CARROT

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

USES

- It is valued as a nutritive food mainly because of high carotene content.
- It is used as a salad, cooked and used in preparation of soups and stew etc.
- It increases the quality of urine and helps the elimination of uric acid.
- Black carrots are used for the preparation of a soft beverage called Kanji, which is supposed to be a good appetizer.
- Red type is good for preparing various types of sweets especially Gajar Halwa in northern India.
- Carrot seed oil is used for flavouring liquors and all kind of food substitutes.
- Carrot seeds are aromatic, stimulant and carminative.

CLIMATIC REQUIREMENTS

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

AREA AND PRODUCTION

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

SOIL

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

CULTIVARS

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

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

A. Classification based on shape of roots

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

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

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

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

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

B. Classification based on temperature response to flowering

1. **Temperate or European or biennial types:** These cultivars are biennial in characters and require low temperature (4.8-10oC) treatments for flowering to occur. These do not produce seeds in the plains of India, e.g. Nantes, Chantenay, Imperator, Danvers, Zeno, Oot-1, Pusa Yamdagni etc.

2. **Tropical, Asiatic or Oriental or annual types:** These cultivars do not require any low temperature treatment for flowering; they seed freely in the plains of India. Examples are Pusa Kesar, Pusa Meghali, Sel. No. 29 and Sel. No. 233.

Pusa Kesar:

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

Nantes:

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

Chantenay:

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

Danvers:

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

Imperator:

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

Pusa Yamdagni:

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

SOWING TIME

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

SEED RATE

- 5-6 kg/ha

SPACING

- 30 × 10 cm

Method of Sowing

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

NUTRIENT MANAGEMENT

- For getting good yield, 200-300q/ha well rotten Farm Yard Manure is thoroughly mixed in soil 15-20 days before sowing of seeds.
- Add 40-60 kg/ha N, 40-50 kg/ha P and 80-100 kg/ha of K.

- Half quantity of N and full quantity each of P and K and Farm Yard Manure should be applied at the time of sowing.
- Remaining quantity of N may be given 30-45 days after seed sowing.

IRRIGATION

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

INTERCULTURAL OPERATIONS

Thinning

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

Weeding

- Weeds are a serious problem and timely control of weeds is essential to avoid heavy loss in yield of top quality roots due to weed competition.
- Timely weeding, hoeing and earthing up therefore should be done.
- Generally two weedings at 15-20and 30-35days after sowing are sufficient to control the weeds.
- Pre emergence application of propazine@ 1.12kg/ha or Amiben@2.24-4.48kg/ha or Diuron and monuron@1kg/ha controls weeds very effectively.

HARVESTING

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

YIELD

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

DISEASES

Fungal Diseases

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

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

Control measures:

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

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

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

Control measures:

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

Powdery mildew : (*Erysiphe* spp.)

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

Control measures:

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

Viral Diseases

Carrot Yellows:

- First appear on leaves which become yellow sometimes accompanied by vein clearing.

- Dormant buds in the crown grow out into chlorotic shoots which give a “witches broom”' appearance on the tops.
- Older leaves are reddish, twisted and may eventually break off.
- The disease is transmitted by six spotted leaf hopper (*Macrosteles divisus*).

Control measures:

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

Root Diseases:

Watery soft rot: (*Sclerotinia sclertiorum*)

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

Gray mold rot: (*Botrytis cinerea*)

- The affected tissue is water soaked and light brown and later become spongy.
- Gray mold appear in moist atmosphere.

Black rot: (*Alternaria radicina*)

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

Control measures of root diseases:

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

Bacterial Diseases

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

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

Control measures:

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

PESTS

Carrot Rust Fly:

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

Control measures:

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

Aphids

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

Control measures:

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

Mustard saw fly: (*Athalia promixa*)

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

Control measures:

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

Physiological Disorders

1. Root splitting: Splitting or cracking of carrot roots is a major problem.

Possible Reasons:

- Wider spacing as larger roots tend to split more
- Dry weather followed by wet weather is conducive to cracking of roots.
- Increases as the amount of N in the soil increases.
- Early cultivars tend to split more readily than late ones.

Correction:

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

2. Cavity spot

- It appears as a cavity in the cortex. In most cases, the subtending epidermis collapses to form a pitted lesion.

Possible Reasons:

- Calcium deficiency associated with an increased accumulation of K and decreased accumulation of Ca.

Correction:

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

3. Forking:

- A common disorder in carrot and radish formed by the enlargement of secondary root growth

Possible Reasons:

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

Correction:

- Avoid excessive moisture
- Avoid heavy soil for root production

Method of Seed Production

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

Root to seed method

First Season:

- Mother roots production

Time of Sowing

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

Preparation of Field

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

Nutrient Management

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

Irrigation

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

Selection of roots for transplanting

- Uproot the plants when they have fully developed roots for making stecklings

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

Planting of selected roots

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

Method of replanting

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

Flowering and Seed Setting

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

Pollination

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

Isolation

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

Roguing

- Rouging should be done at three stages.

Early: check for off type foliage

Lifting and replanting: check for root characteristics like shape, size, colour, texture, sponginess, forked and cracked roots.

Flowering stage: check for isolation, diseased plants and weeds.

Harvesting and Threshing

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

Seed Yield and 1000 Seed Weight

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

SEED CERTIFICATION STANDARDS

A. Field Inspection

Mother root production stage

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

Seed production stage

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

1. Field Standards

a. General Requirements

Isolation:

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

Contaminants	Minimum distance (Meters)	
	Mother root production stage	Seed production stage

	Foundation	Certified	Foundation	Certified
Fields of other varieties of same species	5	5	1000	800
Field of same variety not conforming to varietal purity requirements for certification	5	5	1000	800

b. Specific Requirements

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

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

C. Seed Standards

Factors	Standards for each class	
	Foundation	Certified
Pure seed (minimum) %	95	95
Inert matter (maximum) %	5	5
Other crop seed (maximum) Numbers/kg	5	10
Total weed seeds (maximum) Numbers/kg	5	10
Other distinguishable var. (Maximum) Number/ kg	5	10
Germination (minimum) %	60	60
Moisture (maximum) %	8.0	8.0
For vapour proof containers (maximum) %	7.0	7.0