RADISH

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

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

Types:

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

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

Varieties:

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

A. European/ Temperate Type

They are quick growing and short duration type (25-30 days). Produce roots of good quality, less pungent and smaller in size. The important varieties belonging to this group are as follows:

White Icicle:

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

Pusa Himani:

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

Rapid Red White Tipped:

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

Scarlet Globe:

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

Scarlet long:

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

B. Asiatic or Tropical Type

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

Pusa Desi:

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

Japanese White:

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

Pusa Chetki:

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

Pusa Reshmi:

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

Kalyani White:

- Roots are pure white, 25-30cm long, uniform in growth and blunt tipped.
- It requires 45-50 days for maturation.

Kalyanpuri No. 1:

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

Naduani:

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

Chinese Pink:

- It has 12-15cm long pink coloured roots.
- The lower end of roots is white.

- Roots are crisp and mildly pungent.
- Roots mature in 50-55 days.

Hisar Mooli No 1:

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

Jaunpuri Mooli:

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

Punjab Pasand:

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

Punjab Safed:

- Developed by Punjab Agricultural University, Ludhiana, Punjab.
- Roots are long (30-40 cm), thick (3-5 cm), pure white, tapering, smooth, mild in taste, medium pungent with good flavour and free from forking.
- It is a quick growing type with roots remaining edible for 10 days after attaining full size.

Punjab Ageti:

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

SOIL

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

CLIMATIC REQUIREMENTS

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

SEED RATE

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

SPACING

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

SOWING TIME

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

Schedule of growing radish throughout the year in the plains

Variety	**Sowing time**	**Harvesting time**
Pusa Chetki	Early April-Mid August	Early May- September
Pusa Desi	Mid August- Mid October	Last week of September-Early December
Pusa Reshmi	Mid September- Mid November	Last October- early January
Japanese White	Mid October- Mid December	Mid December- Early March
Pusa Himani	Mid October- Mid February	Mid February- Mid April
White Icicle	Last October-end February	Late November- Early March

METHOD OF SOWING

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

NUTRIENT MANAGEMENT

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

IRRIGATION

- Irrigate the crop once in 6-7 days depending upon weather conditions.
- Before sowing, soil must be moist.
- Moist condition was found to be better than wet condition.
- A light irrigation is given after sowing.

- Uniform moisture through light irrigations before harvesting facilitates easy removal/pulling of roots from the soil.
- Uneven moisture supply causes harsh, fluffy and pungent roots.

INTERCULTURAL OPERATIONS

- One weeding should be given 15-20 days after sowing.
- Thinning of plants must be carried out 15-20 days after sowing keeping a distance of 5-10cm between plants in a row.
- Earthing up is also necessary to get well developed, quality and elongated roots as generally the growing roots tend to push out of the soil.
- Application of Pendimethalin @1.2 kg a.i./ha or Alachlor @1.5 kg a.i./ha or Fluchloralin (Basalin)@ 0.9 kg a.i./ha or Isoproturan @1.0 kg a.i./ha or metalachlor @1.0 kg a.i./ha in 750 litres of water as pre-emergence is very useful for effective weed control.

HARVESTING

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

YIELD

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

DISEASES

FUNGAL DISEASES

White rust: (*Albugo candida*)

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

Control measures:

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

Alternaria blight: (*Alternaria brassicicola*)

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

Control measures:

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

Powdery mildew:

- All plant parts are covered by white powdery growth.

Control measures:

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

VIRAL DISEASES

Radish mosaic:

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

Control measures:

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

PESTS

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

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

Control measures:

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

Flea Beetle : (*Phyllotreta* spp.)

- Flea beetle attacks leaves and makes small circular holes.

- They are active in sunny weather during spring.

Control measures:

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

Mustard saw fly : (*Athalia promixa*)

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

Control measures

- It sometimes causes severe damage to radish and turnip.
- Follow hand picking in kitchen garden and spray malathion (0.05%) or Endosulfan (0.05%).

PHYSIOLOGICAL DISORDERS

1. Akashin

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

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

2. Pore extent or pithiness:

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

Management: Harvesting should be done at appropriate time.

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

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

Management: Use of undecomposed organic manure is recommended.

SEED PRODUCTION

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

A. Temperate Varieties/ European types:

- Which produce satisfactory seed in the temperate hills by over wintering.
- These varieties flower very late in plains.

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

B. Tropical Varieties/ Asian types :

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

Methods of Seed Production

- Root to seed method
- Seed to seed method

Time of Sowing

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

Preparation of Field

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

Spacing

- 45 cm X 45 cm

Nutrient Management

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

Irrigation

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

Interculture

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

Selection of Roots

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

Preparation of stecklings from selected roots

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

Flowering and fruit setting

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

Isolation requirements

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

Roguing

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

Harvesting and threshing

- The crop is cut when plants are fully matured.
- Crop is cut with sickle and brought to threshing floor for threshing.
- There is more often difficulty in threshing the seeds from pods.
- The pod does not break easily to allow the seed to escape.
- It is therefore, important to thoroughly dry them before commencing the threshing.
- Radish pod do not dehisce even after maturity.
- Threshing can be done by beating with the sticks.
- Seeds afterwards should be dried to 6 per cent moisture before storage.

Seed Yield

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

SEED CERTIFICATION STANDARDS

1. Field Inspection

A. Mother root production stage

Minimum of two inspections should be made as follows:

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

B. Seed production stage

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

2. Field Standards
a. General Requirements
Isolation

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

	Foundation	Certified	Foundation	Certified
Fields of other varieties of same species	5	5	1600	1000
Field of same variety not conforming to varietal purity requirements for certification and for rat tail radish (*Raphanus caudatus*)	5	5	1600	1000

b. Specific Requirements

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

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

3. Seed Standards

Factors	Standards for each class	
	Foundation	Certified
Pure seed (minimum) %	98.0	98.0
Inert matter (maximum) %	2.0	2.0
Other crop seed (maximum) Numbers/kg	5	10
Total weed seeds (maximum) Numbers/kg	10	20
Germination (minimum) %	70	70
Moisture (maximum) %	6.0	6.0
For vapour proof containers (maximum) %	5.0	5.0