukta	An early variety with medium sized solid, flattish round and attractive heads, slightly late than Golden Acre and gives higher yield (250-300q/ha), resistant to black rot, a suitable variety for summer season in Zone II and Zone III
3.	Pride of India	Small round compact heads with medium sized frame, matures in about 70-75 days, heads remain small and loose under less favourable conditions, harvesting at proper stage is essential otherwise heads crack, average yield 250-300q/ha.
4.	Pusa Drum Head	Large flattened and solid heads, higher yield but consumers preference is less, late in maturity and ready in 90 days, field resistant to black leg, average yield 375-435 q/ha.

# Planting Time

Mainly grown as a winter crop from October –January in the Northern Indian plains

Zone	Time of nursery sowing
Low Hills	August – September
Mid Hills	August – September February – March
High Hills	April- May

- Seedlings become ready for transplanting in 4-5 weeks time.
- Seedlings 5mm in diameter are better for field setting
- Seedlings must be about 10-12cm in length at the time of transplanting.

## Seed Rate

**Early season: 600-800 g/ha**

**Main season: 200-500 g/ha**

## Spacing

<b>Early varieties</b>	<b>45cm X 45cm</b> <b>45 cm X 30 cm or 30cm X 30 cm</b> <b>(round &amp; smaller heads)</b>
<b>Mid and Late season varieties</b>	<b>60cm X 45cm or 60 cm X 60 cm</b>

# Manures and Fertilizers

## Open pollinated varieties

FYM (q/ha)	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
	(Kg/ha)		
250	125	100	50

- ☺ Full dose of farmyard manure and phosphorus and one-third of N and half of potassium should be applied at the time of transplanting.
- ☺ Remaining part of N should be top dressed at an interval of one month each while half of potassium is to be applied alongwith N during second top dressing.

# Harvesting

- ☺ In general, the heads are harvested when they are firm and solid.
- ☺ The heads are cut with a knife, frequently attached with some non-wrapper leaves which give protection to the heads from bruising injury.
- ☺ Delay in harvesting results in cracking and rotting of heads.

## Yield (q/ha)

Early varieties	250-300
Late season varieties	400-500

# Pre and post harvest handling

- ⇒ Harvesting should be done preferably in the late evening or early morning so that the product remains turgid and fresh
- ⇒ Trimming of diseased, damaged, rotten and discoloured leaves.
- ⇒ Avoid direct contact of heads with the soil and exposure to direct sunlight.
- ⇒ Proper packing to avoid bruising.
- ⇒ Grading for uniform produce.
- ⇒ Sprinkle water over the heads to maintain turgidity and freshness.

## Storage

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

# Cracking

- ❖ Leaves may grow through head.
- ❖ Plant so, crop develops in mild or cool weather.

## Possible Reasons

- ❖ Excess N fertilizer
- ❖ Hot, dry weather

## Management

- ❖ Do not let soil dry out.
- ❖ Fertilize properly.



Head cracking



# **DR. SUBHRAJYOTI CHATTERJEE**

**B.SC. (HORT.), M.SC. (HORT.) VEGETABLE SCIENCE, PH.D.**

**VEGETABLESCIENCE**

**RESEARCHGATE:**

<https://www.researchgate.net/profile/Subhrajyoti-Chatterjee-4>

**GOOGLE SCHOLAR:**

<https://scholar.google.com/citations?user=Fj1lUPoAAAAJ&hl=en&authuser=1>




# Cauliflower



# Cole Crops

*Origin*


*Mediterranean Region*



**The word “cole” seems to have come from the abbreviation of the word “caulis” meaning stem.**



A group of highly differentiated plants originated from a single wild ancestor *Brassica oleracea* var. *oleracea* (*sylvestris*), commonly known as wild cabbage.



**The most popular vegetables grown during winter season**



**Cauliflower and cabbage are the most important**



Broccoli is also gaining popularity due to its high medicinal and nutritive value.

# Uses

- ☐ **These are eaten in the raw state as well as cooked.**
- ☐ **Rich source of vitamin A and C. Also, contains minerals including P, K, Ca, Na and Fe.**
- ☐ **Some protective properties against human bowel cancer.**
- ☐ **Used against ailments such as gout, diarrhea, colic trouble, stomach trouble, deafness and headache.**
- ☐ **Leaves are used to cover wounds and ulcers and also recommended against a hangover.**
- ☐ **Cabbage juice is said to be a remedy against poisonous mushrooms and also used as a gargle against hoarseness.**

# Cauliflower

**Botanical Name:** *Brassica oleracea* var. *botrytis* L.  
**Family:** Brassicaceae  
**Chromosome number**  $2n=18$



☺ A cool season vegetable grown for its white and tender curd formed of undifferentiated flower parts or pre-floral apical fleshy meristem.

☺ India commands the largest area and production under cauliflower in the world.

☺ Physiologically different from other cole crops as possesses an intermediate stage of curding between the vegetative and generative phase.

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

▶ Indian Cauliflower/tropical/hot weather/heat tolerant

✓ result of crossing between Cornish and European types.

▶ European types/Early temperate type/Snowball/late

# Difference between Indian Type and European type

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



# Soils

- ♠ Grown in all types of soils with good fertility and good water regime.
- ♠ Mid season and late crop will grow very well in medium, medium heavy and heavy soils.
- ♠ A light to light medium soil should be preferred for early crop to have easy drainage in rainy season.
- ♠ Water stagnation checks the growth.
- ♠ Prefers pH ranging from 6 to 6.5.
- ♠ Deficiency symptoms of Mg may quickly appear in acidic soils while pH higher than 7 reduce availability of B causing Browning

# CLIMATE

- ♥ Climatic factors play important role during transformation from vegetative to curding and curd development stages.
- ♥ Temperature 10-21°C is good for germination.
- ♥ Thermo-sensitive i.e. temp 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.
- ♥ 4 weeks in Mid-Late group and 5-6 weeks 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.

**Conclusion:** Temperature higher or lower than optimum for curding results in physiological disorders like riceyness, leafyness, blindness, loose and yellow curd.

## Four different maturity groups (I-IV)

Maturity group	Nursery sowing	Transplanting time	Opt. temp. for curding	Varieties
<b>Extra Early: May maturity (May-June)</b>	<b>End of February</b>	<b>March</b>	<b>24°C-30°C</b>	<b>Pusa Meghna, DC 23, Pusa Kartik Sankar</b>
<b>Early I (A) Sept. maturity (mid Sept-mid Nov.)</b>	<b>Mid May</b>	<b>July beginning</b>	<b>20-27 °C</b>	<b>Early Kunwari, Pusa Early Synthetic, Pant Gobhi-3, Pusa Meghna, Pusa Kartik Sankar</b>
<b>I (B) Oct. maturity (Mid Oct-mid Nov)</b>	<b>May end to Mid June</b>	<b>Mid July</b>	<b>20-25 °C</b>	<b>Pusa Katki, Pusa Deepali, Pant Gobhi-2</b>
<b>Mid Early (II) Nov. maturity (Mid Nov-mid Dec)</b>	<b>July end</b>	<b>Sept beginning</b>	<b>16-20 °C</b>	<b>Improved Japanese, 12-C, Pusa hybrid-2, Pusa Sharad, Pant Gobhi-4</b>
<b>Mid late (III) Dec maturity (mid Dec-mid Jan)</b>	<b>Aug end</b>	<b>Sept end</b>	<b>12-16 °C</b>	<b>Pusa Synthetic, Pusa Subhra, Pusa Paushja, Pusa Shukti, Palam Uphar, KT-25, Pant Subhra, Pusa HimJyoti, Pb Giant 35</b>
<b>Late (IV) Snowball (Jan-March)</b>	<b>Sept end to mid Oct</b>	<b>Oct end-mid Nov</b>	<b>10-16 °C</b>	<b>Snowball 16, Pusa Snowball-I, Pusa Snowball K-1, Dania, Ooty-1,</b>

# Varieties recommended for Himachal Pradesh

<b>Early varieties</b>	<b>Early Kunwari, Pusa Deepali</b>
<b>Mid-early Group</b>	<b>Improved Japanese,</b>
<b>Mid-late</b>	<b>Pusa HimJyoti, Palam Uphar, Pusa Subhra</b>
<b>Late season</b>	<b>Pusa Snowball 1, Pusa Snowball K1</b>

# Soil preparation and transplanting

- ♣ Soil should be well prepared by ploughing first with soil turning plough and afterwards with 4 to 5 ploughings with country plough.
- ♣ Ploughing should be followed by leveling and bring it to a fine tilth.
- ♣ The manure should be applied while preparing the field.
- ♣ Drainage is a problem for early and some times in mid season crop when the rains prolong.
- ♣ Transplant early crop (MG II & I) on ridges or raised beds while mid and late (MG III & IV) cultivars on flat beds.
- ♣ Transplanting should be done during late afternoon

# Nursery Sowing Time

Zone	Early group	Mid group	Late group
Low Hills	June-July	August-September	October-November
Mid Hills	April-May	July-August	September
High Hills	-	-	April

## Seed Rate

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

## Spacing

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

# Manures and Fertilizers

## Open pollinated varieties

Farmyard manure (q/ha)	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
	(Kg/ha)		
250	125	75	60

- ☺ Apply full dose of FYM and P and one-third of N and half of K at time of transplanting.
- ☺ Remaining part of N should be top dressed at an interval of one month each while half of potassium is to be applied alongwith N during second top dressing.
- ☺ Sulphur application @ 20-40kg/ha and Mo @ 80-160g/ha helped in increasing cauliflower yield under Palampur conditions.

# Interculture and weed control

- ▶ **A shallow rooted crop, so do shallow hoeing to remove weeds and to avoid any injury to the roots.**
- ▶ **Regular hoeing operation 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) @1.2 kg a.i./ha or Oxyflurofen (Gol) @ 600 ml/ha) can also be used before transplanting if there is problem of annual weeds only.**



# Irrigation

- First light irrigation just after transplantation of the seedlings.
- Needs very careful irrigation which should be sufficient at right time.
- Over-watering and insufficient irrigation is harmful.
- Regular maintenance of optimum moisture supply is essential during growth and curd development.

## Use of growth hormones

- ☺ Treat cauliflower seedlings with NAA (10 ppm) as starter solution effective in enhancing plant stand in the field and vegetative growth.
- ☺ Application of  $GA_4 + GA_7$  @ 80 mg/l of water shortened the period from transplanting to the harvest.

# Blanching

- ❑ An important operation to protect the curds from yellowing 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 curds become over-matured, deterioration of quality and turns into loose, leafy, ricey and fuzzy.
- ☺ Such curds should be eliminated from the consignment to be sent to the market 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 upto 500 q/ha.

# Pre and post harvest handling

- ⇒ Harvesting should be done preferably in the late evening or early morning so that the product remains turgid and fresh
- ⇒ The freshly harvested plants should be put in the truck or cart in such a way that the bruising of the curd is minimum.
- ⇒ These bruised portion of the curd becomes 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 7 days at 0°C-1.7°C and RH between 85-95%.
- ☉ Cauliflower with intact leaves and head size 25-30cm dia are the most suitable for long term storage.

# Packing and Packaging Material

- ♣ Packages protect the contents against undue damage during distribution.
- ♣ Maintain the shape and strength often for long periods at a relative humidity near saturation.
- ♣ 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 market.
- ♣ 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 6-8 months for culinary purpose and for pickling.

## Frozen cauliflower

The curds are washed, cut into pieces, blanched, packed in polybags 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% SO<sub>2</sub> 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 discolouration.**
- **Blanched material is filled in plain cans containing 2% brine, then they are sealed and sterilized .**
- **Pink colouration in the canned product is a problem.**

# PHYSIOLOGICAL DISORDERS



# 1. Buttoning

- ☺ It means development of small curds or buttons.
- ☺ The general basis is that any check in the vegetative growth of the seedlings may induce buttoning.

## Possible Reasons

- Planting of over aged seedlings, which do not get sufficient time to initiate growth before transformation to curding.
- Selection of wrong cultivars means planting early variety late
- Root injury by insects or diseases.



## 2. Riceyness

- ☺ A premature initiation of floral buds or elongation of peduncle stalk of inflorescence is characterized by riceyness.
- ☺ The curds are considered to be of poor quality for marketing

### Possible Reasons

- ⇒ Temperature higher or lower than the optimum required for curding in a particular cultivar
- ⇒ High N and high temperature favour rapid growth and development of curd also causes riceyness

### Management

- 🕒 Proper management of soil moisture and fertility during the development of head or curd.

# 3. Fuzzyness

- ❖ It is the elongation of pedicels of the individual flower.
- ❖ Almost all the prefloral bud which develops precociously on the curd surface give the fuzzy appearance.

## Possible Reasons

- ⇒ Temperature higher or lower than the optimum required for curding in a particular cultivar
- ⇒ High N and high temperature favour rapid growth and development of curd also causes riceyness

## Management

- Proper management of soil moisture and fertility during the development of head or curd.



# 4. Blindness

- ❖ **Blind plants are those which are without terminal bud.**
- ❖ **The leaves of the blind plants are large, thick, leathery and dark green.**

## Possible Reasons

- **Poor fertility of the soil.**
- **Damage by insects, diseases etc.**
- **Genetic irregularity.**
- **Cold temperature.**
- **Damage to the terminal portion during handling at the time of planting**



## Management

- **Healthy and vigorous seedlings with terminal portion intact should be planted.**

# 5. Bracting

- ▶ The bracts are underneath the prefloral meristem which corresponds to axillary buds.
- ▶ These bracts or leaves come out of the curd resulted in poor quality of curds for marketing as they turn green or purple in colour on receiving the direct sunlight at the surface of the curd.

## Possible Reasons

- ♣ Temperature higher than the optimum during curding

## 6. Purple colouring

☀ Some time various pigmentations are occurred on the curd



### Possible Reasons

😊 Fluctuation in temperature.

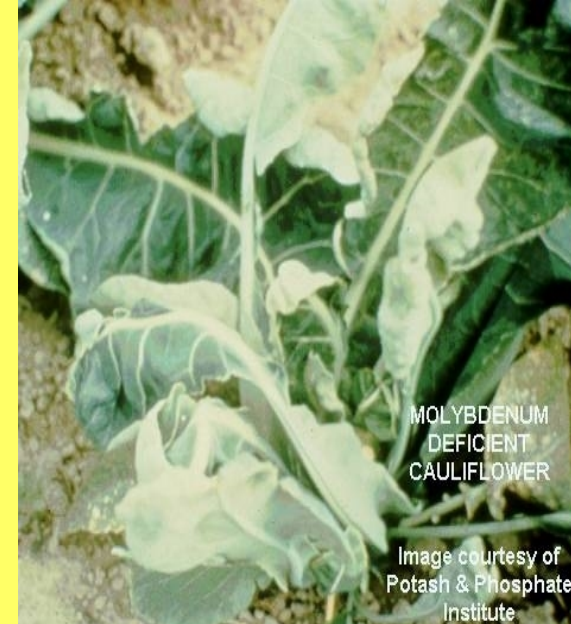


## 7. Whip tail

- ◆ It is caused by the deficiency of Molybdenum (Mo).
- ◆ Young plants become chlorotic and turn white particularly along the leaf margins.
- ◆ They 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”.

### Management

➤ Application of Mo @ 1kg/ha.



## 8. Browning (Red or Brown rot)

- ▶ It is caused by boron deficiency.
- ▶ Smaller water soaked areas in the centre of the curd is the first sign of appearance.
- ▶ In later stages, the stem become hollow with water soaked tissues surrounding the walls of the cavity.
- ▶ In more advance stages, a pinkish or rusty brown area develops on the surface of the curd and hence is known as red or brown rot.

### Management

- ▶ Application of borax @20kg/ha





## 9. Blackspeck

A physiological disorder in cauliflower common with the popular snowball cultivar. Blackspeck 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.



### Management

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



# **DR. SUBHRAJYOTI CHATTERJEE**

**B.SC. (HORT.), M.SC. (HORT.) VEGETABLE SCIENCE, PH.D.**

**VEGETABLESCIENCE**

**RESEARCHGATE:**

<https://www.researchgate.net/profile/Subhrajyoti-Chatterjee-4>

**GOOGLE SCHOLAR:**

<https://scholar.google.com/citations?user=Fj1lUPoAAAAJ&hl=en&authuser=1>

# **KnolKhol**

*(Brassica oleraceae var. gongylodes)*

**Family: *Brassicaceae***

*Origin : Mediterranean region  
(North Europe)*

- ▶ The cultivation of knolkhol or Kohlrabi in India is not very popular except in Kashmir, W.B. and some parts of the south.
- ▶ KnolKhol is characterized by the formation of tuber which arises as thickening of the stem tissue above the cotyledons.
- ▶ This tuber or knob develops entirely above the ground. This portion is used for vegetable. Young leaves are also used.
- ▶ It is high in minerals like Ca, Mg, P, Na & S.
- ▶ It also contains protein, carbohydrates, Vitamin A & C.
- ▶ Knobs are either used as cooked or as boiled vegetable.
- ▶ Also used as salad.
- ▶ Leaves are also used in preparation of soup.

# CLIMATE

- ❖ It is mainly grown as a winter vegetable crop and thrives well in a relatively cool moist climatic conditions.
- ❖ **Seeds of knolkhol germinate well at 15-30°C.**
- ❖ Optimum temperature for its growth is between 15-25°C depending upon cultivars.
- ❖ **Early varieties are more prone to premature bolting.**
- ❖ When grown below 15°C for longer period, these varieties produce flowering stalks directly without forming knobs.
- ❖ **High temperature after planting can delay the bolting of plants.**
- ❖ Crop grows well for the tuber production at 20-25°C though the quality is better under lower temperature.
- ❖ **Purple varieties are more susceptible to pre-mature bolting.**

# Soils

- ❖ **All types of soil though it makes no high demand upon it.**
- ❖ **Good condition and fertility favour growth in a uniform manner.**

# Planting Time

**Under North eastern plains.**

	Seed sowing	Transplanting time
<b>Early crop</b>	<b>August</b>	<b>September</b>
<b>Main crop</b>	<b>September</b>	<b>October</b>
<b>Late crop</b>	<b>October</b>	<b>November</b>
<b>Hills</b>	<b>March-April</b>	<b>May-early June</b>

## Himachal Pradesh

	Seed sowing
<b>Low Hills</b>	<b>July-October</b>
<b>Mid Hills</b>	<b>July-October</b>
<b>High Hills</b>	<b>March-July</b>

## Planting Distance

- 30-40 cm x 20-25 cm (30 x 20 cm in H.P.)
- Optimum yield obtained at 30 cm x 25 cm.

## Seed Rate

⇒ 800-1000 g/ha (950-1000g in H.P.)

## Manures and Fertilizers

FYM (q/ha)	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
	(Kg/ha)		
200-250	100	80	80

- ☺ Half of N and full P and K fertilizers should be applied as basal (at transplanting) and half N one month after sowing planting.



# Interculture and Weed Control

- ❖ Proper moisture should be maintained during its growth.
- ❖ Pre-planting application of weedicide followed by hoeing & weeding in the later stage will keep the crop free of weeds.
- ❖ Any check in the growth will cause development of fibrous knobs.

# Harvesting and Yield

- ✓ Harvest tubers before fully grown, because old tubers eventually become fibrous.
- ✓ Generally, tubers of 5-8 cm dia & bright colour along with the foliage are favoured in the market.
- ✓ Late varieties may attain 10-12 cm dia at harvesting stage.
- ✓ For its marketing, the main root is cut off & the enlarged stem along with the leaves are tied up.
- ✓ Individual tuber may weigh 200-250g
- ✓ The yield/ha may vary from 12-25 t/ha under Indian conditions.

# **DR. SUBHRAJYOTI CHATTERJEE**

**B.SC. (HORT.), M.SC. (HORT.) VEGETABLE SCIENCE, PH.D.**

**VEGETABLESCIENCE**

**RESEARCHGATE:**

<https://www.researchgate.net/profile/Subhrajyoti-Chatterjee-4>

**GOOGLE SCHOLAR:**

<https://scholar.google.com/citations?user=Fj1lUPoAAAAJ&hl=en&authuser=1>



# Broccoli

*(Brassica oleracea var. italica L.)*

**Family : Brassicaceae**

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

# Uses

- ♠ It is becoming popular amongst Indians because of its high nutritive value.
- ♠ It carries organoleptic or anticarcinogenic properties and is a rich source of vitamins, minerals, protein etc.
- ♠ It has about 130 times more Vitamin A contents than cauliflower and 22 times more than cabbage.
- ♠ It is also a rich source of sulphoraphane, a compound associated with reducing the risk of cancer.

# CLIMATE

- ▶ It is mainly grown as a winter crop in most parts, however in high hills may be grown as a spring summer crop.
- ▶ Sensitive to temperature as bud clusters grow loose quickly and give rise to bracts under warm weather conditions.
- ▶ Light frost causes considerable damage to the buds, though vegetative growth is not affected to that extent.
- ▶ An optimum temperature of 12-18 °C is suitable for proper head development

# Different Types of Broccoli

<b>Purple sprouting broccoli</b>	Biennials, branched, purple spears, variable, early and late forms overlapping.
<b>Purple cape broccoli</b>	Biennials, single purple heads, variable
<b>White sprouting broccoli</b>	Biennials, branched, white spears. Distinct early and late maturing forms of which the late type more strictly with in the botrytis group.
<b>Purple Sicilian broccoli</b>	Single heading pale-purple heads also known in horticulture as purple cauliflower.
<b>Couve broccoli</b>	‘Roxo de Cabeça’ Tall purple heading, sprouting type from Portugal.
<b>Calabrese</b>	Green sprouting broccoli from Calabrian region. Now a world wide crop and virtually single heading. Many hybrid cultivars are available.
<b>Black broccoli</b>	Highly branched annual with dark green spears and sickle shaped leaves, from Rome area.





**White sprouting**



**Purple cape**



**Purple Sicilian**



**Calabrese**



**Purple sprouting**



**Couve**



**Black Broccoli**



**Palam Samridhi**



**Palam Vachitra**



**Palam Haritika**

**Palam Kanchan**



# Nursery Sowing Time

**North Indian Plains**

**Mid-Aug. to Mid-Sept**

## Himachal Pradesh

**Low Hills**

**September- October**

**Mid Hills**

**August – September**

**High Hills**

**March- April**

- ▶ **Seedlings become ready for transplanting in 4-5 weeks time.**
- ▶ **Seedlings 5mm in diameter are better for field setting and must be about 10-12cm in length at the time of transplanting.**

## **Seed Rate**

**400-500 g/ha**

## **Spacing**

**45cm X 45cm**

**Field preparation, Manures and fertilizers, Intercultural and weed management, and irrigation requirements are same as cauliflower**

# Harvesting

- ⌘ It is important to harvest the broccoli heads at correct time i.e.
- Before the buds open
- Bud clusters are compact.
- ⌘ The heads are cut off with about 15cm of the stem attached in case of sprouting broccoli.
- ⌘ After cutting, part of the foliage is removed from the harvested shoots.

## Yield



150-200 q/ha

# Storage

- ❑ The shelf life of broccoli heads & sprouts is significantly affected by temperature and not much influenced by relative humidity.
- ❑ At temperature 12 – 17°C and RH between 75% it can be easily stored for 3 days.
- ❑ Under cool storage (3°C & 88% RH) the shelf life of heads can be extended upto 31 days.
- ❑ Packaging in LDPE (Low density polyethylene) bags helps in keeping the broccoli more fresh and green under low temperature.



**Broccoli plants grow to be about 24" tall. The main group of florets, or "head," grows in the center of the leaves.**



**Broccoli leaves are large, blue-green, and lobed.**



**Broccoli leaves and cauliflower leaves are very similar, especially in the immature stage. However, broccoli leaves tend to be blue-green in color (compared to the bright green cauliflower leaves). Broccoli leaves are also broader than cauliflower leaves and have a lobe-like structure(s) at the base of the leaf.**



# **DR. SUBHRAJYOTI CHATTERJEE**

**B.SC. (HORT.), M.SC. (HORT.) VEGETABLE SCIENCE, PH.D.  
VEGETABLESCIENCE**

**RESEARCHGATE:**

<https://www.researchgate.net/profile/Subhrajyoti-Chatterjee-4>

**GOOGLE SCHOLAR:**

<https://scholar.google.com/citations?user=Fj1lUPoAAAAJ&hl=en&authuser=1>

# Brussel's Sprout





**Brussels sprouts are large, immature leaf buds, about one to two inches in diameter. They are green, oval, and have tightly overlapped leaves. They look like very small cabbages**



**The sprouts grow along the central stem of the plant, each bud resting atop a leaf stem.**



**Brussels sprout plants can grow very tall, usually about 2 to 3 feet. Their large, round leaves grow in whorls around a thick, central stalk. The cluster of greens at the top of the plant can be harvested and eaten.**



# **DR. SUBHRAJYOTI CHATTERJEE**

**B.SC. (HORT.), M.SC. (HORT.) VEGETABLE SCIENCE, PH.D.**

**VEGETABLESCIENCE**

**RESEARCHGATE:**

<https://www.researchgate.net/profile/Subhrajyoti-Chatterjee-4>

**GOOGLE SCHOLAR:**

<https://scholar.google.com/citations?user=Fj1lUPoAAAAJ&hl=en&authuser=1>

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

**CARROT - (*Daucus carota* L.)**

**(2n – 2 x 18)**

(Hindi – Gajar)

Family: Apiaceae

Carrot is an ancient cool season root vegetable. Roots are used for making soups, stews, curries, pies, pickles and for salad purposes. Sweet preparation 'gajar halwa' prepared out of carrot is delicious and popular. Roots are also canned. Carrot roots are rich sources of  $\alpha$  and  $\beta$  carotenes (1890  $\mu$  g/100g) and contain sucrose 10 times that of glucose or fructose. Carrot leaves are a good source of leaf protein. It is used as fodder and for preparation of poultry feeds.

Carrot has many medicinal properties. It increases quantity of urine and helps in elimination of uric acid. It has cooling effect and is beneficial for people suffering from gall stones, constipation and heat troubles.

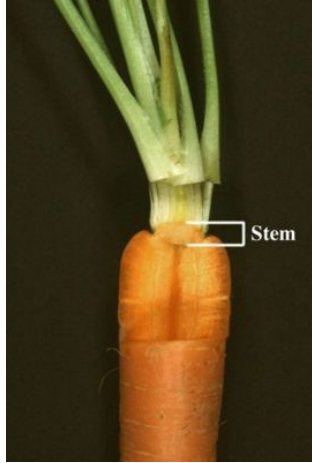
Purple and black carrots are used for preparation of a beverage called 'kanji' which is a good appetizer. In France, essential oil separated from seeds is used for flavouring liquors and all kinds of food substitutes.

**Origin**

According to Mackevic (1929), Afghanistan is the primary centre of origin of carrot since a large diversity for morphological and root characters occur. Considerable variability for root also exists in India, indicating India also as a centre of origin. Root colour varies from absolutely colourless through light lemon light orange, deep orange, light purple, deep purple to almost black.

**Botany**

Carrot is an annual or biennial herb with an erect or branched stem (30-120 cm high) arising from a thick fleshy root. Leaves are pinnate. Edible portion is the fleshy tap root composed of an outer cortex (phloem) and inner core (xylem). Inflorescence is compound umbel and is produced during second phase. Anthesis in a single umbel is completed in 7-9 days. Individual flowers are bisexual with white or yellow petals. The so-called carrot seed is actually a fruit, an indehiscent mericarp, which consists of a single seed. Two mericarps pair to form a single rhizocarp, the real carrot fruit which develops from a two-loculed ovary.



### Root development

In most cultivars, the root first grows in length and then increases its diameter. By 12-16 days after sowing, the tap root reaches its optimum length. Shape and size of roots are influenced by several factors. Varietal characters, un-decomposed organic matter, any obstruction to its downward growth etc. are a few factors causing cracking, forking and branching of roots. Temperature also influences shape of root. Variety Chantney produces longer and more slender roots at 18°C, while they were shorter and thicker at 24°C. High temperature and irregular water supply cause deep depression on roots causing rough root

surface. Excessive irrigation after drought results in white corky outgrowth where side roots may develop.

Temperature has significant influence on colour and development of roots. A temperature range of 15.5 – 21.1°C is the best for colour development. Carotene content decreases above 21.1°C and below 15.5°C. Usually the young roots are yellowish in colour which changes to whitish yellow, light yellow, dark yellow, orange or orange red as a result of accumulation of carotenoids pigments. Carotene accumulation takes place first in old phloem cells followed by old xylem vessels and finally to centre core.

### **Cultivars / Varieties**

Varieties with long, orange coloured and smooth roots are preferred in India. Many varieties, both indigenous and exotic, differing in temperature requirement, length, size, shape and colour of roots and duration of crop are grown in India. Varieties are also classified into temperate and tropical types.

- a. Temperate or European or biennial types require a low temperature of 4-8°C for flowering. They do not produce seeds in plains of India, e.g., Nantes, Half long, Early Nantes, Pusa Yamadagini and Ooty 1.
- b. Tropical or Asiatic or oriental or annual types which do not require low temperature for flowering and they produce seeds in plains of North India. E.g., Pusa Kesar, Pusa Meghali.

A brief description of important varieties is given below:

### **Tropical varieties**

**Pusa Kesar:** Evolved at IARI, New Delhi by selection from a cross between Local Red and Nantes Half Long. Roots are scarlet in colour sufficiently red coloured central core compared to yellow or white core in Local; roots stay one month more than the Local red without bolting; contains high carotene (38 mg/100 g).

**Pusa Meghali:** Selection made at IARI, New Delhi by crossing Pusa Kesar and Nantes. It has long orange coloured tapering roots with self coloured roots.

**Hisar Gairic:** Roots long (18.5 cm), tapering, light brick red in colour, less fibrous with thin self colouring core. Yield 25-30 t/ha.

### **European varieties**

**Nantes Half Long:** The variety commonly known as Nantes is evolved at IARI Regional Station, Katrain; roots are small, slim, rough, sweet, cylindrical and stumpy with abrupt tail; the core is small and self coloured; yield is 15-20 t/ha in 90-110 days.

**Early Nantes:** Roots almost cylindrical terminating abruptly in small thin tail, 12-15 cm long, orange flesh with self coloured core; duration 90-100 days.

**Chantenay:** Suitable for canning and storage; roots are reddish orange with a length of 11.5 – 15.0 cm.

**Chaman:** Developed at SKUA&T, Srinagar; roots long, cylindrical and semi blunt; tolerant to cracking; yields 25-27 t/ha.

**Pusa Yamadagini:** Developed at IARI Regional Station, Katrain; roots 15-16 cm long, orange with self coloured core, slightly tapering and semi-stumpy with medium top; 9-10 t/ha in 90-100 days.

**Ooty-1:** Developed at Horticultural Research Station (TNAU), Udthagamandalam: roots are 25 cm long with deep orange colour; yield 45-50 t/ha in 100-110 days.

**Zino:** Introduced from Germany in the Nilgiris hills of Tamil Nadu by the State Department of Horticulture; roots deep orange with self coloured core; duration 110-120 days.

Imported varieties like Danvers and Emperor are also popular in the country. Gold King Indian Kuroda, Nebora and Super Kuroda are a few of the carrot varieties marketed by private seed industry.

### **Climate**

Climatic and soil factors have great influence on shape and colour development of roots. Carrot is grown as a spring summer and autumn crop in hills and as a winter crop in plains of North India. Ideal temperature for germination of seeds is 7.2-23.9°C, while for root growth and development it is 18.3-23.9°C. Tropical types produce roots even at a temperature of 25°C.

European types require a low temperature of 4.8-10.0°C for 4-6 weeks at any time during development of roots or after they mature either in storage or in field. Seed stalk formation takes place only when plants are subjected to a subsequent temperature of 12.2 – 21.1°C.

### **Soil**

Deep and well drained friable soils are essential for proper root development. For early crop, sandy loam and for heavy yield, silt loam is preferred. Long rooted cultivars perform the best in light soil. In heavy soils, short stump rooted varieties having round and heart-shaped roots are preferred. In hard soils, roots will be rough and coarse. The ideal soil pH is 6.6 – 7.1

### **Land preparation and sowing**

Soil is ploughed to a fine tilth. Utmost care should be taken to remove clods, stones etc. Land is then made to ridges and furrows at 30-45 cm apart in small plots of convenient size for



irrigation. Seeds are sown on ridges or on flat beds either by dibbling in lines or by broadcasting. Seeds are first rubbed to remove fine hairs and mixed with fine sand before sowing to facilitate even distribution. For sowing in lines, a small furrow of about 1.5 cm deep is made at top or on either sides of ridges with finger or with sharp end of a stick. Seeds mixed with sand are dropped in furrow by hand and is covered lightly with soil. Seed rate varies from 6 to 10 kg/ha depending on variety and sowing. Seedlings should be thinned to a plant to plant distance of 5-8 cm, soon after they are established. Otherwise, over crowding leads to deformed roots.

It is advisable to give light irrigation immediately after sowing or to soak seeds in water for 12-24 hours before sowing to hasten germination.

### **Manuring**

In addition to 20-25 tonnes of farmyard manure, a fertilizer dose of 40-50 kg N, 40-50 kg  $P_2O_5$  and 80-100 kg  $K_2O$  is recommended for the crop, of which entire dose of farmyard manure, half N and full P and K are to be applied as basal dose at the time of final land preparation. Remaining dose of N can be applied at the time of first hoeing.

### **Interculture**

Carrot seeds take about a week to germinate and initial growth of seedlings is rather slow. First irrigation should be given immediately after sowing followed by another 4-6 days after. Soil should be kept moist by frequent light irrigation for proper growth of roots. Excessive irrigation, that too towards the last stage, should be avoided as it may result in excessive vegetative growth.

Since seedlings grow very slowly care should be taken to remove weed growth during initial stages.

Carrot roots do not come up like that of radish and hence, earthing up is not required. Soil should be hoed frequently to allow proper aeration and to prevent discolouration of crown.

### **Harvest**

Roots grown on ridges are usually harvested after loosening soil with a spade and by pulling out roots by grasping top. In flat ground, top is removed close to ground and roots are dug out with a spade. A light irrigation is usually given before harvesting for easy uprooting.

Yield varies with season, climate, varieties etc. Tropical types yield 20-30 t/ha. and European types yield 10-15 t/ha.

Harvested roots are put in mulberry basket and dipped in flowering water for washing. Roots are then partially dried, trimmed and graded before sending to distant markets.

Trimming, grading etc. are done at a cool place. Fresh Carrot roots can be stored for 3-4 days under ordinary conditions and for six months at 0°C and 93-98% RH.

### Seed production

Tropical annual types produce seeds in plains and temperate biennial types in hills. Both root to seed and seed to seed methods are recommended for carrot seed production. Seed to seed method is followed to get more seed yield. Root to seed method is followed to get quality seeds. However, in this method, high incidence of root rot is noticed. To check root rot in transplanted crop, planting roots without cutting is recommended.

Carrot is a cross-pollinated crop due to protandry and pollination is done by honey bees. Being a cross-pollinated crop, allow an isolation distance of 1000 m from other varieties. Opening of umbel starts from periphery and completed within 6-7 days. Seed yield is 500-600 kg/ha.

### Pests and diseases

Pests and diseases are not major problems in cultivation of carrots. Among pests, carrot rust fly (*Psila rosae*) maggots burrow into roots resulting in unmarketable roots. **Lycus** bug damages seed crop and reduces viability and germination of seeds. Seed treatment with insecticides controls this pest.

Among diseases, *Cercocpora leaf spot and root rot caused by Fusarium oxysporum* adversely affect stand of crop. Watery soft rot caused by *Sclerotinia sclerotianum* occurs in storage.

### Physiological disorders

**Cavity spot** - This is primarily caused by calcium deficiency induced by excess potassium. Symptoms appear as a cavity in cortex.



**Carrot splitting** – Splitting or cracking of roots is a major problem in carrot cultivation. Though this is a genetic character, other factors are also influencing cracking. Excess nitrogen and its untimely application promote cracking.

\*\*\*\*\*



1. The mode of cross pollination in carrot is due to the presence of \_\_\_\_\_ flower.
  - a. Protogynous
  - b. Protandrous
  - c. Dichogamy
  - d. Duodichogamy
2. Carrot was first introduced in India from \_\_\_\_\_
  - a. Persia
  - b. Sri Lanka
  - c. Paris
  - d. Japan
3. Cavity spot of carrot is due to the deficiency of \_\_\_\_\_
  - a. Boron
  - b. Zinc
  - c. Calcium
  - d. Iron
4. Aster yellow is a disease of \_\_\_\_\_
  - a. Tomato
  - b. Carrot
  - c. Onion
  - d. Beetroot
5. Carrot root is a modification of
  - a. Adventitious roots
  - b. Tap root
  - c. Runner
  - d. Sucker

cuts to ensure better quality and higher seed yield. The selected roots are planted at a distance of 75 cm × 20 cm. It is reported that the stecklings should be given the treatment of one third shoot cut and one fourth to one half root cut to obtain better quality and higher seed yield. If possible, the seed growers may not harvest the seeds of third order umbel, which has poor seed germination, thereby ensuring better germination percentage from the seeds collected from the first two orders of umbel.

The off-type plants including premature bolters should be rogued out before flowering of the stalks. The harvesting is done when the secondary umbels are fully ripe and the third order umbels have begun to turn brown. Shattering is not a serious problem in carrots. The plants can be pulled and stacked for curing. Threshing is done by wooden rollers when the stem becomes brittle.

A seed yield of 450–550 kg/ha from the European varieties and 800–1,000 kg/ha from the Asiatic varieties can be obtained.

## RADISH



Fig. 14. Radish

Radish is probably originated in Western Asia, was cultivated in ancient Egypt, Greece and Rome. It is now spread through-out the world. In Hindi it is known as *mooli*. It is grown widely in northern and southern plains as well as in the hills. In India it is grown in an area of 160,000 ha with a production of 2286,000 tonne and productivity of 14.3 tonne/ha (NHB, 2011).

Radish is an important root vegetable grown all over the country. The enlarged succulent taproot is used as vegetable both raw as salad and cooked in various ways. The tender leaves are also often used as a leafy vegetable. Being a quick growing crop it can be planted as an inter crop or companion crop in other vegetables.

It is consumed almost in every house whether rich or poor. Radish green is very rich in vitamin A, B and C with little of carbohydrates, iron and protein. It is eaten both raw as salad or cooked in various ways. It has a cooling effect and it increases the appetite. It has some medicinal values too. 100 g of edible roots contain 93.7% water, 4.2% carbohydrates, 1.1% protein, 0.1 per cent fat, 0.7% fibre, 30 IU vitamin A, 24 mg vitamin C, 37 mg calcium, 31 mg phosphorus, 260 mg potassium, 15 mg magnesium, 37 mg sulphur and chlorine.

### Botany

Radish (*Raphanus sativus* L., 2n=18) is a member of Cruciferae family. Depending upon flowering radishes may be classified as annual and biennial. The annuals are of mainly tropical origin and do not require chilling for flower induction while the biennials are of temperate origin and require chilling for

flowering and seed production. The enlarged edible roots are fusiform botanically which may differ in colour from white to red. There are two distinct genetical groups in radish. The Asiatic varieties which are primarily for tropical climate, produce edible roots in the first season and seeds in the second season as a biennial crop, whereas the exotic or European varieties produce roots in the plains of tropical and sub-tropical climate and seeds in the hills of temperate climate.

Both types produce fleshy tap roots together with a rosette of leaves arising from a shortened stem. The inflorescence is the typical terminal raceme of the crucifers, and the flowers are white, rose or lilac in colour. Radish is highly cross pollinated crop, pollination occurs primarily by honeybees. Flowers open during the day time from 8 AM onward. Dehiscence generally takes place at warmer temperature condition. Radish fruits differ from that of other crucifers in that it is not a siliqua but a true pod, about 2.5 to 7.5 cm with a pithy interior.

### **Breeding**

Radish is a cross-pollinated crop. The commonly adopted procedures for breeding are mass selection, recurrent selection, hybridization and heterosis. The  $F_1$  hybrids are produced by single crosses, or double crosses. Transgression of useful traits is possible by wide interspecific crosses between *Raphanus* and *Brassica* species by protoplast fusion and genetic engineering. These aspects are important for developing commercial cultivated species of the crop. Some studies on pollen morphology and physiology in radish have been reported. Different useful strains of Asiatic types have been reported from different regions of the country. A good number of temperate and Asiatic varieties were also introduced and some of them have been grown as commercial varieties for decades, but their seed production has been possible only in Kashmir, Kullu Valley and Nilgiri Hills. Usually the Asiatic types are more pungent than the temperate ones. Attempts have been made to improve upon the Asiatic strains by crossing with the exotic varieties to obtain new varieties with root qualities of temperate types and ability to produce seeds in the plains. An important achievement in this direction has been the release of the new radish variety 'Pusa Himani'. Emphasis has also been laid on developing varieties resistant to diseases. 'Arka Nishant', is the variety developed at IIHR, Bengaluru in 1972 which produces high yield with the better quality roots in the southern region. Male sterile line has also been used for hybrid seed production in other countries. In radish Ogura sterile cytoplasm is widely distributed in wild Japanese radish (Nath *et al.* 2002).

### **Improved cultivars**

#### *Asiatic cultivars*

**Japanese White:** Roots are 35–40 cm long, stumpy in shape, pure white, less pungent or sweet in taste. Leaves are of medium size and grayish green. Suitable for sowing from October - December. Maturity 60–65 days. Yield 350–400 q/ha.

**Pusa Desi:** Developed by IARI, New Delhi. Roots are 30–35 cm long, tapering, white with green stem end and mildly pungent in taste. Leaves are of medium

size and green. Suitable for sowing from August - October. Maturity 50–55 days. Yield 300 q/ha.

***Pusa Reshmi:*** Developed by IARI, New Delhi. Roots are 30–35 cm long, tapering, white with green stem end, mildly pungent in taste. Leaves are of small to medium size and green. Suitable for sowing from October - December. Maturity 60–65 days. Yield 350–400 q/ha.

***Pusa Himani:*** Developed by IARI, New Delhi. Roots are 30–35 cm long, tapering, white with green stem end, mildly pungent in taste. Leaves are of small in size and dark green. Suitable for sowing from December - February in plains and during summer season in the hills. Maturity 60 - 65 days. Yield 300–325 q/ha.

***Pusa Chetki:*** Developed by IARI, New Delhi. Roots are 15–20 cm long, stumpy in shape, pure white and mildly pungent or sweet in taste. Leaves are of medium in size, erect, soft and green. Suitable for sowing from mid April - August. Maturity 40 days. Yield 200–250 q/ha.

***Pusa Mridula:*** This is released by IARI, New Delhi. Roots are globular with bright red skin, mildly pungent. Average yield 130 q/ha. Maturity 25 days.

***Pusa Jamuni:*** First purple fleshed unique trait nutritionally rich radish variety. Distinct advantage in root size, shape, yield and consumer preference over the existing varieties. Higher anthocyanins and ascorbic acid.

***Pusa Gulabi:*** This is released by IARI, New Delhi. First entire pink fleshed unique trait nutritional rich radish variety. Medium root size, cylindrical shape, optimal yield and consumer preference over the existing varieties. High total carotenoids, anthocyanins and optimal ascorbic acid.

***Arka Nishant:*** Developed by IIHR, Bengaluru. It is an Asiatic variety. Matures within 45–55 days. Roots are medium sized (25 cm × 3.4 cm), marble white, crisp texture with pleasant aroma; free from early bolting, pithiness, splitting and forking, each root weighing 300–400 g. Root and shoot length ratio is 1: 1. Pungency is mild. It yields 200–300 q/ha.

***Punjab Safed:*** Developed by PAU, Ludhiana. Roots are pure white, tapering, smooth, mild in taste, 30–40 cm long and 3–5 cm thick.

***CO 1:*** This variety is released by TNAU. The crop duration ranges from 40–45 days and hence suitable for cropping systems. It yields 200–250 q/ha. The roots are milky white, long (22 cm), thick (12.5 cm girth) and each weighs 220 g. The roots contain 10.9 mg of vitamin C per 100 g and 1.20% crude fibre. This variety is suitable for growing all the year round under different cropping systems. It bolts and sets seeds in the plain.

### European cultivars

***White Icicle:*** Roots are small (8–10 cm long), thin, pure white, tapering, sweet in taste. Suitable for sowing in kitchen garden or container garden from October - January. Maturity 30 days. Yield 50 q/ha.

***Rapid Red White Tipped:*** Roots are small, round or globular, upper portion of the roots is red and lower portion is white, sweet in taste. Suitable for sowing in kitchen garden or container garden from October - January. Maturity 25 days. Yield 50 q/ha.

### **Climate and soil**

It is a cool season crop, but the Asiatic varieties can resist more heat than the European or temperate varieties. It attains best flavour, texture and size at 10–15.6 °C. A long day as well as high temperatures lead to bolting without adequate root formation. During the hot-weather the roots become tough and pungent before reaching the edible size and therefore should be harvested while young and small in size. Radish is more pungent at higher temperature. Pungency decreases with the advent of cooler temperature. The temperate types are generally small, mild pungent in taste and mostly used as a salad. It may be grown in all kinds of soils but the best results are obtained on sandy loam soils which are friable and contain high amount of humus. Usually the heavy soils produce rough, ill-shaped roots with number of small fibrous laterals. The field should be prepared with at least 4–5 ploughings so as to make the soil very loose and smooth.

### **Cultural requirements**

**Planting time:** Since, it is a cool season crop its cultivation is preferred during winter season in the plains. It can be sown any time between September-January in the northern plains as it is not affected either by frost or by extreme cold-weather conditions. It is grown from March - August in hills. In the regions where summer is mild, it can be grown throughout the year except during few months of summer. In Bengaluru, the radish roots are available practically for 8- 10 months of the year but the best edible roots are available during November-December only. The temperate types are generally not planted till October. The time of sowing in radish varies from region to region. As it is non-tolerant crop for high temperature, August-October is the suitable season for sowing.

**Land preparation and sowing:** Bring the soil to a fine tilth by ploughing the land 3–4 times. Incorporate 25 tonne/ha of well rotten farm-yard manure (FYM) after the first ploughing. Prepare continuous ridges and furrows of convenient length. A spacing of 25–30 cm between the two ridges may be kept depending on the variety grown and spacing between plants within the rows be maintained at 8–10 cm, by thinning out the extra seedlings 15 days after sowing. Apply the fertilizer mixture (@ 50 kg N, 100 kg P and 50 kg K/ha) at bottom of the ridge and cover it with soil. Irrigate the furrows 2 days before sowing the seeds.

Seeds are usually sown on ridges to facilitate good root production. Shallow furrows of 2 cm depth are opened on the ridges using a stick. The seeds are thinly sown in the shallow furrows and covered with soil or pulverized manure. A light irrigation is given immediately after sowing. For continuous supply the seeds of Asiatic varieties are sown ones in 15 days and of European varieties ones in eight days.

### **Intercultural operations**

It is necessary that enough of soil moisture is available to help uniform seed germination and growth of the plant. If enough soil moisture is not available at the time of sowing, the first irrigation should be given immediately after sowing. It is advantageous in case of light soils but it hinders the germination in heavy soil where the soil surface has become dry with hard crust formation before the

seed has sprouted and broken through the soil. In this case, it is always safer if the sowing is done when already enough of soil moisture is available for germination in heavy soils. Depending on the season and the soil moisture available, it may be irrigated once or twice a week. It should be irrigated very frequently, but care should be taken that the field may not become dry and compact so that the root development is not checked.

Weeding should be done at regular intervals to keep down the weeds. Shallow hoeing may be necessary to facilitate root growth. Spacing between plants within the rows should be maintained at 8–10 cm, by thinning out the extra seedlings 15 days after sowing.

Top dress the crop with 50 kg N/ha 25–30 days after sowing (for Asiatic varieties only) and do earthing up which prevents discoloration of roots exposed to the atmosphere and to get better quality roots. When the roots have started growing, earthing up should be done for enlarged root production, otherwise the growing roots may come above the soil surface.

## Pest and disease management

### Diseases

**White rust (*Albugo candida*):** In some areas, it is a very serious disease of radish. It produces a white powdery substance in patches on the under surface of the leaves. It mainly appears on the leaves and flowering shoots which get deformed and bear only malformed flowers. The disease can be controlled effectively by spraying chlorothalonil (0.2%) or mancozeb (0.2%) or copper hydroxide (0.2%).

**Root rot (*Erwinia rhapontici*):** It results in rotting of pith tissues and cavity formation and the plant wilts and dies. Root dip in Agrimycin @ 100 ppm is recommended.

### Insect pests

**Aphids (*Brevicoryne* sp., *Myzus* sp.):** This pest attacks most of the *Cruciferous* crops and persists on the alternate hosts throughout the year. The cloudy and humid conditions are favourable for their quick multiplication. In case of heavy infestation, the plants are completely devitalized, leaves and shoots curl up, get yellowed and finally die. For control, spray the crop with malathion @ 2 ml/l of water at 10–15 days interval.

**Mustard saw fly (*Athalia* sp.):** This is a common pest of radish and turnip. It appears when the crops are in flowering and at vegetative stage. The damage is done by the grub by biting hole in the leaves and fruits. Collect and destroy mustard saw fly larvae and spray neem soap 1% or quinalphos (2.5 ml/L) for controlling mustard saw fly larvae.

**Flea beetle (*Phyllotreta* sp.):** In some areas, it becomes a very serious pest on the vegetative parts of the plant which are eaten by this pest. It can be controlled by spraying with spray chlorpyrifos (0.05%) or quinalphos (0.05%), if required only.

## Harvesting and yield

Irrigate the crop before pulling out the roots as the soil should contain ample



moisture for easy pulling of roots. The European varieties should be uprooted 25–30 days after sowing (DAS). They will become fluffy and pithy (which are unfit for consumption) if kept in the field for a longer time.

The Asiatic varieties can be harvested 45–90 DAS and remain edible much longer than the European varieties. The maturity of the roots for marketing will depend on the size of the roots as well as on the variety. It is necessary that the roots are harvested at the right stage because they tend to become fluffy and unmarketable thereafter. The roots should be harvested at tender stage. Delay in harvesting may result in pithiness of roots. The roots are washed and bunched together along with the shoots for marketing purposes. Roots can be stored at room temperature for 3–4 days without impairing its quality much, and for two months in the cold storage at 0° C and 90–95% relative humidity.

The Asiatic improved varieties produce 150–250 q/ha of roots in 40–60 days, whereas the temperate varieties produce 50–80 q/ha in 25–30 days.

### Seed production

The land should be selected considering the fact that the same kind of crop was not grown within the previous two years to contain seed borne diseases beyond maximum permissible levels. About 4–6 kg seed is required per hectare of land. Cultural practices for seed production are similar to the crop grown for roots. Two methods of seed production, viz. seed-to-seed and root-to-seed methods are employed for radish seed production. Seed-to-seed method is preferred for raising certified seed. This method is not recommended, as the selection of good roots cannot be made and off-type plants which are not true to variety cannot be removed. Also the seed quality and yield are affected. The nucleus seed, however, is invariably produced by root-to-seed method. In this method the roots are uprooted and planted again before the onset of reproduction phase.

**Root-to-seed method:** In root-to-seed method, fully matured roots (before pith development) are harvested, true-to-type roots are selected and after giving proper root and shoot cuts they are transplanted in a well prepared field. Highest seed yield is obtained by giving 1/4<sup>th</sup> root cut and 2/3<sup>rd</sup> shoot cut. The selection and roguing are done on the basis of foliage characters, root shape, size, colour, flesh colour, pithiness, pungency and bolting behavior. Small, deformed, diseased and other undesirable roots are discarded. Hairy, forked roots and early or late bolters are also removed. For high yield of good quality seeds, radish stecklings are planted at a spacing of 45 cm × 30 cm. The field prepared for steckling planting should be fertilized with 50 kg N and 50 kg K/ha.

**Seed-to-seed method:** Usually commercial market seed is grown by this simpler method. The annual radish crop is sown in mid September through October at a spacing of 45 cm × 45 cm in a well prepared land. The crop is allowed to grow and produce seed at their original position (*in situ*). Rigorous roguing should be used to raise seed-to-seed crop.

Radish is a cross-pollinated crop and honeybees are mainly responsible for pollination. Radishes will cross other radishes including daikon, but not turnips (*Brassica rapa*) or other members of the cabbage family. Seed fields must be isolated from other variety of radish, and the same variety not conforming to

varietal purity requirements by at least 1,600 m for foundation seed and 1,000 m for certified seed production. Honeybees are the chief pollinating agents. It is that seed yield in radish is greatly influenced by the number of honey bees visiting the flowers. Those beehives may be provided at the time of flowering, in the field for higher seed yield.

Weeds, especially wild radish, wild turnip, wild mustard should be all removed from the radish field before bolting to avoid possible cross-pollination. One or two irrigation may be given after flowering which results in better seed yield. Sometimes staking is done to provide support to the seed stalk.

The seed plants are allowed to mature fully before harvesting, since there is no natural dehiscence, and there is often considerable difficulty in threshing the seed from the pod. Plants are cut when most of the pods are brown. Pick pods after they dry completely on the plant. Pick every day or two, as the pods will break open naturally to release their seeds soon after drying.

The crop is cut by sickle and brought to the threshing floor for thoroughly drying. The drier the pods, the more easily will they break open during threshing process. Threshing can be done by beating with sticks. The seed after sifting should be dried to 6–8% moisture content before storage. The average seed yield ranges from 800–1000 kg/ha. Radish seeds can last 4 or 5 years if properly stored.

## TURNIP

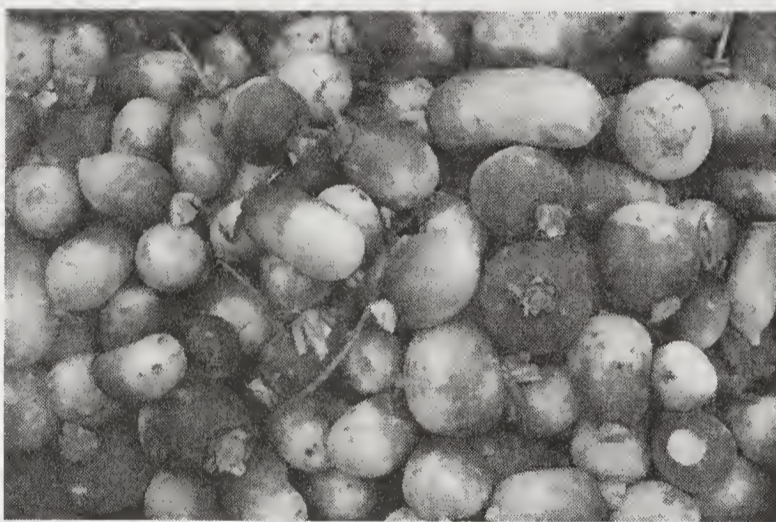


Fig. 15. Turnip

It is not definitely known from where the turnip originated but it is said to be known growing wild in Russia and Siberia. Some regard it as central and western China while others assign it to middle Asia, Punjab and Kashmir. It has been grown in India since a long time. In Hindi it is known as *shalgum*. Turnip is grown in almost all the regions in northern plains along with radish and carrot. It is very

popular especially in Jammu and Kashmir, Punjab, Himachal Pradesh and western Uttar Pradesh.

The turnip is primarily used as a vegetable and to a limited extent it forms the ingredient of salad preparation. Turnip greens are sometimes used as vegetable but are extensively utilized as green fodder. Turnip greens are good source of calcium, iron and vitamin A and C and contain appreciable amount of vitamin B also. The roots contain vitamin B and C in appreciable quantities. The 100 g edible root contains 91% water, 7.6 per cent carbohydrates, 0.5% protein and 0.6% mineral water (Bharadwaj, 2004). European types of turnip are relatively sweet and more palatable and may be eaten sometimes raw. The Asiatic turnips prepare good pickles also. In Jammu and Kashmir it is used in several delicious dishes including the meat.

# **DR. SUBHRAJYOTI CHATTERJEE**

**B.SC. (HORT.), M.SC. (HORT.) VEGETABLE SCIENCE, PH.D.  
VEGETABLESCIENCE**

**RESEARCHGATE:**

<https://www.researchgate.net/profile/Subhrajyoti-Chatterjee-4>

**GOOGLE SCHOLAR:**

<https://scholar.google.com/citations?user=Fj1lUPoAAAAJ&hl=en&authuser=1>

**ORIGIN, AREA, PRODUCTION, VARIETIES, PACKAGE OF PRACTICES FOR TURNIP**  
**(*Brassica rapa*)**

Turnip (*Brassica rapa*) is grown in temperate, subtropical and tropical regions of India. It is extensively cultivated in Bihar, Haryana, Himachal Pradesh, Punjab and Tamil Nadu.



**Climate and soil**

Cool and moist climate is most favourable for growing turnip. However, it can also be grown where summers are mild. The roots develop best flavour, texture, and size at a temperature of 10°–15°C. The short day length and cool weather favour proper development of roots. The long day and high temperature induce early bolting even without adequate development of roots. In hot weather, roots become fibrous, tough and more pungent. The Asiatic types can tolerate high temperature, while temperate types are quick-growing and flourish well under cool weather.

Turnip can be grown in all kinds of soils but it grows well in loam soil having sufficient humus. The well-drained, sandy loam soil is ideal for its cultivation. The extremely light sandy

soil or too heavy soils should be avoided. In such soils either the plant growth is hampered or forked or defective roots are formed which are unfit for market.

### **Varieties**

Turnip varieties are divided into 2 groups- Asiatic or tropical types and European or temperate. These can further be classified on the basis of root shape as well as skin and flesh colour. The varieties recommended for cultivation are:

#### **Early Milan Red Top**

Its roots are deep flat with purplish red top and white underneath. The flesh is pure white, well grained, crisp and mildly pungent. The top is very small with 4–6 sessile leaves. It is an extra early and very high yielding variety.

#### **Golden Ball**

Its roots are perfectly globe shaped, medium sized and smooth. It has bright, creamy yellow skin and pale amber coloured flesh of fine texture and flavour. The top is small, erect with cut leaves.

#### **Punjab Safed 4**

An early maturing variety, commonly grown in Punjab and Haryana. The roots are pure white, round, medium-sized with mild taste.

#### **Purple Top White Globe**

It is a heavy-yielder and large-rooted variety. The roots are nearly round, upper part purplish, lower portion is creamy. The flesh is white, firm, crisp and mildly sweet flavoured. Top is small, erect with cut leaves. It is suitable for growing during cooler months.



#### **Pusa Chandrima**

Its roots are medium to large, nearly flattened globe to globular, smooth, pure white skin with fine grains. The flesh is sweet and tender. Top medium and leaves not so deeply cut. It is an early maturing (50–60 days), heavy cropper with an average yield of 400q/ha. It is suitable for sowing from October to December in plains.

#### **Pusa Kanchan**

It is a selection from the cross of Asiatic (Local Red Round) and European (Golden Ball) varieties. It contains good qualities of both the parents. The roots look just like the Local Red Round. The skin is red, flesh is creamy yellow with excellent flavour and taste. The leaf top is shorter than the Local Red Round. It becomes ready for harvesting in about 10 days later than

the local parent. Its roots can be kept for a longer time than Local Red Round in field without becoming spongy.

### **Pusa Swarnima**

The roots are flattish round with creamy-yellow skin and pale amber coloured flesh of fine texture and flavour. Its top is medium; leaf blade is not so deeply cut. It is suitable for growing from June to October in hills and October to December in plains. It matures in 65–70 days.

### **Pusa Sweti**

Attractive, white roots of Pusa Sweti mature 45–50 days after sowing. A very early maturing variety, it is suited for October sowing in plains.

### **Snow Ball**

This variety is an early temperate type with medium sized small top. Its leaves are erect, cut and medium green. The roots are round, smooth with pure white skin. The flesh is white, fine grained, sweet and tender.

### **Cultivation**

The method of land preparation for turnip is the same as for radish. Asiatic turnips are sown from July to September, whereas European types from October–December in northern plains of India. In hills, sowing time is usually from July–September. Its seeds are sown directly either in lines or on ridges. Normally, flat beds are used for sowing turnip but sowing in low lying area or during the rainy season should be done on ridges. Seeds are sown on ridges or rows 30cm apart while a spacing of 5–7cm is kept within the row. The seeds are sown 1.5cm deep. Seeds can be mixed with sand or ash to facilitate uniform sowing. Generally thinning is done 10–15 days after germination. The plants are spaced 10–15cm apart within rows. Bold seeds germinate better than the medium ones. About 90–95% seeds germinate. Seeds remain viable for 4–5 years under good storage conditions. Seeds take 4–6 days to germinate.

### **Manuring and fertilization**

The quantity of manures and fertilizers to be applied depends upon climate, fertility status, pH level and texture of the soil. The proper time of application is equally important to facilitate optimum intake of plant nutrients for good harvest. Different doses of NPK have been recommended for various agroclimatic zones of India. However, a basal dose of 20–25 tonnes/ha of farmyard manure should be applied at the time of land preparation. This is supplemented by applying 70–100kg of N and 50kg/ha each of P and K. The complete dose of P, K and half of N should be applied before sowing. Phosphatic and potassic fertilizers are

applied 7–8cm deep before sowing. The remaining half of N is given in 2 split doses: first at the time of root formation and the second during development of root knobs.

Micronutrient requirement is almost similar to that of radish. Intake of B, Ca and Mo is more in turnip. Therefore, deficiency of these micronutrients is overcome by spraying 1kg/ha of Micnef MS-24 one or two times depending upon the requirement. It helps to control hollow-stem, pith formation and brown heart in turnip.

### **Irrigation**

Irrigation requirement of turnip is similar to that of radish. This is generally irrigated at 8–15 days interval depending upon weather conditions. The increase in moisture stress drastically affects its yield. Therefore, optimum required moisture is maintained by irrigating the crop at proper time.

### **Interculture**

About 2–3 hoeings are done to keep the crop weed-free and to conserve moisture. The earthing-up is done during second and third hoeings after top dressing of nitrogenous fertilizers to produce better quality roots. Usually 2–3 weedings are done till the crop is harvested. However, at the latter stage of crop growth, the fully developed leaves also restrict the weeds. The pre-emergence application of herbicide, Tok E-25 (Nitrofen) @ 2kg/ha effectively controls the weeds.

### **Seed production**

The method of raising seed crop as well as the techniques of seed production is the same as for radish. The Asiatic turnips produce seed in plains, whereas European ones in hills only. The selected roots are used to prepare the stecklings by pruning the root tip from the base and leave one-third of crown after trimming off the top. These stecklings are transplanted 60cm × 60cm apart in the hills and 45cm × 35cm apart in the plains. An isolation distance of 1,000–1,600m should be kept from Chinese cabbage, mustard and other turnips to avoid contamination by crossing with these crops. Application of 84kg of N, 50kg/ha each of P and K results into good seed yield in turnip. When 70% of the pods turn light yellow, they should be harvested immediately to avoid shattering and damage by birds. On an average, seed yield of 5–6q/ha is obtained.

### **Harvesting and postharvest management**

The fully developed tender roots of turnip are uprooted on attaining the marketable size. Normally the roots are harvested when they are 5–10cm in diameter depending upon the variety. The roots become tough and fibrous if harvesting is delayed. The harvesting should be done in

the evening. The yield of turnip varies with varieties as well as growing season. On an average it yields 200–400q/ha.

Its harvested roots along with the green tops are properly washed to remove the adhered soil. The side roots are trimmed off. These are sent to the market in baskets either along with green tops or after cutting them off near the surface of the crown. After removing old and diseased leaves the foliage is made into bunches for marketing. The roots are sorted into different grades according to colour, shape and size to give an attractive appearance in



the market. Then these are immediately transported to the market and disposed off. The roots can be stored safely for 2–3 days under cool and moist conditions. However, it can be stored for 8–16 weeks at 0°C with 90–95% relative humidity.

#### Physiological disorder

Whip tail is caused due to deficiency of Mo. This is more common in acidic soils. Young leaves become narrow, cupped, showing chlorotic mottling especially around the margin, develop deep patches which ultimately affect the root growth. The affected plants are removed from the field during thinning. Further appearance of this disorder can be controlled by liming the soil and bringing the pH to 6.5. However, it is controlled by the application of 1.2kg/ha of sodium or ammonium molybdate.

\*\*\*\*\*

1. Example of an extra early variety of turnip
  - a. Pusa Swarnima
  - b. Pusa Kanchan
  - c. Early Milam Red Top
  - d. Purple Top White Globe
2. \_\_\_\_\_ variety of turnip is a cross between Asiatic and European types
  - a. Pusa Kanchan
  - b. Pusa Chandrima
  - c. Pusa Swarnima
  - d. Pusa Sweti
3. Isolation distance practiced in seed production of turnip
  - a. 700-1000 m
  - b. 1000-1200 m
  - c. 500-700 m
  - d. 1000-1600 m
4. Deficiency of Molybdenum in turnip is called \_\_\_\_\_
  - a. Sponginess
  - b. Witches broom
  - c. Internal breakdown
  - d. Whip tail



5. Cross pollination in turnip is due to
- a. Monoecy
  - b. Male sterility
  - c. Sporophytic self incompatibility
  - d. Gametophytic self incompatibility

# Beet Root



# Beet Root

**Botanical Name:** *Beta vulgaris sp vulgaris.*

**Family:** Brassicaceae

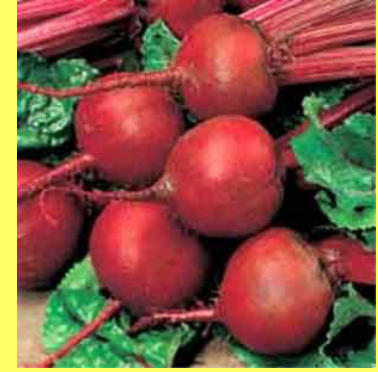
**Chromosome number**  $2n=18$

**Origin :**

**Europe, North Africa & West Asia**



# Uses



- ☺ **Roots are served as boiled, pickled or salad.**
- ☺ **Tops may be used much like spinach as leafy greens for salads or boiled.**
- ☺ **The tender leaves & young plants are used as greens (pot-herbs).**
- ☺ **Large sized beets are used for canning.**
- ☺ **Rich in protein, CHO, Ca, P, Fe & vitamin C.**

- ☺ **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*.**
- ☺ **The ratio of these two pigments varies with cultivation & changes during growth and with environmental conditions.**
- ☺ **Betanin appears to be a potent anticancer compound**

# *Betalains and Cancer Chemoprevention*

- **Betainin appears to be a potent anticancer compound**
- **Betacyanin-rich beets – most efficient to scavenge free-radical** (Wettasinghe *et al.*, 2002)
- **Beetroot extract have the chemopreventive properties against lung and skin cancers** (Kapadia *et al.*, 1996)
- **Betalains have slightly higher protection against skin and lung tumors than anthocyanins and carotenoids** (Lila, 2004)



# Soils

- ♠ Good beets are produced on a wide variety of soils.
- ♠ Deep, well drained loams or sandy loams are considered best.
- ♠ Sensitive to soil acidity.
- ♠ A soil pH 6-7 is considered best for beet..
- ♠ Beet is one of the few vegetables that can be grown successfully on saline soils.

# CLIMATE

- ♥ Cool season crop that can tolerate mild frosts and light freezes.
- ♥ It grows best in the winters in the plains of India.
- ♥ Seed germination over a wide range of soil temperature (40-85°F) but optimum germination occurs between 65 & 75 °F.
- ♥ Beets are very sensitive to low temperature & if exposed to 4.5°C – 10 °C for 15 days leads to bolting before the roots attain marketable size.
- ♥ It grows well in warm weather but attains best colour, texture and quality in a cool weather condition.
- ♥ Excessive hot weather causes ‘zoning’ – the appearance of alternating light & dark red concentric circles in the rot.
- ♥ Under cool weather, the roots have a high sugar content, quality roots with intense colour (18.3-21.1 °C).
- ♥ Beets require abundant sunshine for development of storage roots.

## Varieties

**Deteroid Dark Red**



## Land Preparation

- ♥ The soils should be thoroughly prepared by ploughing 15-20 cm deep followed by sufficient disking & hoeing to pulverize the clods.
- ♥ The soil surface should be smooth & loose & free from all clods and trashes.
- ♥ Well rotten FYM or compost is also added at the time of land preparation.

## Sowing Period

<b>North India</b>	<b>Sept-Nov</b>
<b>South India</b>	<b>July-Nov</b>
<b>In hills</b>	<b>March-July end</b>

- ♥ Seeds sown early when the temperature is high, may produce beets with coarse and woody fresh and dull colour



# Seed Rate & Spacing

- ☺ Beet seeds are sown directly in the field by sowing seed balls that contain one or more seeds.
- ☺ The seed balls are planted at a rate of 7-9 kg/ha in rows 45-60 cm apart and thinned later to an in-row spacing of 8-10 cm
- ☺ Multigerminant seeds or beet seed is a fruit containing usually 2-6 seeds.



## Thinning

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



# Manures and Fertilizers

Open pollinated varieties

Farmyard manure q/ha)	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
	(Kg/ha)		
150-200	60-70	100-120	60-70

☺ Application method same as other root crops.

# Interculture and weed control

- ▶ More or less the same as that of radish & turnip.
- ▶ Care should be taken to provide proper spacing between the plants by thinning the excess seedlings after germination.
- ▶ One or two earthing ups are also given to prevent the exposure of roots to sunlight which causes greening & lowers the quality of produce.
- ▶ Pre & post emergence sprays of propachlor (2.5 kg/ha) gives weed control for 40-50 days & increased yield.

# Irrigation

- || The soil should be kept sufficiently moist until emergence of seedlings.
- || Water requirement has been reported to be 300 mm supplied in 5-6 irrigations.
- || 3 irrigations are sufficient when there are winter rains.

# Harvesting

- ☺ The marketable maturity is just depending on the size ranging from 3-5 cm dia.
- ☺ Usually the top is removed for marketing the roots.

## Yield



250-300 q/ha.

## Storage

- ☑ At temperature of 32 °F and 98-100% RH topped beets can be stored for 4-6 months while bunched beets for 10-14 days
- ☑ Only for 2-3 days at room temperature.



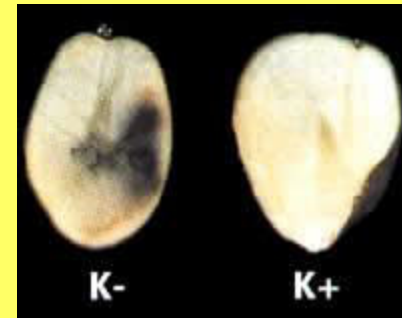
# PHYSIOLOGICAL DISORDERS

# 1. Internal Black Spot

☺ Also known as brown heart or heart rot.

## Possible Reasons

- Boron deficiency.
- Plant usually remains dwarf or stunted
- The leaves are smaller than normal.
- In general, boron deficiency appears more often in a dry season particularly when a long dry spell is followed by wet period favouring rapid growth because the root system in the upper soil layer ceases to function during dry period and thus intake of B is reduced.



## Management

- Application of 10-15 kg of Borax/ha.

# Garden Pea

**Botanical Name:**

*Pisum sativum L.*

**Family:**

Fabaceae

**Chromosome number**

2n=14

**Origin :**

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



# Uses

- ☐ **Highly nutritive containing high %age of digestible protein (very valuable for the vegetarians) alongwith carbohydrates and vitamins A and C.**
- ☐ **It is also very rich in minerals Ca and P.**
- ☐ **Excellent food for human consumption taken either as a vegetable or in soup.**
- ☐ **Large proportion is processed (canned, frozen or dehydrated) for consumption in the off-season.**
- ☐ **Being N fixing legume, recognized as a soil building crop on account of its value as a green manure crop.**
- ☐ **Pea is being used in a growing snack market.**

# Soils

- ♠ **Grown on all kinds of soils but the best crop can be taken from well drained and fertile loam soil.**
- ♠ **Light soils are good for early crop whereas heavy soils are found suitable for main crop and produce high yield.**
- ♠ **The soil pH 6-7.5 is the best for its proper growth and development.**

# Climate

- ⇒ **A cool season crop and requires frost free weather particularly at flowering and pod formation stage though vegetative growth is not affected by the frost**
- ⇒ **The optimum temperature for better growth and yield is 13-19°C.**
- ⇒ **High temperature reduces the pod quality as sugars in the seeds changes to hemicellulose and starch.**

# Cultivars are grouped on the basis of various characters

## a) According to seed

1. Round or smooth seeded cultivars
2. Wrinkled seeded cultivars.

## a) According to height of plant

1. Bush or dwarf types
2. Medium tall types.
3. Tall types.

## a) According to maturity period

1. Early – 65-80 days
2. Medium – 90-100 days.
3. Main season – 110-120 days.

## a) According to use of pods

1. Fresh market types
2. Freezing types.
3. Canning types.
4. Dehydration types

# Some important cultivated varieties

## Early Wrinkle seeded

**Arkel**

**Matar Ageta 6**

**Azad P3**

**Pant Matar 2 (PM-2)**

**VL Ageti Matar 7 (VL-7)**

**Early Badger**

**Little Marvel**

**Kelvendon Wonder**

**Early December**

**Jawahar Matar 3 & 4**

## Edible poded

**Sylvia, Punjab Mithi Phali**

**Alaska, Early Superb, Meteor**

## Early Smooth Seeded

**Asauji**

**Lucknow Boniya**

**Alaska**

**Early Superb**

**Meteor**

## Main season wrinkle seeded

**Bonneville**

**Lincoln**

**Azad P-1**

**PB-89**

**Palam Priya**

**VL-3**



**Azad P-1**



**Lincoln**



**Palam Priya**



**Edible poded**



Palam Sumool



Pb-89



Punjab-89 A high yielding variety having desirable horticultural traits and field tolerance to powdery mildew

# Cultivars suitable for growing in Himachal Pradesh

## Early Varieties

Arkel

Matar Ageta 6

VL Ageti Matar 7 (VL-7)

## Main Varieties

Punjab-89

Palam Priya

Lincoln

Bonneville

Azad P1

VL-3

Kinnauri

Solan Nirog

Punjab Round

# Sowing Time

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

## Sowing Time for H.P.

Zone	Early varieties	Main season varieties
Low Hills	September - October	November
Mid Hills	September (first fortnight)	Late October- November
High Hills	March -June	October- November, March - June



## Seed Rate

<b>Early varieties</b>	<b>120-130</b>
<b>Main season varieties</b>	<b>75-100</b>

## Depth of sowing

**5-7.5 cm**

## Spacing

<b>Early varieties</b>	<b>30cm X 5cm</b>
<b>Main season varieties</b>	<b>45-60cm X 10cm</b>

## Seed inoculation

- 😊 Inoculation of seed with *Rhizobium* culture can be used.
- 😊 The culture material is emulsified in 10% sugar or jaggery solution sufficient to moist the seed.
- 😊 Mix thoroughly with seed and dried in shade before sowing.
- 😊 Seed inoculation helps in quick nodulation on the roots which in turn fix atmospheric nitrogen.

## Seed treatment

- 😊 The seeds may be treated with fungicides like thiram or captan (3g/kg of seed) or bavistine (2.5g/kg of seed) to save the crop against 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.

# Manures and Fertilizers

## Open pollinated varieties

Farmyard manure (q/ha)	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
	(Kg/ha)		

- ☺ Full dose of farmyard manure and phosphorus, potassium and N should be applied at the time of sowing.
- ☺ Less responsive to fertilizer than most vegetables.
- ☺ Short growing season and the ability to fix atmospheric N, and residual N from fertilizers and decomposition of soil organic matter
- ☺ Sensitive to excess salts during germination and fertilizer should not come in direct contact with the seed.

# Interculture and weed control

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.
- ▶ Hoeing should be followed by earthing up to strengthen the plants and to encourage the root growth.
- ▶ Herbicides have also been found beneficial in controlling weeds.
- ▶ Pre-emergence application of Alachlor 3litres/ha or Pendimethalin @ 3litres/ha or Fluchloralin @ 2.5 litres/ha may take care of weeds.
- ▶ In case of severe infestation, one or two weeding may be done to ensure weed free crop.

# Irrigation

- || Water requirement of crop depends largely on agro-climatic conditions of the locality.
- || Pea seed can tolerate dehydration in initial stage of imbibitions but once the seeds begin metabolic activity, dehydration causes damage to cotyledons and embryo.
- || In general, one pre-sown irrigation is essential for proper germination.
- || One irrigation before and one during flowering and another at pod formation stage are important to obtain quality and good yield.
- || Possible to grow under rainfed conditions but sufficient moisture must be present in the field at the time of sowing.

# Harvesting

- ❑ The peas are harvested when the pods are fully green and well developed.
- ❑ The seeds should be 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 (q/ha)

Early varieties

60-85

Main season varieties

100-150

# 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 40°F as the threshold temperature or base temperature & 85°F 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

- 😊 **Rapid handling & removal of field heat are essential to prevent loss of quality after harvesting especially during periods of high temperature.**
- 😊 **Green peas loose much of their sugar content unless they are promptly cooled to 32 °F.**
- 😊 **Hydrocooling is the preferred method for precooling.**
- 😊 **At 32 °F & 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.**
- 😊 **2 weeks in cold storage at 0 °C & 85-95 % RH.**
- 😊 **Temperature at 21.5 °C become unfit for sale at the end of 5 days.**



# Diseases

1. Powdery mildew (*Erysiphe polygoni*)

Karathane, Dikar (Monocap), Sulfex

2. Fusarium wilt (*F.oxysporum f.pisi*)

Seed treatment with bavistine, soil drenching, long crop rotation

3. Root rots (*Rhizocotonia*, *Fusarium*, *Pythium*)

-do-

4. Bacterial blight

- ✓ Slurry treatment of seed with streptomycine sulphate (2.5 g/kg of seed)
- ✓ Soaking seeds in streptomycine solution for 2 hours

5. Viral diseases

Spread by aphids

**Powdery mildew**



**Bacterial blight**



***Fusarium* wilt**

# Insect-pests

<b>Insect</b>	<b>Control measure</b>
<b>Pea aphid</b>	<b>Spray malathion(0.05%)/oxy demeton methyl(0.025%)</b>
<b>Pod borer</b>	<b>Spray carbaryl 0.1%</b>
<b>Pea Weevil</b>	<b>Fumigation of dry peas with methyl bromide</b>
<b>Leaf minor</b>	<b>Spray methy demeton(0.025%)or cypermethrin(0.0075%)</b>

# Sugar snap peas

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

# Sugar Snaps





INTEGRATED OUTLOOKING OF HORTICULTURE  
AND HONEYBEE'S  
PROJECT TITLE  
PRODUCTION OF QUALITY SEED OF BROAD BEAN &  
PEAS/BEAN FOR THE BENEFIT OF VEGETABLE  
GROWERS OF HIMACHAL PRADESH  
DATE OF START : JUNE 1 2004  
DURATION : 3 YEARS  
TOTAL BIDDY OUTLAY: Rs. 13.72 LAKHS

# Thanks

The image features a dark blue gradient background. At the bottom, there is a silhouette of a mountain range in shades of brown and tan. In the center, a large, light blue oval with a white border contains the text "Broad Bean" in a white, serif font.

Broad Bean

# Botanical description

Scientific Name	:	<i>Vicia faba</i> L.
Chromosome Number	:	2n=12, 14
Family	:	Fabaceae
Centre of Origin	:	North Africa or South Caspian Sea.



## Nutritive value: (per 100 g of edible portion)

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

- **Broad bean** (*Vicia faba* L.) also known as faba bean or horse bean.
- It 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 beans are used as green, shelled and dry beans and as a feed for livestock.

## 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 6.5 to 7.5.
- Acidic soils are not good for broad bean.
- It can tolerate salinity up- to some extent.
- Land should be prepared thoroughly by giving repeated ploughing to get fine tilth.

# Varieties

- **Long pod type:-** Aquadule Claudin, Imperial White Long pod, Masterprice Green Long Pod, Imperial Green Long pod, Red epicure .
- **Windsor Type:-** Imperial White Windsor, Giant four seeded green Windsor, Imperial Green Windsor

# Indian Varieties

- **Pusa Sumeet:** Plants are 75cm tall having on an average of 10 branch/plant. A plant bears about 100 pods. The pod length and thickness are 6.0cm and 1.3cm respectively. It has attractive dark green pods and borne in cluster. The average yield potential is 180q/ha.
- , “Selection BR-1”
- “SelectionBR-2” are black and yellow seeded varieties respectively developed from Bihar state.
- **Jawahar Viva 73-81’** is a dormant type, reported from Madhya Pradesh.

**Seed Rate :** 70 - 100 kg/ha

- **Sowing** is done in the month of September-October and February-March.
- Seeds are sown in shallow furrows of 15 cm width formed at a spacing of 75 cm.
- 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 45x15 cm

## Manuring

FYM - 10 tonnes/ha

N - 25 kg/ha

P - 50 kg/ha

K - 40 kg/ha



## Use of PGR

Certain plant regulators like PCPA @ 2ppm, alpha-naphthyl acetamide @ 2-25ppm or beta-naphthoxy acetic acid @ 5-25ppm. When normally pods do not set, induce fruit set. Thus by spraying some plant regulators, higher, early 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 a 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 30cm to 60cm above the ground.

## Harvesting and Yield

- The pods are ready for harvesting in 3-4 months for spring sowing and 6-7 months 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.
- Pod yield of 7-10 tonnes/ha
- Green bean yield of 1.8-2 tonnes /ha is expected

# Plant Protection

## Insect Pests

Stem flies, thrips and mites are some of the insect pests attacking bean crop. Spraying 2ml/litre of Dimethoate (Rogor) or Monocrotophos for the control of thrips and stem fly. Mites can be controlled by spraying Dicofol (kelthane) 2.5ml/litre.

# Diseases

1. Yellow mosaic, anthracnose, Phytophthora pod rot, rust, angular leaf spot, ashy stem blight and rhizoctonia root rot are some of the diseases affecting bean crop.
2. The diseases can be effectively controlled by spraying Blitox or Difoliton at the rate of 2kg/litre.
3. Root rot can be controlled by drenching captan 2g/litre.

4. Foliar fungal diseases can be controlled by spraying Dithane M-45
5. Yellow mosaic vector white fly can be controlled by spraying Monocrotophos 1.25ml/litre.
6. Rust can be controlled by spraying sulfex 2g/litre.



Thanks





# Beet leaf Spinach



**includes spinach beet, spinach, fenugreek etc**

## **Uses**

- **Highly nutritious and rich sources of vitamin A and C and minerals like iron, calcium and phosphorus.**
- **Appreciable quantity of proteins is also found in these vegetables.**
- **Keep people healthy and help children to grow strong.**
- **Provide roughage and have an important place in balanced diet.**
- **Grown for their tender and succulent leaves.**
- **Easily cooked with other vegetables like potato, onion, brinjal and fried alone.**
- **It is used in the preparation of soups and stew etc.**
- **Available at cheaper rate in the market as compared to other vegetables.**

# Types of spinach

- ✦ Desi or common palak (spinach beet or beet leaf).
- ✦ Vilayati palak (spinach)

## Difference between beet leaf and spinach

- *Beta vulgaris* var. *bengalensis*.
- Chr. No.  $2n=18$ .
- Leaves with entire margins.
- Produces bisexual flowers.
- Tolerates high temperature and grows well in hot weather.

- *Spinacea oleracea*.
- Chr. No.  $2n=18$ .
- Leaves with lobed margin.
- Produces staminate/ pistillate and/or hermaphrodite flowers.
- Purely a cool season crop and cannot tolerate high temperature. In warm season and long days, it quickly tends to flower.

# Beet leaf

- **Botanical Name** : *Beta vulgaris var. bengalensis* L.
- **Origin** : Indo - Chinese region
- **Family** : Chenopodiaceae
- **Chromosome number:**  $2n=18$

❖ It is closely related to beet root and Swiss chard.

❖ Leaves of this might have first used in Bengal and hence known as *var. begalensis*

## Composition

Vit. A- 9770 IU	Fe- 16.2mg	Protein- 3.4g
Riboflavin- 0.56g	P- 30mg	H <sub>2</sub> O- 86.4g
Thiamine- 0.26mg	Ca- 380g	CHO- 6.5 g
Vit.C- 70mg	Minerals- 2.2g	

# Importance and 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.

# Cultivars

Two groups on the basis of pigmentation of midrib and leaf veins

reddish midrib and leaf veins.



green midrib and leaf veins.



Jobner Green

Pant Composite 1

Pb Green

Pusa Bharati

Palak No. 51-  
16

Pusa Jyoti

Banerjee's Giant

Arka Anupama

All Green

Pusa Palak

Pusa Harit

Pb Selection

HS-23

# Cultivars suitable for growing in Himachal Pradesh

## 1. 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.

## 2. Banerjee's Giant:

- ❖ Large thick leaves with very succulent stem and fleshy root,
- ❖ Suitable for all zones,
- ❖ Average yield 150-190q/ha.

# Soils

- It can be grown in any type of soil having sufficient fertility and proper drainage system.
- Sandy loam soils are not suitable.
- High yields of better quality greens are produced in neutral soils having a pH 7.0.
- It is highly salt tolerant vegetable and can be successfully grown in saline sodic soils.
- 3-4 ploughings followed by planking are required to make the soil well pulverized and leveled for raising the crop.



# Climate

- **It is predominantly a cool season crop but can be grown throughout the year under mild temperature conditions.**
- **The crop can withstand frost and tolerate warm weather but high temperature leads to early bolting without giving sufficient cuttings.**

# Sowing Time

Sowing time varies from region to region.

In plains of India, grown 3 times in a year:

- Early spring.
- In the beginning of rainy season.
- As main crop during Sept.- Nov.
- Throughout the year in places with mild climate.

## In Himachal Pradesh

Zone	Time of sowing
Low Hills	July-November, February-March
Mid Hills	July-October, February-April
High hills	March-June

# Seed Rate

**Summer crop: 25-30 kg/ha**

**Winter crop : 10-15kg/ha**

**Seeds are soaked in water overnight before sowing to improve germination**

## Sowing method

**Broadcast method or by line sowing**

## Spacing

**30cm X 5-10cm**

**(Thinning is done to maintain the spacing with in the rows)**

# Manures and Fertilizers

Farmyard manure (q/ha)	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
	(Kg/ha)		
100	70	50	50

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

# Interculture and weed control

- **To keep away the weeds from the field and to loosen the soil for proper aeration, 2-3 hoeings cum weedings are required.**
- **Herbicides like pyrazone at 2.4-2.8 kg/ha can also be used to control the weeds as pre-emergence application.**

# Irrigation

- **A pre-sowing irrigation is to be given to help the seeds absorb moisture and germinate properly.**
- **The spring summer crop needs frequent irrigation at 6-7 days interval**
- **Autumn winter crop requires irrigation at about 10-15 days interval.**
- **However, rainy season crop requirement depends upon the intensity and duration of rain.**

# Harvesting

- The crop will be ready for harvesting in about 3-4 weeks after sowing.
- Subsequent cuttings are done at 15-20 days interval.
- Only well grown green succulent and tender leaves should be trimmed.
- Winter crop gives more cuttings than spring-summer crop.
- On an average palak gives 4-6 cuttings

**Yield**

**150-200q/ha**

# INSECTS

- 1. Aphids: Spray oxy demeton methyl@ 0.025% or malathion@0.05%**
- 2. Catterpillar: Spray malathion@0.05% or deltamethrin@0.0028% or **cypermethrin@0.0075%****



Advance Production Technology of

# Coriander

(*Coriandrum sativum* L.)



G. Lal

S.S Meena

M.M Anwer

R.S Mehta

S.P. Maheria



ICAR -National Research Centre on Seed Spices,  
Tabiji, Ajmer-305206 (Raj.), India

Website:[www.nrcss.res.in](http://www.nrcss.res.in)



# *Advance Production Technology of Coriander*

**Correct Citation:** G.Lal, M.M. Anwer, S.S Meena, R.S Mehta and S.P. Maheria Advance Production Technology of Coriander  
ICAR-National Research Centre on Seed Spices Tabiji. Ajmer- 305 206 (Rajasthan)

**Published by:** Director,  
ICAR-National Research Centre on Seed Spices  
Tabiji Ajmer 305 206, Rajasthan  
Phone- 0145-2684400  
Fax- 0145-2684417  
Email: nrcss.director@gmail.com  
Website :[nrcss.icar.gov.in](http://nrcss.icar.gov.in)

**Secretarial Assistant:** Cherian Mathews, Syed Farook Ali & Mahesh Punia

**Photographs by:** R.S.Meena, Krishna Kant, Y.K. Sharma & S.P. Maheria

**Printed:** February 2010 (500 Copies)

**First edition:** 2010

**Revised in:** 2021

**Revised by:** Dr. S.N. Saxena, Dr. Y.K. Sharma, Dr. O.P. Aishwath, Dr. Ravindra Singh, Dr. Krishna kant, Dr. R.S. Meena, Dr. M.D. Meena

**Secretarial Assistant:** Shyam Sunder Barotia

**Printed at:** Job Offset Printers  
Ajmer  
98294 72031

## PREFACE

Among the seed spices, coriander occupies the top place in terms of area, production and export. The major producing countries other than India are Morocco, Russia, Bulgaria, Mexico, Argentina, China, Romania, Japan and Italy. In India, coriander is largely cultivated in Rajasthan, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Orissa, Uttar Pradesh, and Uttaranchal states. Rajasthan is major coriander growing state with its share of about 60% in the total area and production of the country. Many production technologies have been generated at National Research Centre on Seed Spices and under All India Co-ordinated Research Project on Spices. Here in this publication efforts have been made to present specific recommendations for different area, states for increasing the production and productivity of coriander. Besides this, the publication deals with IPM strategies for coriander which is a burning need of the era for sustainable agriculture. We are assured that this publication shall prove highly useful to various stake holders such as field functionaries, growers, exporters, students and others having interest in cultivation of coriander scientifically.

We hope that this technical bulletin will provide relevant information. Suggestions if any for its improvement are welcome for future publications.

Ajmer

Authors

February , 2010

## **Introduction**

Coriander (*Coriandrum sativum* L ) is an important seed spice crop of family Apiaceae. It is an upright and branched annual plant that grows to a height of 80 cm. The leaves of the plant in our rural and urban areas are used to make chutney. The whole plant is aromatic. The flowers are small, white and pink in colour produced in umbels. Fully mature seeds on getting dried turn light brown in colour. The green leaves are also used in salads, soups and prickles. Most of housewives give a generous sprinkling of the green leaves on cooked dishes of meat, pulses and vegetables before they are served. The seeds are also used in thickening and flavouring soups, curries and liquors. The stems of the plant are used in cooking in Vietnam. The roots have little use in our cooking, but the Thais greatly relish them in their cuisines. Thus no part of the plant goes waste. It is known as coriander in English and Dhania in Urdu. In the US, it is known as Cilantro, a word derived from the Spanish language. It is believed to be a native to southern western Asia to North Africa. It grew wild in the north-eastern and the southern part of Europe.

## **Climate and soil**

Coriander is a tropical crop and can be grown throughout the year (except very hot season i.e. March-May) for leaf purpose. For seed purpose a dry and cold weather, free from frost especially during flowering and fruit setting stage is required. Germination of coriander is severely reduced at temperature above 30°C and below 10°C. Heavy rains are harmful for the crop and continuous cloudy weather invites diseases and aphids. For green, it can be grown throughout the year provided moisture is made available. However, it does not grow well in spring summer season for greens, because it switches over within short time from vegetative growth to reproductive phase as soon as temperature raises beyond 20°C

The coriander can be grown in any type of soil suitable for cultivation. It is cultivated both as irrigated and un-irrigated crop. As an irrigated crop, it can be cultivated in almost all type of soils having sufficient organic matter but dry land crop may be taken only on heavy soils having good water retention capacity. pH of soil should be near 7.0 for better growth and quality produce of coriander. Saline, alkaline and sandy soils are not suitable for its cultivation.

## **Field preparation**

Coriander is mainly grown as dryland crop on heavy soils. For dryland coriander cultivation, field must be ploughed after rain for conservation of soil moisture. Field must be kept either fallow or short duration crop like green gram or black gram may be grown and should be harvested as early as possible at physiological maturity stage to take dryland crop of coriander. In rainy season, if

field is kept fallow or just after harvesting of previous *Kharif* crop, first ploughing should be done with soil turning plough. It should be followed by 2-3 ploughing with cultivator or harrow or *desi* plough to obtain fine soil tilth. To avoid loss of soil moisture and to break the clods, the field should be planked immediately after ploughing. For irrigated coriander if soil moisture is not sufficient, preparatory tillage should be carried out after giving pre-sowing irrigation. Application of pre-sowing irrigation will also help to germinate the weed seeds which will be uprooted, killed and turn in the soil at the time of field preparation. This practice is termed as stale seed bed preparation which will help to minimize the weed competition, particularly during early crop growth period. Less number of ploughing are required in light soils whereas more number of ploughings are required in heavy soils. At the time of sowing, soil must be friable to obtain better seed bed for better seedling emergence and their further establishment.

### **State-wise recommendations**

#### **(A) Andhra Pradesh Varieties**

**Swathi:** It is developed by mass selection from CS 6 of Nadia region, A.P. at Regional Research Centre, Lam (APAU), Guntur in 1989. It is an early maturing dual purpose variety. It is suitable for cultivation under dry land conditions of A.P. It possesses field tolerance to white fly, mites and aphids. Plants are of medium in height and seeds are oval, bold and of straw colour. It matures in about 100 days with 1000-1100 kg seed yield/ha.

**Sindhu:** It is developed at Regional Research Center, Lam (APAU), Guntur. It is suitable for inter cropping and dryland farming system of Andhra Pradesh state. The plants are dwarf type and bear oval shape and medium bold seeds with straw colour. It is a medium duration variety and mature in about 100-105 days with an average seed yield of 1000 kg/ha. It is tolerant to wilt, powdery mildew and aphids.

**Lam Selection CS 2:** It was developed at Regional Research Center, Lam (APAU), Guntur and is suitable for A.P. Its plants are bunchy with more branches and medium in height. Seeds are of good quality, which contains about 0.40 per cent essential oil. It matures in about 110 days and gives about 1030 kg seed yield/ha. It is relatively tolerant to harmful diseases and insect pests.

**Sadhna:** A semi erect variety developed at APAU, Regional Research Centre, Lam, Guntur. It is an early maturing and dual purpose variety. It is suitable for cultivation under rainfed conditions

of AP and also possess field tolerance to white fly and mites. It matures in 100 days with an average yield of 1030 kg/ha of bold, oval, straw coloured grains.

**Sowing time:** The seeds are sown between 15<sup>th</sup> of October to 15<sup>th</sup> of November.

**Spacing:** Row to row spacing 30cm and plant to plant spacing in a row should be kept 10-15cm.

**Manures and Fertilizers:** 10-15 tonnes of FYM + 30:40:20 kg NPK/ha in single dose in last ploughing. Apply N in two equal splits at sowing and 60DAS. At the time of field preparation full dose of P & K should be applied with first split of N in the soil.

### **(B) Bihar**

**Rajendra Swathi:** It was developed in the year 1988 for Bihar state through mass selection from R.D. 44 at Regional Research Center, Rajendra Agricultural University, Dholi, Bihar. Plants are medium in height and suitable for mixed/inter cropping. Its seeds are round, fine, small, aromatic and contains high essential oil. It is resistant to stem gall and moderately resistant to wilt, aphids and weevil. It matures in 100 days with seed yield of 990-1170 kg/ha.

**Rajendra Sonia:** It is a medium-tall, high yielding variety, developed at Rajendra Agricultural University, Regional Research Centre Dholi in Bihar. This variety gives an average yield of 1200kg/ha. Crop matures in about 110 days and is resistant to stem gall, moderately resistant to wilt, aphid, weevil and tolerant to fruit fly.

**Sowing time:** First week of October

**Spacing:** 30 cm x 20 cm

**Manures and Fertilizers:** 60:40:20 kg NPK/ha under irrigated conditions. Apply N in two equal splits at sowing and 60DAS. At the time of field preparation full dose of P & K should be applied with first split of N in the soil.

### **(C) Haryana**

**Hisar Sugandh:** This variety is developed at CCS Haryana Agricultural University, Hisar. It is a high yielding dual purpose variety of coriander, suitable for Haryana. It has wider adaptability to different soil conditions and can be grown as rain fed as well as irrigated crop. On an average, it gives 1400 kg/ha seed yield.

**Hisar Anand:** It is a dual purpose high yielding variety developed at CCS, Haryana Agricultural University, Hisar. This variety has wider adaptability to different soil conditions. The average yield is 1400kg/ha seeds.

**Hisar Surabhi:** A high yielding variety having medium sized seed developed at CCShAU, Hisar. It is frost tolerant, less susceptible to aphids and grains having good oil content (0.425%). The plants are bushy, erect, 15cm tall, duration is medium (130-140 days) and yields 1800-2000 kg/ha.

**Sowing time:** Second week of November

**Spacing:** 50 cm x 20 cm

**Manures and Fertilizers:** 60kg N, & 37.5 kg P/ha. Nitrogen should be applied in two split doses as basal and at flower initiation stage and P& K as single basal dose before last ploughing.

### **(D) Gujarat**

#### **Gujarat Coriander -1 (GCr-1)**

This variety was developed by selection method from local variety at Spices Research Centre (Jagudan under AICRP on Spices in Sardarkrushinagar Dantiwada Agricultural University, Gujarat. It was identified in 1974 and had been recommended for Gujarat state. The plants are erect and medium in height having more branches. Seeds are round and having green-yellow colour. It matures in 112 days and It gives seed yield 1100 kg /ha. It is also suitable for sowing as early crop under irrigated condition.

#### **Gujarat Coriander- 2 (GCr-2)**

This variety was developed by All India Coordinated Research Project on Spices at Spices Research Center Jagudan in Sardarkrushinagar Dantiwada Agricultural University, Gujarat. It was improved through breeding technique and developed from Co- 2 germplasm. It was developed for whole Gujarat and Rajasthan and is suitable for early sowing under dry-land condition. . The plants are semi spreading in growth habit and bear more secondary branches with dense and dark green foliage having large sized umbel and medium bold seeds. It matures in 110-115 days and gives an average seed yield 1400- 1600 kg/ha. It is mostly suitable for seed purpose but can also be grown as leafy purpose. It is moderately tolerant to wilt and powdery mildew.

#### **Gujarat Coriander-3 (GCr-3)**

This variety was developed by selection method from local variety at Spices Research Centre (Jagudan under AICRP on Spices in Sardarkrushinagar Dantiwada Agricultural University,

Gujarat. The plants are erect and medium in height having more branches. Seeds are oval and having seed colour light brown. It matures in 110-120 days and It gives seed yield 1100-1200 kg/ha. It is also suitable for sowing as early crop under irrigated condition.

**Manures and Fertilizers:** 20 tonnes of FYM + 60:60:30 kg NPK/ha. Nitrogen should be applied in two split doses as basal and at flower initiation stage and P & K as single basal dose before last ploughing.

### **(E) Rajasthan**

#### **Ajmer Coriander-1 (ACr-1)**

This variety was developed through mass selection method and released at state level in 2015 by SVRC. It is a variety of late maturity group developed at NRCSS, Ajmer is suitable for leaves and seeds production, and grows well under irrigated. It contains essential oil 0.6 per cent and gives an average yield 1250 kg/ha. The plants are tall erect, seeds are medium in size, round in shape and suitable for export purpose. The plants are resistant to stem gall and having tolerance to powdery mildew. This variety is also suitable for growing as greens during off-season under shade net.

#### **Ajmer Coriander-2 (ACr-2)**

This variety was developed through recurrent selection method and identified for national release in 2017. It is a variety developed at NRCSS, Ajmer is suitable for leaves and seeds production, and grows well under irrigated essential oil content up to 0.5 per cent and average yield 1290 kg/ha. The plants are semi erect, seeds are medium in size, seed shape is oval and suitable for export purpose. The plants are resistant to stem gall and have tolerance to powdery mildew. This variety is suitable for growing as greens during off-season also under shade net.

#### **Ajmer Coriander-3 (ACr-3)**

This variety was developed through recurrent selection method and identified for national release in 2018. It is a variety developed at NRCSS, Ajmer is suitable for seeds production, and grows well under irrigated essential oil content up to 0.55 per cent and average yield 1689 kg/ha. The plants are semi erect, seeds are medium in size, seed shape is oval and suitable for export purpose. The plants are moderately resistant to powdery mildew.

#### **Ajmer Green Coriander-1 (AGCr-1):**

This variety was developed through recurrent selection method and released proposal in 2018 at state level. It is developed at NRCSS, Ajmer is suitable for only leaves purpose well grown in



shade net in summer (off season ), and essential oil content up to 0.05 per cent and average yield 74.3 q/ha. The plants are tall erect, seeds are medium in size, oval in shape and suitable for export purpose. The plants are resistant to stem gall and have tolerance to powdery mildew.

### **Rajasthan Coriander-41 (RCr-41)**

This variety was developed at Sri Karan Narendra Agriculture University, Jobner (Rajasthan) during 1988. It is also found suitable for Gujarat and Haryana. It is suitable for both seeds as well as leafy purpose. It matures in 130-140 days and gives 1100-1400 kg/ha seed yield. Its potential yield is 2700 kg seed yield/ha. It was developed through re-selection of UD-41 and is also known as UD-41 and "Karan". It is best suitable for irrigated conditions but can also be taken as dry land crop in heavy soil type region. Its plants are erect, good in height having purple pinch colour on base of the stem. Seeds are small round in shape having test weight (1000 seeds) of 7-9g and contain 0.25 per cent essential oil, which is about 2-5 per cent higher than local cultivars. It is highly resistant to stem gall and wilt but moderately tolerant to powdery mildew.

### **Rajasthan Coriander-20 (RCr-20)**

The variety was developed at Sri Karan Narendra Agriculture University, Jobner (Rajasthan) during 1996, under All India Coordinated Research Project on Spices. It was tested under the name of UD- 20 and also known by this name. It is suitable for dry land cultivation or with limited moisture. Its plant is bushy and spreading with medium height and produces large-size oval seeds. It is moderately tolerant to powdery mildew, wilt and stem gall diseases.

### **Rajasthan Coriander-435 (RCr-435)**

It was developed at Sri Karan Narendra Agriculture University, Jobner (Rajasthan) in the year 1995 for Rajasthan state. It is an erect, bushy and medium maturing type, also having medium size of seeds with test weight of 10.4g. It is well adapted to irrigate conditions under high soil fertility. It matures in about 135 days and gives 1000-1400 kg seed yield/ha. The variety is moderately resistant to root knot nematodes and powdery mildew disease.

### **Rajasthan Coriander-436 (RCr-436)**

This variety was also developed in the year 1995 by Sri Karan Narendra Agriculture University, Jobner (Rajasthan). It is suitable for cultivation in heavy soils of Rajasthan as dry land crop. Its plants are semi dwarf with early and quick growth habit and bears bold seeds having 13-14 g of test weight. It is an early maturing type and matures in 90-110 days and gives an average seeds

yield of 1100 kg/ha under limited moisture conditions and gives potential yield 1400-1600 kg/ha under favourable climatic condition.

### **Rajasthan Coriander-684 (RCr 684)**

It was developed in the year 1997 at Sri Karan Narendra Agriculture University, Jobner (Rajasthan). It is suitable for irrigated cropping system of Rajasthan. It is a medium maturity variety (130 days) and gives an average seed yield of 1000 kg/ha. Seeds are bold and having 14.14g of test weight. It is resistant to stem gall disease.

### **Rajasthan Coriander-446 (RCr- 446)**

It is a variety developed at Sri Karan Narendra Agriculture University, Jobner (Rajasthan). It is medium in maturity and bears bold seeds. This variety is suitable for irrigated condition. It matures 130-10 days and gives an average yield 1200kg/ha.. It is moderate resistance to stem gall and wilt disease.

### **(F) UttarPradesh**

**Pant Haritma:** It was developed at GB Pant University of Agriculture and Technology, Pant Nagar (Uttaranchal). It is a high yielding dual purpose cultivar of coriander bearing fragrant leaves. It is tolerant to stem gall disease. It is a late maturing type and medium in plant growth habit. Its yield potential is as high as 1500 kg seed/ha.

**Sowing time:** Middle of October to first week of November.

**Spacing:** 30 x 10cm

**Fertilizer:** 60:30:30 NPK /ha. Full dose of P & K and 20 kg nitrogen should be applied at the time of sowing and the rest N in two equal splits at 30-35 DAS and second at flowering stage.

### **(G) Tamil Nadu**

**Co-1:** Coimbatore-1 variety of coriander was developed through selection at Tamil Nadu Agricultural University, Coimbatore in 1981. It is suitable for both leaf and seed production. Its plants are small structured with globular and bear small dusty brown seeds. This variety requires less water and is thus suitable for dryland areas of Tamil Nadu. It is resistant to grain mould disease of coriander. It matures in about 110 days with an average seed yield of 450 kg/ha.

**Co-2:** Coimbatore-2 variety was developed at Tamil Nadu Agricultural University, Coimbatore in 1982, through re-selection of P-2 culture of Gujarat. It is suitable for both *Rabi* and *Kharif* seasons

for saline, alkaline and drought prone areas of Tamil Nadu. It is dual purpose variety growing for both, seed as well as leaves. Its plants are erect and bear oblong, medium size seeds having dull colour with an average seed yield of 520 kg/ha. When it is grown for leaf purpose it gives 1000 kg /ha green leaves at 40 days crop growth stage.

**Co-3:** Coimbatore-3 variety was developed through pure line selection from ACC No. 695 of IARI, New Delhi at TNAU, Coimbatore. It was identified in the year 1991 for Tamil Nadu state. It is superior to both Co-1 and Co-2 in adaptability as well as seed production. It is suitable for both seed as well as leaf purpose. It is an early maturing type and matures in 85-100 days and gives 650-700 kg seed yield/ha. The plants are dwarf with oblong, medium bold, brownish yellow seeds containing 0.35-0.40 per cent essential oil. The variety is suitable for cultivation in both *Kharif* and *Rabi* seasons in Tamil Nadu. It is tolerant to wilt, powdery mildew and grain mould diseases of coriander.

**CS-287:** It was developed through re-selection of CS-6 of A.P. for its better improvement. It has been developed for Tamil Nadu at TNAU, Coimbatore and suitable for both dryland as well as irrigated conditions of Tamil Nadu and Andhra Pradesh. Its plants are early maturing type and mature in 80- 100 days with 540-630 kg seed yield/ha. Seeds are oblong, medium in size having straw colour. It possesses field tolerance to wilt and grain mould .

**Sowing time:** June-July (*Kharif*), September-October (*Rabi*)

**Spacing:** 20 x 15 cm (*Kharif*) and 15 x 15 cm (*Rabi*)

**Fertilizers and Manures:** In coriander 10-15 tonnes of FYM + 30:40:20 kg NPK /ha should be applied for proper growth, development and quality yield. Under *Kharif* condition full dose of fertilizer may be added to the soil at the time of field preparation just before sowing. For *Rabi* N may be applied in three splits.

### **Seed rate:**

Seed rate depends upon seed size, growth habit, irrigation availability (irrigated or unirrigated), soil type and availability of soil moisture at the time of sowing. Seed germination is better in irrigated conditions, which requires relatively less seed rate than rainfed conditions where seed germination is poor due to less availability of water in soil. The seed rate generally required is 10-12 kg per hectare for irrigated and 20 kg for rainfed cropping system

## **Seed treatment:**

Coriander is propagated through seed (botanically fruits called schizocarp). Being bilocular each schizocarp has two mericarps and thus before sowing fruits are rubbed to split into two halves. After splitting the seeds should be treated with *Trichoderma* @ 4.0- 6.0 g/kg seed. After seed treatment, seed should be inoculated with *Azotobacter* and phosphate solubilizing bacteria.

## **Sowing method:**

The crop is usually sown by broadcasting of seeds but line sowing is better which allows proper weeding, hoeing, application of pesticides etc. Seed depth should not exceed 2.5cm otherwise germination will be reduced. Soaking seeds in water for 8-12 hours before sowing hastens germination. The field should be prepared well in order to produce fine seed bed. For rainfed crop, the field should be prepared before the onset of monsoon so as to make seed loose to absorb maximum of moisture to give good germination.

## **Manures and fertilizers**

The manures and fertilizers should be applied based on soil testing report. In general the organic manure should be applied three weeks before sowing of the crop so that they can be decomposed in soil. One third of N and full dose of P and K should be applied as basal dose at the time of last ploughing while preparing field and remaining 2/3<sup>rd</sup>N should be applied in two equal split doses as top dressing at 30 and 60 days after sowing.

## **Irrigation**

For irrigated crop, depending upon temperature and soil type 3-6 irrigations are required in addition to those given for germination. For heavy soils only 3-4 irrigations are sufficient whereas for light textured soils about 6 irrigations are required. The critical stages for irrigation are seedling stage (30-40 DAS), grand growth period (50-60 DAS), flowering (70-80 DAS) and seed formation stage (90-100 DAS). Duration of these stages will mainly depend upon variety used (short/ long duration) and type of soil. Care should be taken that adequate moisture is available to crop after flower initiation, particularly at the time of seed formation. Stagnation of water is harmful for the crop; hence proper drainage must be provided especially where it is grown as *Kharif* crop.

## **Crop rotations**

Crop rotation is an important agro technique which provides sustainability to the soil, with higher productivity of quality produce. The influence of insect-pests, diseases and weeds is also reduced by proper crop rotation. Some important crop rotations suggested are:

- Maize-Potato-Coriander
- Summer moong- Bajara- Coriander
- Rice- Coriander- Summer moong/ fallow
- Green gram/Black gram Coriander-Okra
- Cowpea-Coriander- Okra
- Cluster bean-Coriander- Summer maize.

**Yield reducing factors:** Though coriander occupies the first position in area and production among all the seed spices, yet the productivity is very low. The major reasons for low productivity of coriander are the biotic and abiotic stresses. The widespread introduction of high yielding cultivars and adoption of intensive crop management practices resulted in substantial increase in yields. Side by side it has also improved the conditions for insects, diseases, weeds, rodents and nematodes. All living organism, which causes loss to the crop in terms of yield and quality are called pests. Yield losses due to these pests ranges from 30-40%. Thus the role of plant health coverage in agriculture production cannot be overlooked. Like any other technology, the concept of plant protection is also changing.

### **Biotic stresses:**

**Weeds:** Being a *Rabi* season irrigated crop, coriander is facing weed problem a lot. The weeds exert competition to the crop with respect to water, nutrients, space, light and air. The important weed flora generally found in coriander crop are: Bathua (*Chenopodium album*), Kharbathua (*Chenopodium murale*), Sanji (*Melilotus indica*), Piyaji (*Asphodelus tenuifolius*) and Krishan neel (*Anagallis arvensis*).

### **Weed management:**

In North India the coriander is taken as a *Rabi* season crop. Where as in South India it is taken both in *Kharif* and *Rabi* season. The weed problems in crop thus differ with the season. Further the crop is slow growing up to 40-45 DAS, therefore crop need to be kept weed free up to 50 DAS. Two to three hand weeding and hoeing are necessary for effective management of weeds. Two weedings followed by hoeing should be practiced at 30 and 60 days after sowing. If required, third weeding can be done. During first weeding the plants should also be thinned to maintain proper spacing for ensuring recommended plant population, if plant population is higher in the field. Chemical control of weeds can be done with a pre plant application of the herbicides. In India the crop is mostly taken as rain fed crop (70-80%) and for weed control during the vegetative phase pre-plant

incorporation of Fluchloralin @ 0.75 to 1.0 kg/ha or per-emergence application of Oxyflurofen @ 0.15 kg/ha or Pendimethalin @ 0.75 to 1.0 ka/ha after dissolving in 400-500 litres of water is recommended. After chemical control of weeds, one had weeding at 50-55 DAS is necessary to ensure weed free condition till harvesting of the crop. Since coriander is taken on medium to heavy soils, summer ploughing is also advisable in the crop to alleviate the weed problem In areas where coriander is taken as an intercrop with gram, linseed or sugarcane the weed control measures should be taken keeping in view both the crops.

### **Diseases:**

#### **1. Powdery mildew:**

This is one of the important diseases of coriander, which generally appears in all coriander growing areas. The disease is caused by *Erysiphepolygoni*. The disease symptoms appears as a white powdery mass on the leaves and twigs of the plants in initial stage and later on whole plant is covered with whitish powder. It generally appears in the month of February March and causes significant loss to the crop yield.

#### **Management strategies:**

- Early sowing of coriander is effective for management of powdery mildew.
- Application of sulphur dust @ 25kg/ha, spray with Wettable Sulphur suspension (0.1%) spray is alsoeffective against powdery mildew control in coriander. The spray should be repeated at 10-15 days interval if required.
- Seed treatment with Thiram proved effective in reducing severity ofthe disease and increased the seed

**2. Wilt (*Fusarium oxysporiurnf.sp. coriandri*):** Younger plants are more susceptible to wilt. Yellowing as well as drooping of leaves and terminal branches are symptoms of disease. The infected plant dries up due to wilting in later stage.

#### **Management strategies:**

- The pathogen is coriander specific, thus to follow crop rotation is an important tool for disease management.
- Solarization of soil during summer, use of disease free seed, seed treatment with Captan or Thiram @ 3.0g/ kg of seed should also be followed.
- Seed treatment with *Trichoderma viridae* @ 4g/kg seed is also effective in reducing wilt incidence in coriander.

**3. Stem gall (*Protomycesmacrosporus*):** The symptoms appear as galls on the stem, leaf stalk and peduncles. The seeds are deformed and the yield is reduced.

**Management strategies:**

- Seed treatment with Captafol 2g/ kg seed is effective in inhibiting seed borne infection with the disease.
- Spraying 0.1% Carbendazim or Captan 0.2%, 2-3 times at an interval of 10-15 days.
- Soil solarization and use of resistant varieties are effective for the management of disease.

**4. Nematodes (*Meloidogyne incognita*):**

**Management strategies:** Growing of resistant cultivars like RCr-41, Co-1, Co-2 is recommended.

**Insects:**

Coriander crops attracted large number of insect pests and pollinators during its crop growth in the field. It also attracts numbers of storage pests during storage of seeds. The appearance of pests started at early vegetative stages and lasted till the seed mature. Since this crop attract large number of natural enemies of the pests and pollinators, it is important to apply judicious use of insecticides to control the pests and prevent the loss of beneficial insects like predators/parasitoides/pollinators which is vital components of IPM.

**Coriander aphid, *Hyadaphiscoriandri* (Das)**

The coriander aphid is also known as *Moila*, *Chainpa* or *Manhu*. Coriander aphid *H. coriandri* recorded in all major growing areas of India. . This species is also major pest of fennel and dill crop. The Coriander aphid is most abundant on coriander crop during winter season particularly December to March. Females of *H. coriandri* give birth to young ones (nymphs) parthenogenetically and nymphs grow up through three nymphal instars for 4-5 days depending upon available host and environmental conditions. The entair life cycle is completed in 16 to 20 days. There are several generations complete in a year. Cloudy and wintry weather is quite favorable for raphid multiplication of this species of aphid. On coriander plant aphids colonize on leaves, tender apical shoots and umbels where both nymphs and adults suck cell sap and devitalize the plant. Infestation in early stages causes distortion in plant growth, yellowing of leaves and reducing their vigour. The heavy infestation of aphid on coriander occurred between December to march and cause the loss of more than 50% of yield in unprotected crop.

## Thrips:

Thrips are tiny insects. It is also one of pests coriander crop. Amongst the species of thrips attacking seed spices, *Thrips tabaci* is the major specie found on most of the seed spice crops. Both nymphs and adults feeds on umbel. leaf sheath and stems of plants . Both nymphs and adults congregate in between the leaf sheath and stems of plants which results in drying of the leaves. Severe infestation results in drying of flowers and production of shriveled fruits

## Mite:

Among the other sucking pests the tetranychidae mite *Petrobiatens* is another serious pest on coriander and cumin. It found infesting semi arid and arid region of Rajasthan. *P. lateens* have also been reported on coriander crop in southern part of India. The brown wheat mite, *Petrobiatens* was first reported feeding on coriander. It remains active during winter with peak activity in March. It is a minute, non webbing and swift moving mite and has a tendency to dislodge from the plant when disturbed. The larva, nymphs and adults feed on upper as well as the lower surface of leaves, leaf sheaths and floral parts. Infested leave started withering from top downwards. The plants become chlorotic due to loss of cell sap, resulting in poor seed formation. Heavily infested plants show sickly yellowish or bronzing appearance. The mites become serious pests only where excessive use of insecticides is made and they develop resistance to these chemicals faster than the insects.

## Management of Aphids/Thrips/Mites

- Use botanicals Neem seed kernel extract (NSKE) 5.0%, Neem oil 2.0%, Azadirachtin 10000ppm @2.0ml/lire and bio-pesticides like *Verticillium lacanii*1x10<sup>8</sup> CFU's/gm5.0 g. /litre of water as foliar spray on the crops.
- For mite control use bio pesticide *Hirsutellsthompsoni*1x10<sup>8</sup> CFU's/gm5.0 g. /litre of water as foliar spray on the crops.
- There is no level claim of any insecticides in coriander crop. However in case of severe infestation need based use of chemical insecticides i.e.Emamectin benzoate @ 10 g ai/ha or Thiacloprid @ 0.24% orDimethoate 30EC @ 0.03% to prevent losses.

## Seed wasp, *Systole albipennis* (Walker)

*Systole albipennis* is specific pest coriander and other seed spice crops. It causes the damage in field condition but the immature stage present inside the seed emerged at storage. The adult wasp is a phytophagous pests. It is a minute hymenopteran wasp, about 1-1.5 mm long, having transparent



wings on black coloured body. The larva damage the seed and survive inside the fruits. The infestation of this insect continue in the seeds till storage. Female adults lays eggs inside the developing seeds. The eggs hatches inside seed and developed larva feeds upon and destroys the embryo and/or endosperm consequently. Adult emerge out by making exit hole in the seed. They complete their life span within 25 days from egg to adult's stage. The immature stages present inside the seed after harvest emerged in storage condition and takes two to three months or even more. The newly hatched larvae feed upon developing fruits and destroys the embryo and/or endosperm which loss seed viability. The yield loss incurred approximately 30 percent in coriander. If infestation is more severe, the yield of coriander is above 50 percent

**Management of Seed Wasp:**

- Apply botanical products i.e. neem products NSKE 5% @ 5ml/lit, neem oil 2% otkaraj oil 2% is effective against this pest.
- Soil application of Karanj meal 500 kg/ha. + Spray of Karanj oil 2%.
- There is no level claim of any insecticides for seed wasp in coriander crop. However in case of severe infestation need based use of chemical insecticides i.e. Abamectin 1.9EC @ 2ml/lit or Thiacloprid @ 0.24% to prevent losses.

**Table 1. IPM and IDM strategies**

Stage	Pest / Disease	Practices to be adopted
Pre-sowing	Soil borne diseases, insect and nematodes	Deep summer ploughing. Follow crop rotation. Add well decomposed organic manure.
Sowing	Wilt & blight	Treat seed just before sowing with <i>Trichoderma viridae</i> or <i>T. hazianutn</i> @ 4 g/kg seed or treat seed with Carbendazim @ 2g/kg seed Select healthy and disease free seed.
	Nematode, diseases & Insects	Apply neem cake @ 150kg/ha Sowing should be completed within recommended time.
Vegetative	Wilt & stem gall	Avoid over watering. Maintain optimum moisture level. Adopt recommended plant spacing. Spray Carbendazium @0.1%.
	Aphids , whitefly and defoliator	Conserve <i>Coccinella</i> , <i>Chrysopides</i> , <i>Syrphid</i> fly etc). Release of <i>Coccinellids</i> @ 1000 beetles at 10 days interval. Spray 5% NSKE Spray Endosulfan (0.07%) need based

Reproductive stage	Powdery mildew	Spray of Dinocap (0.1%) or wettable Sulphur (0.25%) or dusting with Sulphur @ 20-25 kg/ha during flower initiation
	Stem gall, blight or grain mould	Spray Carbendazium @0.1%
Storage	Pest and disease	Store in gunny bags with moisture proof lining.

**Table 2. Pest and disease tolerant / resistant varieties of coriander**

S. No	Variety	Area of adoption	Tolerant I resistant to
1	RCr-41	Rajasthan	Resistant to stern gall and tolerant to powdery mildew.
2	RCr-435		Moderately resistant to stem gall and wilt.
3	RCr-446		Moderately resistant to stem gall and wilt.
4	RCr-20		Resistant to wilt, stem gall and nematodes.
5	CO-3	Tamil Nadu, Gujarat and Andhra Pradesh	Tolerant to wilt, powdery mildew and grain mould.
6	CS-287	Tamil Nadu	Tolerant to wilt, powdery mildew and grain mould.
7	GCr-1	Gujarat	Tolerant to wilt and powdery mildew.
8	GCr-2	Gujarat	Tolerant to wilt and powdery mildew.
9	RajendraSwathi	Bihar	Moderately resistant to wilt, stem gall, aphids and weevil.
10	Sadhana	Andhra Pradesh	Tolerant to white fly, mites, aphids, wilt and powdery mildew.
11	Swathi		Tolerant to white fly, mites, aphids, wilt and grain mould.
12	Sindhu		Resistant to powdery mildew, wilt and aphids.
13	Pant Haritma	Uttar Pradesh	Resistant to stem gall, moderately resistant to wilt, aphid and weevil.

### **Abiotic stress**

**Frost:** It damages the crop frequently in north India, particularly under unirrigated conditions. Burning of waste materials on the bunds of field in night is useful in protecting the crop during the frost prone period. Spraying of 0.1% sulphuric acid at flowering stage protect the crop from frost. Irrigation may be applied if possible.

**Harvesting:** Coriander crop matures in about 100-150 days of sowing depending upon varieties and climate. The green leaves are normally harvested 60-75 days after sowing and left for flowering and seed formation; whereas coriander crop grown exclusively for green leaves is harvested after 30-45 days of sowing. The coriander compound leaves with stem are prepared in bunches of desirable size for marketing. The stage of harvest depends upon the market requirement. For green coriander seeds, the crop is harvested when seeds are green and have attained full size. The green seed crop is dried under shade for retaining the green colour. Keeping in view, the market requirement, the crop can be harvested at yellow or brown colour of seeds. Delay in harvesting should be avoided, otherwise shattering and splitting of seeds may occur. Harvesting should be done by cutting the whole plant when 60% of seeds in main umbels attain desired size and colour and piled into small stacks in partial shade to dry for 2-3 days.

### **Yield:**

An average seed yield of 4.5 to 6.0 q / ha can be obtained from rainfed crop, whereas average seed yield of 8-12q/ ha along with additional marketable leafy yield of about 5-7q/ha can be obtained from irrigated crop. The crop grown exclusively for leaf purpose yielded green leaves of about 50-80q/ha with 3-4 cuttings depending upon situations. Some improved varieties cultivated scientifically can give yield up to 27 q/ha of seed.

### **Processing For Green and dehydrated leaves:**

**Processing:** The fresh greens consisting edible portions are the tender leaves and stem which are cut to length of about 5-7 cm above ground. The yellow, diseased and damaged leaves are trimmed off and weed plants and straw is culled during cleaning and dressing. Healthy and disease free leaves are tied into small bunches for the convenience in handling, transportation and marketing. The leaves of coriander are sun dried or dehydrated in a suitable dehydrator, for further use in off-season.

**Storage:** The fresh coriander leaves are highly perishable and deteriorates rapidly at temperature above 5°C. Therefore the fresh leaves bunch should be marketed soon after harvesting. The leaves can be stored only for about 24-36 hours after harvesting under ambient condition. However in cold store at 0°C temperature and 90% relative humidity, the storage period can be extended for one week.

### **For Seed:**

Harvested plants are dried in the sunlight for 1-2 days to bring the moisture level down to 18%. The dried plant is then threshed to remove the seeds. Seeds are further dried in the shade to bring

the moisture level down to 9%. Coriander seed is mainly processed into powder by crushing and the powder which enjoy an aroma, is used as food ingredient. Seeds which contain 0.1-1.5% of oil are used to extract essential oils.

**Storage:** The dried seed is filled in plastic bags or in gunny bags lined with plastic sheet. Each bag is sealed and stored under clean dry and ventilated place.

### **Grading:**

Coriander is classified into different grades based on quality of the produce. In general, coriander has been classified into grades like Badami (Brown), Eagle/ Scooter (Medium Green), Single/ Double Parrot (Green Colour).

### **For Powder:**

The coriander seeds are washed, manually to remove dirt, soil and any other adhering materials. It is then dried. Sun drying is widely used being cheaper. Drying is followed by powdering in disintegrator and micropulverizer. The powder is then shifted and tested according to standard procedures.

### **For Essential oil.**

The mature dried seed of coriander are distilled to obtain the essential oil. Hydro or steam distillation method is generally used for extraction of essential oil. On an average, the dried seeds yield 0.1-1.7% volatile oil depending upon variety and location.

### **Cultivation of coriander under protected environment during offseason**

Most of the seed spices including coriander are grown during *Rabi* season in a given set of agro-climatic condition. The seed spice crops are highly sensitive to the abrupt variations in climatic parameters. Frost and sudden development of the cold waves cause huge loss of the crop. The coriander crop can be taken for green leaves purpose under protected conditions given by different type of plastic nets, sheets etc. in the shape of tunnels, which can reduce the influence of extreme temperature. It was observed that plastic walk in tunnel and low pressure drip irrigation exhibited encouraging results. Most healthy plants with better growth and development, maximum number of umbels per plant, number of seeds per umbel and highest yield/ ha were obtained under plastic walk in tunnel and low pressure drip irrigation treatments. The minimum incidence of diseases and aphids was recorded under the same treatments.

Off-season crops always fetch high price in the markets due to its freshness. Moreover, in seed spices the quality aspect is very important parameter which affects it's competitiveness in

respect to their export value. Offseason coriander was grown at NRCSS Ajmer with 6 protection treatment namely control, white net, green net, black net (75%), black net (60%) and black net (50%). The coriander was grown on three different dates *viz.* 18<sup>th</sup>March, 2<sup>nd</sup>April and 17<sup>th</sup>April. Observations were taken on initial germination, completion of germination, plant height at 30 DAS, number of basal leaves per plant, number of leaves per plant and yield. Findings revealed the off season summer cultivation of coriander under white net and green net on all the dates of sowing exhibited best results with respects to germination, vegetative growth and leaf yield.

### **Products**

The volatile oil is used chiefly as a flavoring agent for liquors, cocoa and chocolate industry and it is also valuable ingredient in perfumes. Good quality oleoresin can be extracted from coriander seeds. The oleoresin is used for flavouring, beverages, pickles, sweets and sausages. The other important product is Dania Dal, which is a major adjunct in Supari and Pan masala.

### **Export scenario of Indian coriander**

India is the largest producer and exporter of coriander in the global market. The exports have increased significantly in the past few years due to strong demand from the overseas market. The changing pattern of food consuming or consuming of more spicy foods, especially in developed countries and the large populations of Indian living in these countries have resulted in good export market. The major importers for Indian coriander are Europe, US, Singapore and Gulf countries. Coriander export have touched 26,000 tonnes amounting to 110.25 crores of rupees during 2007-08.

### **Export oriented market centres of coriander**

- Guntur, Varavakonda, Nandyal-(Andhra Pradesh)
- RamganjMandi, Baran, Kota-(Rajasthan)
- Thiruchirappilly, Virudhunagar-(Tamil Nadu)
- Davangore-(Karnataka)
- Varanasi, Jaunpur-(Uttar Pradesh)

### **Good agricultural practices**

- Deep ploughing is to be done on bright sunny days during summer.
- Do not plank or irrigate the field just after ploughing.
- The field should be kept exposed to sun light at least for 2 to 3 weeks.
- Grow varieties suitable for the season or region.
- Grow only recommended pest / disease tolerant / resistant varieties.

## *Advance Production Technology of Coriander*

- Do not use seed without seed treatment with biocide chemicals.
- Always treat the seeds with approved chemicals for the control of seed borne disease.
- Don't grow in disease affected fields in subsequent years.
- Practice crop rotation in severely infected fields.
- Don't spray insecticides which are harmful to the honey bees.
- Spray during the evening hours when honey bees activities are minimum because honey bees are major pollinators in coriander crop.
- Don't grow coriander continuously for more than three years in the same field to avoid wilt disease.
- Survey the field regularly to monitor pest/ disease appearance.
- Don't use plant protection measures on calendar basis.
- Use cement concrete threshing yard or tarpaulin during processing of harvested material.
- The quicker the drying time, the better the final microbial quality of the product.

**Table 3. Monthly operations to be done in coriander field for better production:**

Name of Month	Field operation
July	Sowing of cluster bean for green manuring
August	Maintenance of green manuring crop.
September	Incorporation of green manure crop in the soil and field preparation. Apply 50% N and full dose of P& K as basal dose with FYM and / compost.
October	Incorporation of Methyl-Parathion 2% or Endosulfan 4% dust@25 kg/ha in soil for control of soil borne insect pest and the crop should be sown in 2 <sup>nd</sup> fortnight of October
November	Sowing may also be done in 1 <sup>st</sup> forth-night of October for late season crop. The irrigation should be given as per requirement. Apply 50% of remaining dose of N 30 DAS as top dressing in standing crop after first weeding and hoeing.
December	Weeding, hoeing and thinning is done during the period and irrigate the crop as per requirement. The top dressing of remaining N through urea should be done 60 days after sowing.
January	Irrigate the crop as per requirement and make the arrangement of smoke in the field to protect the crop from frost injury. Prophylactic spray of fungicide must be done to control blight in the crop.
February	Irrigate the crop as per requirement and prophylactic spray of fungicide and insecticide must be done to control fungal diseases and insects pests.
March	Irrigate the crop as per requirement and prophylactic spray of fungicide and insecticide must be done to control fungal diseases and insects

	pests.
April	Harvesting of the crop must be done at physiological maturity stage.
May	Threshing and winnowing of the crop is done during the period.
June	Cleaning, grading and bagging, of the crop is done during the period.

## **Uses**

- In Asian folk medicine, coriander has been used to treat stomach problems, nausea, fevers, measles, colds, etc.
- It mask the unpleasant taste of various medicines.
- It contains next to no calories, it's a favourite herb of dieters.
- Add fresh, tender, young leaves to salads, and use as a garnish for fish and soups.
- Coriander seeds are a vital ingredient of curry powder.
- Use coriander seeds, either whole or ground, in pickles, soups, sauces, fruit desserts, such as stewed apples or prunes, and with all types of meat dishes.
- Add to mulled wine to impart a warm, summery flavour.
- Ground coriander is used commercially to flavour baked goods and processed meats such as hot dogs and sausages.
- The oil extracted from the seeds is used in the preparation of canned soups, sauces, candy, chewing gum, ice cream, liquors, gin, and even tobacco products.
- The roots are boiled and used in Thai-style, to flavour soups and chicken dishes.

## **Acknowledgement:**

This matter has been collated from original research work carried out at NRCSS and from research reports of other centres and also from AICRP on spices. It includes the following references.

1. Bhati, D.S. (2005). Advances in production technology of Coriander. A course manual for winter school on Advances in Seed Spice Production at NRCSS, Ajmer during September,2-22,2005. p 196-200.
2. Parthasarathy, V.A., Shiva, K.N. and Johny, A.K.(2005). Research and Development in seed spices under AICRPS. A course manual for winter school on Advances in Seed Spice Production at NRCSS, Ajmer during September,2-22,2005.p 255-271.
3. Anandraj, M.V.A., Shiva, K.N. and Johny, A.K. (2007). Research and Development in seed spices under AICRPS. In Production, Development, Quality and Export of Seed Spices by S.K. Malhotra and B.B.Vashishtha(Eds.).p 370-395.
4. Malhotra, S.K. and Vashishtha, B.B. (2008). Package and Practices for production of seed spices. NRC on Seed Spices,Tabiji,Ajmer. pp. 98.

# Advance Production Technology of Fenugreek

(*Trigonella foenum-graecum* L.)



R.K. Kakani

M.M. Anwer

S.S. Meena

S.N. Saxena



ICAR -National Research Centre on Seed Spices,  
Tabiji, Ajmer-305206 (Raj.), India

Website:[www.nrcss.res.in](http://www.nrcss.res.in)





# *Advance Production Technology of Fenugreek*

**Correct Citation:** Kakani, R.K., Anwer, M.M., Meena, S.S. and Saxena, S.N. (2009).  
Advance Production Technology of Fenugreek.  
ICAR-National Research Centre on Seed Spices Tabiji. Ajmer- 305 206  
(Rajasthan)

**Published by:** Director,  
ICAR-National Research Centre on Seed Spices  
Tabiji Ajmer 305 206, Rajasthan  
Phone- 0145-2684400  
Fax- 0145-2684417  
Email: [nrcss.director@gmail.com](mailto:nrcss.director@gmail.com)  
Website :[nrcss.icar.gov.in](http://nrcss.icar.gov.in)

**Secretarial Assistant:** P.K. Agrwal & Shyam Sunder Barotia

**Photographs by:** M.A. Khan & G.K. Tripathi

**Printed:** November 2009 (500 Copies)

**First edition:** 2009

**Updated in:** 2021

**Updated by:** Dr. S.N. Saxena, Dr. Y.K. Sharma, Dr. O.P. Aishwath, Dr. Ravindra  
Singh, Dr. Krishna kant, Dr. R.S. Meena, Dr. M.D. Meena

**Secretarial Assistant:** Shyam Sunder Barotia

**Printed at:** Job Offset Printers  
Ajmer  
98294 72031

## **PREFACE**

Fenugreek (*Trigonella foenum-graecum* L.) is an annual crop belonging to the legume family. It is regarded as the oldest known medicinal plant in recorded history. Its seed and leaves have medicinal value, and have been used to reduce blood sugar and lower blood cholesterol in humans and animals.

Major fenugreek producing countries are India, Argentina, Egypt, France, Spain, Turkey, Morocco and China. India is the largest producer in the World. In India, Rajasthan, Madhya Pradesh, Gujarat, Haryana, West Bengal and Uttaranchal are the major fenugreek producing states. Rajasthan has maximum area and production of about more than 37 and 33% of India's total area and production, respectively. The productivity level of fenugreek crop in the country is 1566 Kg/ha (2019-20).

The technology that has emanated out of research efforts made at NRCSS, Ajmer and different centres located in the various agro-climatic regions, under the AICRP on Spices at various SAU's. This has been compiled in the form of Advance Production Technology of Fenugreek. We are sure that this publication shall prove highly useful to various stake holders such as field functionaries, growers, students and others having interest in growing fenugreek scientifically.

We hope that the technical bulletin provides relevant information for fenugreek production. Suggestions if any are welcome for further improvement of this bulletin.

Ajmer-

1<sup>st</sup> November, 2009

Authors

## Introduction

Centre of origin of fenugreek is South-Europe, Mediterranean area and Western Asia. India is also to be a native of fenugreek and found growing wild in Kashmir, Punjab and upper Gangetic planes. Fenugreek is commercially important spice crop due to its multifarious uses and is extensively grown in almost every part of the country for seeds, tender shoots, and fresh leaves during winter season. There are two cultivated species of genus *Trigonella* viz. *foenuni-graecum* (common fenugreek) and *corniculata* (Kasuri type fenugreek). The major fenugreek producing countries are India, Argentina, Egypt, Southern France, Morocco, Spain, Turkey and China.

## Production in India

In India, its production is concentrated mainly in the states of Rajasthan, Madhya Pradesh, Gujarat, Haryana, West Bengal and Uttaranchal. Major fenugreek growing districts with higher productivity in India are given in Table 1. During 2019-20, a total of 1,88,480ton of fenugreek seed was produced from 1,20,340 hectare area which is 11.22 % and 6.92 % of total seed spices production and area, respectively. The current productivity of fenugreek is 1566 kg/ha (DASD, Kozhikode).

Table 1. Major fenugreek producing states with zones / districts

State	High productivity	Agro- region
Gujarat	Banaskatha, Dahod, Patan, Surendranagar, Mehasana	Gujarat plain & hill region
Rajasthan	Bikaner, Sikar, Jodhpur, Churu, Pratapgarh	Western dry region
Madhya Pradesh	Ratlam, Mandsaure, Neemuch, Ujjain, Rajgarh, Shajapur, Guna, Dhar, Sehore, Betul , Khargone	Central plateau & hill region
Chhattisgarh	-	Central plateau & hill region
Haryana	-	West plateau & hill region
Maharashtra	-	Central plateau & hill region.

27,660 Metric tonnes of fenugreek seed of worth Rs. 1638.36 million was exported from India during 2019-20. The major importing countries for Indian fenugreek are USA, Y.A.R., UAE , South Africa, Korea, U.K., Nepal, Bangladesh, Saudi Arabia, Egypt, Shri Lanka, Germany and Sudan.

## **Cultural Requirements**

The cultural requirements including practices for higher fenugreek production are summarized as under:

### **Climate**

Fenugreek requires cool climate for its better growth. A cool growing season without extremes of temperature is favourable for best development. It is cultivated both in tropical as well as temperate region. In India, it is mainly grown as a *Rabi* season crop but in South India, it is also grown as rainy season crop. The crop can be grown in areas of low to moderate rainfall but cannot withstand heavy rainfall. Continuous moist and cloudy weather invites insect – pests and a number of diseases. Dry weather during crop maturity is essential for harvesting better seed yield. Having wider adaptability, the crop can be grown successfully both in tropical and temperate regions up to an altitude of 2000 m above mean sea level (MSL).

### **Soil**

Fenugreek can be grown in almost all type of soils having good drainage but grow best on well-drained loamy soils. Organic matter rich clay-loam soil may also be used if adequate drainage facilities are available. However, it can be grown on sandy or gravelly soils with slightly compromising yield. For rainfed cultivation, black cotton soils are best suited for its successful cultivation. Although the crop is sensitive to salinity except very low yet it can tolerate the pH up to 8.5, but in neutral soils having a pH range from 6.0 to 7.0 it always gives higher yield with better quality of leaves.

### **Cropping System**

Fenugreek can be grown as mixed or intercrop. Being leguminous crops it fits well as component crop for most of inter cropping systems involving fennel, coriander, ajwain, dill and winter vegetable crops. Likewise crops should be grown as per standard principal of crop rotation.

Some of the crop rotation systems suggested are:

1. Maize/pearl millet- Fenugreek
2. Sesame-Fenugreek
3. Sesame-Fenugreek Summer Maize

### **Cultivated Varieties**

Variety selection depends primarily on its adaptation to the soil and climatic conditions and preferably should have resistance / tolerance to pests and diseases prevailing in that region. There

are many varieties released for cultivation to different areas. The description of some of the important cultivated varieties recommended for different states are given as under:

### **(A) Rajasthan**

#### **Ajmer Methi 1 (AFg-1)**

The variety has been developed through pure line selection from local germplasm at NRCSS, Ajmer. The seed are bold and large. The number of seeds per pod ranges from 17-20 with 17-20 g. test weight. The crop takes 137 days to mature and gives seed yield of 27.2 q/ha. The crop grown exclusive for leave purpose yield 76 q/ha green leaves from three cuttings.

#### **Ajmer Methi 2 (AFg-2)**

The variety has been developed through pure line selection from local germplasm at NRCSS, Ajmer. The seed are small in size. The number of seeds per pod ranges from 16-18. The crop takes 138 days to mature and give seed yield of 18.1 q/ha. The crop grown exclusive for leave purpose yield 72 q/ha green leaves from three cuttings.

#### **Ajmer Methi 3 (AFg-3)**

The variety has been developed through pure line selection. The seed are bold and large. The crop takes 137-140 days to mature with an average seed yield of 13-14 q/ha. Quality profile shows the presence of 1.79% diosgenin and 0.97% 4-hydroxyisoleucine content in seeds which enhances its medicinal quality for use in controlling diabetes. Moderately resistant to powdery mildew.

#### **Ajmer Methi 4 (AFg-4)**

The variety has been developed through pure line selection. The seed are bold and large. The crop takes 122-130 days to mature showing earliness, gives an average seed yield of 18-19 q/ha. Seed contain 1.74% diosgenin and 0.94% 4-hydroxyisoleucine in seeds. Moderately resistant to powdery mildew and root rot and usable as corrective measure for diabetes.

#### **Ajmer Methi 5 (AFg-5)**

The variety has been developed through pure line selection. The seed are bold and bigger in size. The crop takes 106-141 days to mature with an average seed yield of 17-18 q/ha. Seeds of AFg-5 showed higher antioxidant properties (66.4 mg BHT g<sup>-1</sup>). Moderately resistant to powdery mildew and Alternaria blight.

## **RMt 1**

It was developed at SKN College of Agriculture, Jobner (RAU, Bikaner) through pureline selection from local collection. The plants are semi-erect, tall and moderately branch, bold, typically containing yellow coloured grains. It is suitable for Gujarat and Rajasthan states and mature in 140-150 days, gives an average yield of 14.7 q/ha. It is moderately resistant to root rot and tolerant to powdery mildew. An average grain yield of 15 q / ha can be obtained over crop duration of 140 150 days.

## **RMt-143**

It was developed at SKN College of Agriculture, Jobner through pure line selection from Jodhpur region and identified for release in 1997. It is suitable for Rajasthan and give average yield of 16.0 q/ha. It is suitable for Bhilwara, Jhalwar and Jodhpur areas of Rajasthan.

## **RMt 305**

It was developed at SKN College of Agriculture, Jobner through mutation breeding in RMt-1 and is the first determinate type of fenugreek, yielding an average 1300 kg/ha. The plant is dwarf, determinate, multipoded, early maturity, resistant to powdery mildew and root knot nematode and suitable for all fenugreek growing areas.

## **(B) Gujarat**

### **GM-1**

This variety was developed by Gujarat Agriculture University. Its plants are dwarf and having average yield 18.6 q/ha. this variety is suitable for Gujarat region.

## **(C) Tamil Nadu**

### **CO-1**

It was developed by Tamil Nadu Agriculture University through selection from TG 2336 of IARI and released in 1982. The plants are short and green with medium sized brownish orange seeds. It is tolerant to root rot. It matures in 95 days and gives an average yield of 6.80 q/ha.

## **(D) Bihar**

### **RajandraKranti**

It was developed by Rajendra Agricultural University through mass selection from Raghunathpur germplasm and released in 1987. The plants are tolerant bushy green with medium sized golden

yellow seeds. It is moderately resistant to powdery mildew, caterpillars and aphids. It mature in 120 days, and gives an average yield of 12.50 q/ha.

### **(E) Andhra Pradesh**

#### **Lam Selection-1**

It was developed by Andhra Pradesh Agriculture University through selection from germplasm collected from M.P. and released in 1992. The plants are bushy with medium sized golden yellow seeds. It is tolerant to root rot, powdery mildew, caterpillars and aphids. It mature in 90 days and gives an average yield of 7.40 q/ha.

### **(F) Haryana**

#### **Hisar Sonali**

It was developed by Haryana Agriculture University through pure line selection from local germplasm and identified in 1983. The plants are bushy, semi-erect with bold yellow attractive seed (13-15 g/1000 seeds). It is moderately resistant to leaf spot and root rot complex disease. It mature in 140-150 days and gives an average yield of 19.0 q/ha.

#### **Hisar Suvarna**

This variety was developed through pure line selection from local germplasm by CCS Haryana Agriculture University, Hisar. This is a dual purpose cultivar and suitable for Haryana, Rajasthan and Gujarat. This variety is resistant to powdery mildew and moderately resistant to downy mildew with an average yield of 19-20 q/ha.

#### **Hisar Mukta**

This variety was developed at CCS Haryana Agriculture University, Hisar. It is a natural green seed coat mutant, selected from IL-335-1 germplasm line, a collection from U.P. Yield is around 20-23 q/ha. It is resistant to downy mildew and moderately resistant to powdery mildew. It is suitable for cultivation under all fenugreek growing states of North India.

#### **Hisar Madhavi (HM-350)**

It was developed by CCS Haryana Agriculture University through single plant selection from the line PLME 46-1, a pure line selection from collection from U.P. It is medium in maturity and having average yield 19-20 q/ha. This variety is resistant to powdery mildew and moderately resistant to downy mildew.

## (G) Uttar Pradesh and Uttaranchal

### **Pant Ragini**

This variety was developed by GB Pant University of Agriculture & Technology, Pantnagar. It is a dual purpose variety suitable both for leaf as well as seed purpose. Plants are tall and bushy type. The variety is resistant to downey mildew and root rot. It matures in 170-175 days.

### **Pusa Early Bunching**

It was developed at IARI, New Delhi. It matures in 100-125 days and is quick growing variety with upright shoot having bold seeds. It is suitable for seed as well as leaf cutting and gives average seed yield of 12 q/ha.

### **Pusa Kasuri**

It is small seeded *kasuri* type variety, mainly cultivated for leaf Purpose and not for seeds. It is late flowering variety with rosette type leaves and 5-7 cutting may be taken. It is heavy yielder of green leaves with special fragrance. It has been developed at IARI, New Delhi. It gives average seed yield of 5-7 q/ha and the crop grown exclusively for green leaves, produces an average yield of about 80 q/ha.

## **Cultural Practices**

### **Preparation of Land**

The land should be well prepared for better germination and growth of fenugreek. A total of 3-4 ploughings are required. The first ploughing should be done by soil turning plough followed by 2-3 ploughing with harrow to bring the soil to a fine tilth. At the time of sowing there should be good moisture in the soil for better germination of seed.

### **Sowing Time**

Fenugreek, being cool season crop, is sown in the month of October to November in northern plains, whereas, in hilly tracts, it is sown from March to May, depending on altitude. In areas with mild climate, fenugreek for fresh greens may be grown round the year except extreme hot months of summer and rainy season. In southern states of India, particularly Karnataka, Andhra Pradesh and Tamil Nadu, fenugreek is sown twice, Once in *rabi* (September- December) and again in *Kharif* season (June-July). *Kasuri* type varieties require preferably extra cool weather for longer duration, is thus raised more successfully in northern states during winter than the southern states of India. For higher yield, it is better adjusted sowing time such that the pod development and seed



maturity phase may coincide with a dry and rain free period. Recommended sowing time for seed crop in different states is given in Table 2.

**Table 2. Sowing time recommended for different states in fenugreek.**

State	Sowing time
Rajasthan	First week of October to last week of November
Gujarat	Last of September to First week of October
Bihar	Middle of October
Uttar Pradesh	October- November
Tamil Nadu	First week of October
Haryana	Middle of October up to November (First week of November is ideal)
Andhra Pradesh	First week of October

## Seed Rate

The quantity of seed required for the sowing of unit area depends on the purpose for which the crop is sown. For common type the seed requirement is 20-25 kg/ha and for *Kasuri* type the seed requirement is 10-12 kg/ha. Seed rate recommended for different states are given in Table 3.

**Table 3: Seed rate recommended for fenugreek.**

State	Seed rate
Rajasthan	20-25 kg/ha
Gujarat	20-25 kg/ha
Bihar	20-25 kg/ha
Uttar Pradesh	15-20 kg/ha
Tamil Nadu	20-25 kg/ha
Haryana	20-25 kg/ha
Andhra Pradesh	30 kg/ha

## Seed Treatment

Fenugreek is a legume crop, it fixes nitrogen about 283 kg per hectare per year from the atmosphere into the soil. The role of *Rhizobium* in fenugreek production is well established, and thus inoculation of seed with *Rhizobium* culture before sowing has proved beneficial in getting higher seed yield. Seeds should be treated with *Rhizobium meliloti* local culture prior to sowing, especially when the crop is sown in new field. Seed should also be treated with *Trichoderma* culture 10g/kg seed for the control of seed and soil borne fungal diseases.

## Sowing Method

Fenugreek can be sown either in lines or by broadcasting seeds in well- prepared flat seedbeds and raking the bed surface prudently, however, sowing in lines is comparatively better than the broadcasting since it facilitates the intercultural operations, like hoeing and weeding. Line to line spacing of 25-30 cm is required and later the plants are thinned to maintain 10-15 cm spacing within the lines. The seed germinates in about 5-7 days of sowing. The field should have adequate moisture at the time of sowing. Although the depth of the sowing seeds depends on soil type and soil moisture at the time of sowing, but being small size, the seeds of common fenugreek are usually sown at a depth of 3 cm and kasuri fenugreek at 1.0-1.5 cm.

**Table 4: Crop geometry recommended for fenugreek**

State	Spacing
Rajasthan	25 cm x 10 cm row spacing
Gujarat	15 cm x 10 cm and 30 x 10 cm
Bihar	20 cm x 10 cm
Uttar Pradesh	30 cm x 10 cm
Tamil Nadu	15 cm x 10 cm or 22.5 x 10 cm
Haryana	30 cm x 10 cm

## Manures and Fertilizers

The fenugreek crop has been reported to show very good responsive behaviour towards absorption of both macro as well as micro-nutrients. The crop removes N, P and K in the ratio of 2 : 1 : 1 from the soil, in the uptake order of 10 , 3.5, 8.2 kg respectively. Therefore to maintain a steady state of productivity, application of FYM (10 t/ha) has a beneficial effect on the enhancement of vegetative growth and resulted in higher dry matter production of fenugreek. Application of one ton per hectare of neem cake has also proved beneficial. The microbial inoculation with *Azospirillum*, *Azotobator* and *Rhizobium* has been reported to be suitable means for organic cultivation of fenugreek. The *Azospirillum* combination with organic manure 10 t/ ha yield high seed yield of 13.9 q/ ha, which was 25% less than the yield obtained from combinations applied with chemical nitrogen with reduced incidence of root rot (8.4%). Doses of fertilizer depend on fertility status of the soil and variety. State wise recommendation of fertilizer requirement is given in table 5.

**Table 5: Fertilizer recommended for fenugreek**

State	Fertilizer recommended
Rajasthan	10 FYM at the time of field preparation. 40 kg N(applied at the time of sowing and at post flowering stage), 40 kg P <sub>2</sub> O <sub>5</sub>
Gujarat	40 kg N, 40 kg P <sub>2</sub> O <sub>5</sub> /ha
Bihar	40 kg N, 60 kg P <sub>2</sub> O <sub>5</sub> , 20 kg K <sub>2</sub> O
Uttar Pradesh	60 : 50 : 10 kg NPK/ha
Tamil Nadu	N 50 kg/ha, 25 kg/ha and 40 kg K/ha
Haryana	40 kg/ha P

## Irrigation

Fenugreek, being primarily an irrigated crop, requires light irrigation at frequent interval for its quick growth but can also be cultivated under rainfed conditions in certain parts of the country. Usually the crop is sown when the field is having plenty of soil moisture so irrigation is not applied unless the seedling attain 2- 4 true leaves, however, if the initial moisture in the field at sowing is inadequate, a light irrigation should be applied very soon after sowing and should be followed by another light irrigation on third day to facilitate rapid and uniform germination. Subsequent irrigations are given at 12 to 15 days interval, depending on soil type, season, rainfall, and other temporary weather conditions. In general, frequent and light irrigations are essential for quick foliage growth and as a thumb rule, each cutting should be followed by a light irrigation. The early growth period and seed setting are the critical stages for irrigation requirement. Too much irrigation is also as harmful as the scarcity of moisture, since excessive moisture in any form and at any stage increases the incidence of root rot and powdery mildew. Application of seven irrigations at 1.0 IW/CPE ratio of 0.75 was found optimum for Gujarat conditions. Care should be taken to avoid water stress at pod and seed development stages. Normally 6-7 irrigations are required in light soil and 4-5 irrigations are needed in heavy soil.

## Inter-Culture Operations

Fenugreek, being leguminous crop, needs proper soil aeration for normal development of root system, thus, hoeing and weeding during early stages of plant growth are very essential to make the soil loose around the roots and to control the weeds. Weeds, due to slow growth of fenugreek seedlings may pose problem in initial stages, however, in later stages, when the crop canopy is fully developed, weeding is not at all required as the crop itself suppresses the weeds. Weeds emerging 30 DAS caused a very little reduction in yield and there was no significant gain in increasing weed free period beyond 30 days, thus, first 30' days were identified as a critical period with respect to crop weed competition in fenugreek. Generally 2-3 hand weeding are required to

keep the crop weed free and reducing the crop weed competition for growth resources like nutrients, moisture, light and others. The first hoeing and weeding is done at the time when the plants are 5 cm tall.

Two weedings and hoeings, are required, first at 10-20 days after sowing, along with thinning of the plants and second weeding at 40-50 days after sowing. Integrated weed management using pre- sowing application of pendimethalin @ 1 kg/ ha (Haryana), pre sowing application of fluchlorin @ 0.75 kg/hg in 500-600 liters of water, supplemented with one hand weeding once in 50 DAS is very effective method of weed control for realizing higher yield and benefit in fenugreek cultivation.

## **Crop Protection**

Fenugreek crop are attacked by numbers of insect pests and diseases from germination to pod maturity. The important among them are sucking pests (aphid, white fly, mites, jassidsetc), leaf miner, pod borers etc. Powdery mildew, downy mildew, *Alternaria* leaf blight and root rot are commonly observed diseases of fenugreek. The plant protection measures should include selection of resistant varieties, crop management practices such as time of sowing, balanced nutrition, crop rotation, green manuring etc.

## **Insect-Pests**

### **A- Sucking Pests**

#### **Aphids (*Acrythosiphonpisum*, Henis. and *Aphis craccivora*, Koch.):**

The most common insect that attacks the fenugreek crop is aphid and are found in colonies sometimes very serious in patches on tender leaves, stem and inflorescence. Both nymphs and adults suck sap from the tender leaves thus reducing market value. The severe infestation affects the yield and quality of leaves badly.

#### **White fly (*Bemisiatabaci*)**

White fly is serious pest of fenugreek in some area. It attacks the crop at early stage to pod formation stage. Nymph and adult suck the sap of plant causes yellowing of plant and subsequently plant die.

#### **Jassids (*Empoasea* spp.)**

Jassids attack on fenugreek crop at early stage. Nymph and adult suck the leaf sap causing browning of leaves.

## **Mites (*Pertobialatens*)**

Infestation of mites can be seen occasionally. The insect mostly feeds on young leaves. The severe infestation affects the yield and quality of leaves. Small mites are seen on lower side of leaves and when serious, cause webbing and feed within the web. Plants get stunted at severe infestation.

### **Control of Sucking Pests:**

- Trapping and monitoring with yellow stick trap
- Timely sowing of crop help in lower build up of pests population. Late sown crops are more prone to heavy attack by number of insect pests.
- Crop should sown in desired geometry.
- Recommended doses of nitrogenous fertilizers should be applied. Because higher application of nitrogenous fertilizers causes more succulent to the crop.
- Spraying of Neem seed kernel Extract (NSKE) @ 5 % or Neem oil 2% effectively check the early population build up of aphids on the crop.
- Application of entomopathogen *Verticillium lecanii* ( $10^8$  spores/g) powder formulation @5.0 g/litre of water gives good result.
- At high aphid population any one of the synthetic insecticides should he sprayed i.e Dimethoate 0.03%, Metasytox-0.03%, Emamectin benzoate @ 10 g ai/ha, or Imidachlorprid - 0.005%.
- Spray ethion 0.05 % or dicofol 0.07 % for mite management.

## **Leaf eating caterpillar (*Spilarcitia oblique* and *SpodopteralitumFabricius*):**

The large numbers of caterpillar appear and destroy the leaves. The eggs are laid in clusters and young larvae gregariously feed on leaves. They scrap out the green matter from the leaves and gives the appearance of papery white structure. The last instars of larvae feed voraciously causing defoliation of plants and thereby causing considerable losses in yield and quality of greens.

### **Control**

- Destroy the egg mass and gregarious young larvae.
- Monitoring of adult population through pheromone/light trap.
- Spray neem seed kernel extract (NSKS 5%) or neem oil 2% in the early stage of larvae.
- Use of nuclear polyhydrosis virus (NPV) @ 250 LE/ha and *Beaveriabassiana* @  $10^{10}$  spores/ml is an effective biological control.
- Spray quinalphos - 0.05 % at 7 to 10 days intervals

## **Pod borer (*Helicoverpa armigera* Hubner):**

The pest is found to feed on leaves, flowers and pods. Eggs are laid on young leaves, which are later damaged by young larvae. The first instars of larvae bore the fruits and damage them, causing 10-90 % losses, if left unprotected.

### **Control**

- Monitor adult population through pheromone / light trap.
- Release of *Trichogramma chilonis* @ 50,000 eggs/week, spray of *Beauveria bassiana* @ 10<sup>10</sup> spores/ml or HaNPV @ 250 LE/ha is an effective biological control.
- Spray of NSKE 5% or neem oil 2% controls when population build up is at low level.
- Spray quinolphos 0.05% when population reaches at higher level.

## **Leaf minor (*Empoasca* spp.)**

Excess mining of leaves at early stage causes stunting growth of plant. Heavy infested crop gives less production.

### **Control**

- Spray dimethoate 0.03% or Emamectin benzoate @ 10 g ai/ha
- Spray neem oil (2%)

## **Diseases**

### **Root rot (*Rhizoctonia solani* Kuhn.):**

This is a soil borne disease. The symptoms include varying degrees of rotting of the root leading to foliage yellowing generally in 30-45 days old plants. The affected plants wither and dry up later on. It is a serious problem in major fenugreek growing areas and drastically reduces the yield.

### **Control**

- Seed treatment with thiram or captan @ 2 to 3 g / kg of seed.
- Seed pelleting with antagonistic fungi like *Trichoderma viride*, *T. harzianum* (Talc based formulation @ 4 g/kg of seed) followed by soil application of neem cake 150 kg/ha.
- Drenching of carbendazim (0.1%) once at initial appearance of disease and after one month.
- Deep summer ploughing of field and adoption of crop rotation practice.
- Use of bio-inoculants *Azospirillum* or *Azotobacter* plays significant role in reducing incidence of root rot to 8.2%.

## **Powdery mildew (*Erysiphepolygoni* D.C. and *Laveillulaturica* Lev.):**

The disease generally appears late in the season. The symptoms include the appearance of whitish fungal growth on leaves and other above ground parts of the plant. The disease becomes serious at temperatures between 15°- 25°C and at a relative humidity more than 60%.

### **Control**

- Dusting with 300 mesh sulphur (25 kg/ha) or by spraying wettable sulphur (0.25%) or hexaconazole (0.1%) twice commencing from initiation of disease at 15 days interval.
- Grow resistant /tolerant varieties.

## **Downy mildew (*Peronospora trigonella* Gaum.):**

Symptoms include the presence of yellow patches on the upper surface and downy growth on the lower surface in the corresponding areas. In the advance stage of infection, the leaves turn yellow and shed, thus plant growth is checked adversely.

### **Control**

- Spray 400-500 lit solution of 0.2% copper oxychloride or chlorothalonil. Repeat the spray after 10 days interval if needed.
- Spray of metalaxyl+mancozeb (1g/Lit) at 15 days interval is also recommended.
- Give hot water treatment to seed before sowing.

## **Damping off (*Pythium aphanidermatum*):**

The infected seedlings appear water-soaked, discoloured and soft, emitting a bad odour. The infection mostly occurs at or below the ground level and the seedlings topples down and withers off.

### **Control**

- To minimize the source of infection seed treatment with carbendazim (2.5 g/kg seed) is recommended in reducing the seedling mortality.
- Use of soil amendments like neem cake @ 10 q/ha and farmyard manure @ 10-25 t/ha is beneficial.
- Adoption of proper crop rotation and deep summer ploughing.
- The antagonistic fungus *Trichoderma viride* and soil application of neem cake effectively control the disease.

## **Leaf spot (*Cercospora traversiana* SOCC):**

This is a minor disease of fenugreek in India. The disease symptoms appeared with the presence of round spots beneath the leaves. The spots are white at the center and brown at the periphery.

The affected leaves drop-off prematurely. Symptoms also appear on pods in later stage. The occurrence of disease adversely affects the market quality of green leaves.

## Control

- Follow at least 2 year crop rotation in infested areas.
- Healthy seed must be used.

## Rust (*Uromycesanthyllidis*):

The yellow spots bearing aecia in clusters are earlier symptoms of the disease. The disease is observed in the form of minute brown pustules on both the surfaces of leaves. The disease is of minor importance but under cool and wet climate in northern India entire plant may be damaged with the disease.

## Control

- Adopt good cultural operation and field sanitation.

## Harvesting and Yield

The common fenugreek becomes ready for cutting fresh green leaves and young shots in about 20 days after sowing while *kasuri* type fenugreek is ready in 25-30 days after sowing and subsequent cuttings may be taken at an interval of 15-20 days. The crop when grown for dual- purposes after taking one cutting, which does not affect the seed yield, is left for seed production. The crop after harvest is bunched and marketed. The cutting is usually done with sharp knife by leaving stubs 3-4 cm above the ground level and after taking 4-5 cutting the crop grown exclusively for green leaves is uprooted. Common fenugreek can be harvested by clipping the young plants from the base and the clipped plants are allowed to grow further and their tops are nipped periodically until flowering. If fenugreek is harvested late, its leaves develop a bitter taste.

Depending upon variety and season of growing the seed crop takes about 80-165 days from sowing to harvesting. The entire plants is either pulled out of cut from the base with sickle when 70 % of the pods turn yellow, and made into small bundles for drying them in sun. Seeds are separated by beating with stick and winnowing. The seed is cleaned and sun dried before packing in jute bags containing polyethylene lining.

The fenugreek yield depends upon the variety used, location and season of growing. Usually, the cultivars yielding higher grain yield tend to produce low fresh green leaf yield. Under irrigated conditions, the common type fenugreek varieties normally give a fresh green leaf and seed yield of 70-80 and 15-20 q/ha, respectively, and *kasuri* type 80-100 q green leaves per hectare. However,



higher yield can further be expected under good management practices. The *kasuri* type fenugreek varieties give higher yield due to more cuttings in comparison to common fenugreek.

## **Storage**

Green leaves are very perishable in nature, therefore, they are marketed soon after harvesting. However, well dried leaves can be stored for about 10-12 months. The leaves can be stored only for about 24 hours after harvesting under ambient conditions, however, in cold stores at 0°C temperature and 90-95 % relative humidity the storage period can be extended up to 10 days. Seeds are stored in gunny bags lined with polythene film. Vacuum gravity separator is used for cleaning fenugreek seeds. The properly cleaned fenugreek seeds are stored with an initial moisture level of 7-8 % and at an equilibrium relative humidity of 40 %. Fenugreek seeds well packed is stored in ventilated dry and cool place under ordinary conditions till sowing of next season crop.

## **Post Harvest Management**

Keeping in view the requirement of targeted market, the post harvest operations are advised to follow suitably for green leaves as vegetable, dehydrated leaves and seeds. In case of fresh greens, the edible portion is the tender leaves and stem, which are cut to length of about 7-10 cm. After harvesting, the yellow, diseased and damaged leaves are trimmed off and thereby healthy and disease free leaves are tied into small bunches for the convenience in handling and marketing. Since the dried leaves can be stored for one year for further use in off- season, the fenugreek leaves are sun-dried or dehydrated in a suitable dehydrator. However, during dehydration, chlorophyll is oxidized and ascorbic acid is lost, so as to retain green colour of leaves, blanching in boiling water (80°C) for 3-6 minutes can be practiced. The palatability of fenugreek leaves improve with steaming and with addition of seasoning rather than with boiling or frying. The average vitamin C value in fenugreek leaves is 43.10 mg/100 g and after boiling in water or steaming and then frying, the leaves lose 10.8 % and 7.4 % of this vitamin, respectively.

## **Uses**

Every part of this multipurpose crop is useful and utilized in one or the other form as food, fodder, medicine, and cosmetics. Its green fresh leaves and tender immature pods are used as green cooked vegetable. Sun dried leaves, which are having aromatic qualities, are used as spice for seasoning of foods in off- seasons. Being odoriferous, the dry seeds and their powder are used as condiment/flavoring agent and for medicinal purposes. The seeds are also used for making dye

and extraction of alkaloids or steroids. In certain parts, the green or dry fodder is usually fed to the cattle. It is recognized well as commercial uses in syrups, pickles, baked foods, condiments, chewing gums, icings, and cooked food seasonings. The fenugreek leaves and seeds have use in cosmetics and hair conditioning. In Punjab, dried plants are added to store grains as insect repellent.

### **Medicinal Uses**

Fenugreek, one the few spices is used extensively for medicinal purposes owing to its hypoglycemic and hypocholesteremic properties. The seeds are carminative, tonic and aphrodisiac and customarily used for the treatment of colic, flatulence, dysentery, diarrhea, dyspepsia with loss of appetite, chronic cough, dropsy, enlargement of liver and spleen, rickets, gout and diabetes, and are good for the elimination of bad breath and body odor. It is believed that regular intake of fenugreek seed reduces the level of glucose total cholesterol, and triglycerides in blood. Fenugreek is known to possess galactagogue properties, and thus Indian women consume the seeds for its power to promote lactation. Fenugreek seeds substantially contain diosgenin (0.40-1.26 %), which is used as a starting material in the synthesis of sex hormones as stimulant and contraceptive.

Fenugreek also helps to combat dandruff and is a cure for baldness. The ground powder mixed with cotton seed is fed to cows and buffalos for increasing the flow of milk. It is used in cattle feeds and in veterinary medicines also.

### **Economics of fenugreek cultivation:**

Based on the primary survey of the farmers during 2018-19, average input cost of cultivating one hectare of fenugreek farmers incurred input cost of Rs. 31698 per ha. Average yield harvested at surveyed farmer's field was 19 quintal per hectare valued at Rs. 83632. The return after adjusting input cost was arrived at approx 52 thousand per ha yield an average return of 2.64 rupee per rupee of cost (A2).

<b>S. No.</b>	<b>Particulars</b>	<b>Value in rupees</b>
1	Cost of production per hectare (Cost A2)	31698.00
2	Gross return per hectare	83632.00
3	Returns over cost A2 per hectare	51934.00
4	Return per rupee of cost A2	2.64

### **Acknowledgement**

This matter has been collated from original research work carried out at NRCSS and from research reports of other centres and also from AICRP on spices. It includes the following references.

1. Bhati, D.S. (2005). Advances in production technology of fenugreek. A course manual for winter school on Advances in Seed Spices Production at NRCSS, Ajmer during September, 2-22, 2005. p201-208.
2. Parthasarthy, V.A., Shiva, K.N. and Johny, A.K. (2005). Research and Development in seed spices under AICRPS. A course manual for winter school on Advances in Seed Spices Production at NRCSS, Ajmer during September, 2-22, 2005. P255-271.
3. Anandraj, M., Shiva, K.N. and Johny, A.K. (2007). Research and Development in seed spices under AICRPS. In Production, Development, Quality and export of Seed Spices by S.K. Malhotra and B.B. Vashishtha (Eds.). p370-395.
4. Malhotra, S.K. and Vashishtha, B.B. (2008). Package and practices for production of seed spices. NRC on Seed Spices, Tabiji Ajmer. pp. 98.
5. Malhotra, S.K. and Vashishtha, B.B. (2008). Organic production of seed spices. NRC on Seed Spices, Tabiji Ajmer. pp. 98.

# LETTUCE (*Lactuca sativa*)



# Lettuce(*Lactuca sativa*)

<b>Family</b>	<b>: Compositae</b>
<b>Chromosome No.</b>	<b>: 2n=16,18</b>
<b>Origin</b>	<b>: European-Siberian</b>

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

# Types of Lettuce

## 1. Head type (*L. sativa* var. *capitata*)

### I. Butter head type:

- Produces relatively small & loose heads.
- The outer leaves are green in colour
- Inner leaves are creamy or yellow which are oily, crumpled & soft texture.
- They do not withstand shipping and handling.



### II. Crisp head type:

- Popular in North America & European countries
- Brittle textured a tightly folded large heads (upto 1 kg).
- Excellent shipping & handling abilities.
- Leaves are wrinkled, non-wrapped and round.
- The outer leaves are green and inner leaves are very thin, crisp & soft.



## 2. Leafy or bunching type (*L. sativa* var. *crispa*)

- **Non-heading type.**
- **Colour of leaves varies from light green to red.**



## 3. Cos or romain type (*L. sativa* var. *longifolia*)

- **Plants are straight growing and about 25 cm in height**
- **Produces elongated leaves to form a loaf shaped head.**
- **The outer leaves are slimy & light green coloured**
- **Inner leaves are finer & light in colour.**
- **Coarse leaves with good eating quality.**



## 4. Asparagus or stem type (*L. sativa* var. *asparaginia*)

- Also known as celery lettuce.
- Produces thick stems which are consumed either raw or cooked as vegetable after peeling.
- The leaves are also edible but inferior in quality than other types.



Mixture of different types of lettuce



# Varieties

<b>White Boston</b>	<b>:</b>	<b>Butter head type</b>
<b>Dark green</b>	<b>:</b>	<b>Butter head type</b>
<b>Green lakes</b>	<b>:</b>	<b>Crisp head type</b>
<b>Great Lake, Imperial 859</b>	<b>:</b>	<b>Crisp head type</b>
<b>Slobolt, Chinese Yellow</b>	<b>:</b>	<b>Leafy type</b>
<b>PH-Lettuce</b>	<b>:</b>	<b>Stem type</b>

# For H.P.

<b>Alamo 1</b>	<b>:</b>	<b>Head type.</b>
<b>Simpson Black Seeded</b>	<b>:</b>	<b>Leafy type.</b>
<b>Eves Wonder</b>	<b>:</b>	<b>Heading type.</b>
<b>Ruby</b>	<b>:</b>	<b>Leafy &amp;purple</b>

# Climate

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

# Soil

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

## **Seed rate**

**400-500 g/ha**

**Leafy type is sown directly in the field**

## **Spacing**

**45 x 30 cm**

## **Planting time**

**N.I. Plains: September-October of nursery**

**Low hills : September-November**

**Mid hills : September-October**

**High hills: March-July**

# Manures & Fertilizers

FYM (q/ha)	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
	(Kg/ha)		
<b>100</b>	<b>60</b>	<b>40</b>	<b>40</b>

Method of application same as other leafy vegetables

## Irrigation

- ❖ **Immediately after transplanting**
- ❖ **Subsequently, irrigate the crop at an interval of 8-12 days.**

# Interculture & weed control

- 😊 **Shallow hoeing & weeding are essential to keep the field free from weeds & to maintain proper aeration.**
- 😊 **About 3-4 hand weeding at 15-21 days interval are sufficient.**
- 😊 **Pre-transplant application of Fluchloralin @ 1.0-1.5 kg/ha effectively controls most of the weed.**

# Harvesting

- ☀️ **The leafy var. become ready for harvesting within 50-60 days of sowing**
- ☀️ **Harvest when the leaves attain full size but remain tender.**
- ☀️ **Head type var. takes 60-70 days to harvest.**
- ☀️ **Heads are harvested when they attain a good size & become solid.**

## Yield

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

## Seed production

**Isolation distance: 25 m**

# PHYSIOLOGICAL DISORDER

## Tip burn

Tip burning of the lateral margins of the inner leaves of mature heads.

### Reasons:

- © High temperature, light intensity & long duration
- © Excess N
- © Ca & B deficiencies.
- © High Mn content.

### Management:

- © Spray the crop with  $\text{CaCl}_2$  @ 0.5%



## DISEASES

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

## INSECTS

Aphids: Spray oxydemeton methy@0.025% or malathion@ 0.05%

*Thank You*