

Cole Crops

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

Cauliflower

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

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

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

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

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

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

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

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

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

Nursery sowing

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

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

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

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

Spacing:

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

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

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

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

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

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

Yield (q/ha):

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

Physiological disorders:

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

3. **Fuzzyness:** It is the elongation of pedicels of the individual flower. Almost all the prefloral bud which develops precociously on the curd surface give the fuzzy appearance. The possible reasons for the occurrence of this disorder are same as that of receyness in cauliflower.
4. **Blindness:** Blind plants are those, which are without terminal bud. They do not form curd. It is due to poor fertility of the soil or damage to the terminal portion during handling at the time of planting or by insects, diseases *etc.* Healthy and vigorous seedlings with terminal portion intact should be planted.
5. **Bracting:** The bracts are underneath the prefloral meristem which corresponds to axillary buds. These bracts or leaves come out of the curd resulted in poor quality of curds for marketing as they turn green or purple in colour on receiving the direct sunlight at the surface of the curd. Temperature higher than the optimum during curding leads to this disorder.
6. **Purple colouring:** Some time various pigmentations develop on the curd which deteriorates the quality of the final produce. Fluctuations in the temperature are the main reason for this disorder.
7. **Whip tail:** It is caused by the deficiency of Molybdenum (Mo). Young plants become chlorotic and turn white particularly along the leaf margins. In older plants, the lamina of the newly formed leaves is irregular in shape and leaves have only a large bare midrib. This is because of this condition, the disorder is called as “Whip tail”. Apply molybdenum @ 1kg/ha to manage the deficiency.
8. **Browning (Red or Brown rot):** It is caused by boron deficiency. The stem become hollow with water soaked tissues surrounding the walls of the cavity. In more advance stages, a pinkish or rusty brown area develops on the surface of the curd

Cabbage

Botanical name:	<i>Brassica oleracea</i> var. <i>capitata</i>
Family:	Brassicaceae
Origin:	Mediterranean region
2n:	18
Edible portion:	Head

Varieties: White cabbage cultivars are divided into three groups on the basis of maturity of heads after transplanting. These are as under:

Early Group: It takes 55-70 days for maturity. The commonly grown varieties are Golden Acre, Pride of India, Copenhagen Market, Pusa Ageti, Pusa Mukta, Pusa Cabbage Hybrid-1 (KGMR-1).

Mid season Group: The cultivars fall between early and late maturity groups. September, and Pusa Drum Head are the common varieties from this group.

Late Group: It takes about 85-130 days for maturity *e.g.* Late Large Drum Head

Cabbages are classified into three broad groups:

White cabbage: It is the most commonly cultivated. Pointed, Round and Flat or Drumhead

Red cabbage – Leaves have distinct coat of wax and tolerant to diamond back moth.

Savoy cabbage – Blistered leaves and the shape is pointed round and flat

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

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

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

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

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

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

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

Late varieties: 60cm × 45cm or 60 cm × 60 cm

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

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

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

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

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

Knol Khol

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

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

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

Climate and Soil: It is mainly grown as a winter vegetable crop and thrives well in relatively cool moist climatic conditions. Seeds germinate well at 15-30°C. Optimum temperature requirement for its growth is between 15-25°C depending upon cultivars. It can be grown on all types of soil but sandy loam and clay loam are best soils for cultivation. It does not grow in acidic soil. pH of soil should be 5.5-5.8

Sowing and transplanting

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

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

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

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

Diseases and Insect-pests of cole crops

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

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

Management:

Use disease free seed.

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

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

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

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

Insect- pests:

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

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