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Advances in Production Technology of Radish

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Introduction



Figure 1.1: Radish

The botanical name of carrot is *Raphanus sativus* which belongs to the family Brassicaceae having haploid chromosome number of x = 9 and is believed to be originated from Europe and Asia. Radish is one of the most ancient and popular leaf cum root vegetables in both tropical and temperate regions. Radish probably originated in Europe and Asia. Radishes were extensively cultivated in Egypt and ancient records show that radishes were eaten before the pyramids were built. It had spread to China during 500 BC and to Japan during AD 700. The recent study has indicated that east of Mediterranean region, most probably China is the centre of origin of radish. Wild state of radish is not known. Previously it was believed to haveevolved from a common weed *Raphanus raphanistrum* Linn in Europe but now it is believed to have been evolved from more a variety of sources. As it is a short duration annual or biennial crop, it can be widely used in sequence cropping, companion cropping and intercropping in widely spaced crops. Roots are pink in colour due to presence of anthocyanin pigment. The characteristic pungent flavour of roots is due to the presence of volatile alkaloid isothiocyanate.

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Nutritional composition

Radish is a rich source of Ascorbic acid containing 15 to 40 mg/100 g and has a wide variety of minerals. Pink skinned radish has higher ascorbic acid than white skinned radish. The pungent flavour of radish is due to the presence of volatile isothiocyanates. Major sugar present in radish is Glucose.

Nutritional composition of radish roots, tops and fruits (values are in 100 g edible portion)

Constituents	Radish roots		Radish tops	Radish fruits
	White varieties	Pink varieties		
Moisture (g)	94.4	90.8	90.3	90.5
Protein (g)	0.7	0.6	2.7	2.3
Fat (g)	0.1	0.3	0.6	0.3
Fiber (g)	0.8	0.6	0.9	1.4
Carbohydrate (g)	3.4	6.8	3.4	4.7
Minerals (g)	0.6	0.9	2.1	0.8
Calcium (mg)	50	50	310	80
Phosphorus (mg)	22	20	60	100
Iron (mg)	0.4	0.5	16.1	2.8
Vitamin A (IU)	50	50	18.66	50
Thiamine (mg)	0.06	0.06	0.03	0.07
Riboflavin (mg)	0.02	0.02	0.16	0.05
Nicotinic acid (mg)	0.5	0.4	0.3	0.2
Vitamin C (mg)	15	17	103	69
Energy (kcal)	17	32		

Source: Aykroyd (1963); Gopalan *et al*. (1982); Bose and Som (1986); Hazra and Som (1999)

Uses

Radish commonly known as muli is known for its young tender roots which are eaten raw as salad or cooked as a vegetable. Radish is a common pungent ingredient used in various abdominal disorders and considered as an appetizer. Leaves are also cooked as a vegetable. Radish is useful for liver and gallbladder troubles. They are also used in neuralgic headaches, sleeplessness and chronic diarrhoea in homeopathy. Roots, leaves, flowers and pods of radish are very effective against gram positive bacteria. (Kirtikar and Basu, 1935). All parts of the plant are used in medicine. The seeds are expectorant, digestive, diuretic, laxative and carminative and the root extracts has been reported to have anti-urolithiatic properties. (Alqasoumi *et al.,* 2008).Pocasap *et al.* (2013) reported that the extract of thai rat tail radish showed cancer preventive effect.

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Botany

Botany is the scientific study of plants, and the botany of radishes is concerned with the growth, structure, function, and classification of the radish plant. Radishes belong to the family Brassicaceae and are classified as *Raphanus sativus,* Radishes are native to the Mediterranean region but are now grown in many parts of the world. Radish is an annual or biennial depending on its ecotype. Edible portion of radish develops from primary root and hypocotyl. The rosette leaves of radish are pinnatified, lyrate and are in various sizes *viz.,* 10 to 15 cm in cultivars with small roots and 45 cm in cultivars with large roots. Its inflorescence is a typical terminal raceme. Flowers are small, usually white in colour. Sepals are erect and 4 in number. Fruit type of radish is siliqua. The ripe and mature seeds are yellow and as they age, they turn reddish brown. Radish is highly cross-pollinated because of the presence of sporophytic self-incompatibility. It is mainly pollinated by Honey Bees. Bud pollination is used for selfing in radish. Flower buds are pollinated two days before they open by collecting the pollen from the flowers of same plant which are previously bagged.

The radish plant has an edible root, which is usually white with a pink or red exterior, and edible leaves that are often used as a cooking green or in salads. The root of the radish is the main part that is harvested, and it contains a high level of water and a crunchy texture. The radish plant is a fast-growing crop that is relatively easy to grow in well-drained soil and full sun. The seeds are usually sown directly in the ground and germinate quickly, producing a mature plant in as little as four weeks. The leaves of the radish plant are generally green, and the flowers are small and white or yellow, depending on the variety. In conclusion, the botany of radishes encompasses the growth, structure, function, and classification of this important plant species. Radishes are a fast-growing, easy-to-grow crop that is both nutritious and versatile, and have been cultivated for thousands of years for their culinary and medicinal uses.

Taxonomy

According to Banga (1976), there are four types of radish cultivars in various regions of the world are as follows

i) small, cool season radish

ii) large radish with wide range of temperature adaptation

iii) Rat-tail or mougri radish forming no fleshy root but forming long slender (20-60 cm) pods.

iv) Fodder radish also producing no fleshy root. All four types of radish belong to the species *Raphanus sativus* L. with 2n=18, and botanically they are

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known as varieties *radicula, niger, mougri (*or*caudatus*) and *oleifera*, respectively. All the four types inter cross freely with each other and also with related wild species.

Cultivated radishes are put under 3 different species based on the plant morphology and ecological requirements.

i) ***Raphanus indicus***: These are Indian types which are heat-tolerant, pungent, and mostly used for pickle- making.

ii) ***Raphanus sativus***: These are European types which are frost-tolerant, rich in carotene, long-day plants, and strictly annuals.

iii) ***Raphanus sativus***: These are Japanese types which are intermediate to Indian and European types, growing in the coastal regions of Japan and neighbouring regions, and turnip-shaped giant radishes cultivated in Sakurajima Island of Japan.

Turnips are classified into the following categories

Rank	**Scientific Taxonomical Details**
Kingdom	Plantae
Subkingdom	Tracheobionita
Superdivision	Spermatophyta
Division	Magnoliophyte
Class	Magnoliopsida
Group	Dilleniidae
Order	Brassicales
Family	Brassicaceae
Genus	*Raphanus*
Species	*Raphanus sativus* L.

Soil and Climate

Radishes can be grown in all types of soils, but the best results are obtained in deep, well drained, light, friable loam soil that contains ample humus. Since it is a short duration crop, it can be grown on soils that are not considered satisfactory for other root crops. For early crop, sandy or sandy loam soils are preferred; however, for summer crop a cool and moist soil gives best result. Usually, heavy soils produce rough, ill-shaped roots with a number of small fibrous laterals, and such soils should be avoided.

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Field preparation

The soil should be deeply ploughed and harrowed to make it friable and free from clods. Organic manures are very useful for making the soil fit for development of roots. 20 to 25 tonnes of well rotten farm yard manure should be applied during land preparation about 20 to 25 days before sowing. Amount of farm yard manure may vary depending upon the availability of NPK in the soil.

Commercial Varieties

There are many commercial varieties of radish available, which are developed to meet specific market demands and growing conditions. Some popular commercial varieties of radish include:

Asiatic type varieties

Their crisp, juicy texture and are often used in salads, sandwiches, and as a garnish. Some Asiatic type varieties of radish are characterized by their elongated or cylindrical shape and a crisp, juicy texture. They typically have a white, red, or black skin and a white, red or purple flesh. They are generally larger in size and have a more intense, spicy flavour compared to European type radishes. Asiatic type varieties of radish are typically faster to bolt (forming seed stalks) than European types, which means they are better suited to the summer planting. They are also known for their large size and intense, spicy flavour, making them ideal for use in pickling and stir-fries. These varieties are also popular in Asian cuisine, where they are often sliced thin and eaten raw as a garnish or condiment. In general, Asiatic type varieties of radish are known for their large size and intense, spicy flavour, making them ideal for use in pickling and stir-fries. They also come in a variety of shapes and colours, and are popular in Asian cuisine. These radishes are also known for of the most popular Asiatic type varieties include:

1. Pusa Chetki: It is more tolerant to high temperature and can flourish during the hot months. In southern and western parts of India, it can be grown round the year. The roots are pure white, smooth, very soft in texture, mildly pungent in taste, medium long, and thick in size, and almost stumpy in shape. The average length of roots ranges from 12 cm in summer to 20 cm in early monsoon season. Growing period is from April to early September and its best growing period is from July to early September. This variety becomes ready for harvesting in 40-45 days after sowing and yields 20 to 25t/ha.	

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2.Pusa Desi: It is a derivative from mass selection. Developed for growing during *kharif* season in north Indian plains and can be grown from middle of August to middle of October. Roots are pure white, mildly pungent, 30 to 35 cm long with green stem end. It becomes ready for harvest 50 to 55 days after sowing.	
3. Pusa Reshmi: It is developed at Indian Agricultural Research Institute, New Delhi. It is suitable for sowing in cooler months from mid-September to early October. Roots are white, slightly pungent, 30 to 35 cm long with green shoulder. Crop duration is 55 to 60 days.	
4. Japanese white: It is developed through introduction at IARI Regional Station, Katrain. Suitable for sowing between October to December in plains and September in hills. Roots are white, 20 to 30 cm long, cylindrical, slightly pungent with green shoulder. It yields about 15 to 30 t/ha in 60 to 65 days after sowing.	
5. Punjab Agethi: It is developed at PAU, Ludhiana. Roots are medium sized, red skinned at the top and white skinned at the lower half, less pungent, smooth surfaced with few hair. The best suitable variety for sowing from April to august. The average yield is 37 t/ha.	
6. Punjab safed: It is developed at PAU, Ludhiana from a cross between 5-white and Japanese White. The roots are white with green shoulder, 30 to 45 cm long, mildly pungent, smooth with no hair, tapering into a semi blunt tip and free from forking. Suitable for September to October sowing. It is quick growing and takes 50 to 60 days from sowing to harvesting.	
7. Punjab Pasand: This variety has been developed by repeated crossing of selected plants from a base population of cv.Pusa Chetki. Roots are long, pure white, semi-stumped, free from hair and suitable for sowing in October and November. It is a main season and quick growing variety attaining marketable maturity within 40 days after sowing with a root yield of 53t/ha.	

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8. Kalyanpur White: It can be grown all-round the year except during summer months. The roots are pure white, mildly pungent, 25 to 30 cm long, uniform in size with blunt end and white top. Matures in 45 to 50 days after sowing.	
9. Kalyanpur No-1: Roots are white with green shoulders, 22 to 23 cm long and tapering.	
10. Chinese pink: This variety has 30 to 40 cm long shining red and smooth surfaced roots with semi blunt end. The root flesh is white, crispy, mildly pungent and solid. It takes 50 to 55 days for root formation. This variety grows well in plains under mild climate.	
11. Arka Nishant: It is an improvement over a collection IIHR-72 from Singapore developed at IIHR, Bangalore after 10 cycles of mass selection. It has long, marble white, mildly pungent and crisp textured roots which do not develop pithiness. It is resistant to premature bolting, root branching and forking. It sets seeds freely in plains. It is a multiple disease resistant variety of radish.	
12. CO-1: This was developed by TNAU, Coimbatore. Roots are milky white, cylindrical and 23 cm long. It is a short duration variety of 45 days with root yield of 22 t/ha.	
13. Kashi Aardra: Developed from IIVR, Varanasi in 2019. Suitable for sowing during mid-September to mid-December. Roots are attractive white in colour, long and icicle in shape. Sowing time is Rabi. Roots are ready to harvest in 40 to 45 days after sowing. It yields about 24 to 40 t/ha.	
14. UHFR-12-1: It is developed in 2019. Roots are round to slightly tapering, 10 to 12 cm in length and white in colour, weighing about 180 to 200 g at edible maturity. Roots are ready to harvest in 55 to 60 days after sowing. It yields about 35t/ha.	
15.Pusa Gulabi: Entire pink fleshed variety with average yield of 35 t/ha. High total carotenoids, anthocyanins (3.93 mg/100g) and optimal ascorbic acid.	

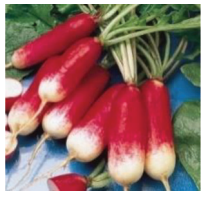
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16. Pusa Jamuni: First purple fleshed variety with average yield of 30 t/ha. Rich in anthocyanins (8.51 mg/100g) and ascorbic acid. Useful in the purification of the blood and eliminate toxins, waste and useful in treating jaundice.	
17. **Kashi Lohit:** It is a variety of radish have roots with an eye-catching red hue and an icicle-like form. They are ideal for use in salad dressings and contain high levels of antioxidants, which are up to 100% higher than those found in white radish. Additionally, these radishes are a good source of anthocyanin and phenolic content and have a low risk of becoming tough or fibrous. The root yield for these radishes is estimated to be between 40-45.0 tons per hectare.	
18. Kashi Mooli-40: The Kashi Mooli-40 variety of radish is well-suited for summer cultivation and can withstand high temperatures (35-42 °C). It is less prone to bolting and has a low risk of becoming tough or fibrous. The roots have an icicle shape and a beautiful white color. Under normal conditions, this radish has a root yield of 30-35 tons per hectare, but this may decrease to 20-23 tons per hectare during the summer season. The recommended seed rate is 5-6 kilograms per hectare.	

European type varieties

European varieties of radish are characterized by their round or oblong shape, smooth skin and a mild, slightly spicy flavour. They typically have a white or light-colored flesh and are relatively small in size, with a diameter of 2-3 inches. European type radishes are typically slower to bolt (forming seed stalks) than other types of radishes, making them a good choice for spring and fall plantings. They are also less prone to becoming woody or tough, which makes them ideal for fresh eating. In general, European -type varieties of radish are known for their mild, slightly spicy flavour and crisp, white flesh, and are a versatile choice for salads, sandwiches, and garnishes. They are also relatively small in size and have a smooth, round or oblong shape. Some of the most popular European type varieties include:

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1. Pusa Himani: This variety was developed at IARI Regional station, Katrain. The roots are pure white, 30 to 35 cm long, crisp, sweet flavoured with mild pungency, semi stumped to tapering with green shoulders. It is suitable for growing throughout the year except winter months in hills. It becomes ready for harvest in 55 to 60 days after sowing and yields about 32 t/ha.	
2. White Icicle: This variety was developed at IARI Regional Station, Katrain. It is an extra early European cultivar, which becomes ready for harvest in 25 to 30 days. Roots are pure white, smooth, thin, medium short, icicle shaped, straight, tapering and bright red with white tip. Roots become pithy within a week after attaining maturity which is a main disadvantage of this cultivar.	
3. Scarlet Globe: It is a quick growing variety. Roots are bright red in colour, round, small with white flesh. It takes 25 to 30 days for harvesting from sowing.	
4. Scarlet Long: It is a table type variety introduced from Europe. Roots are long, tapering with red skin and crispy white flesh. It takes 25 to 30 days to attain maturity after sowing.	
5. French Breakfast: Roots are olive like with red skin and white tips. Flesh is crunchy, mild and sweet in taste.	
6. Rapid Red White Tipped: It is an extra early European cultivar which matures in 25 to 30 days. This cultivar is suitable for spring summer sowing. Roots are small in size, round, smooth, bright red in colour with white tip, flesh is pure white, crispy and snappy and produce short foliage.	

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7. Japanese White: This is an introduction from Japan. Roots are snow white, smooth, thick, cylindrical and stumpy with 22 to 25 cm length and 5 cm diameter with pure white, crispy and mild pungent flesh. It matures in 45 days after sowing.	
8. Kashi Sweta: It is a selection made at IIVR, Varanasi from Chetki population. Roots are 25 to 30 cm long, straight and tapering with pointed tip. It takes 30 to 35 days for harvesting from maturity and yields about 45 t/ha.	
9. Pusa Mridula: Suitable for growing in kitchen gardens, container gardens as well as in per-urban areas for higher return. Mature in 28 to 32 days with average yield of 13.5 t/ha. It help to fight against cancer, heart disease and stroke.	

Seed rate and Seed treatment

8 to 10 kg seed of tropical varieties and 10 to 12 kg seed of temperate varieties is sufficient for sowing in a1-hectare area. It has been found that germination is influenced by seed size. The highest germination percentage (81 to 87%) was observed in medium-sized seeds weighing 1.38 g/100 seed in radish cv. *Punjab Safed* (Gill and Singh, 1979).

Hardening of radish seeds by two cycles of wetting and drying improves germination. Seed treatment with GA_3 gives better germination of radish seeds.

Sowing and transplanting

Generally small seeded vegetables respond well to nursery raising and transplanting as they generate numerous fibrous roots after transplanting. In contrast bold seeded vegetables and root vegetables don't respond well to transplanting because once their embryonic roots are damaged, they fail to develop lateral fibrous roots. Because of its tap root system and it is a root crop, the radish seeds are directly sown in the field. Lavanya *et al.* (2014) found that early sowing on 1st October with the closer spacing of 45 cm x 10 cm performed well in respect of yield.

Nutrition Management

Tripathi *et al.* (2017) reported that higher level of Nitrogen fertilizer and spacing maximises the ascorbic acid content and total soluble solids in radish var Kashi Sweta. Khalid *et al.* (2015) reported that the combination of organic, inorganic and biofertilizers has given best result and recommended dosage

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is NPK @ 80:60:60 kg/ha, FYM @ 20tones/ha and PSB@5kg/ha for radish. MSM Imthiyas and TH Seran (2017) have revealed that 20t/ha compost alone or 10 t/ha compost with half dose of NPK fertilizers as basal application with topdressing is the best choice for increasing the marketable tuber yield of radish. Poudel *et al.* (2018) revealed that 250 kg/ha of Nitrogen was optimum for better yield. Cong *et al.* (2015) reported that B deficiency severely affected the rhythmic stomatal closing and opening, preventing the normal functioning of stomata. Kushwah *et al.* (2020) stated that the application of 75 % NPK + 25 % nitrogen through vermicompost showed highest growth, yield and better return in radish.

Irrigation

Irrigation is an essential factor in the growth and development of radish. Adequate and proper irrigation helps to provide the right amount of moisture to the root system of the radish plant, which is crucial for its growth and health. Inadequate irrigation can lead to wilting, stunted growth, and reduced yields. The frequency of irrigation depends on various factors such as weather conditions, soil type, and the stage of growth of the radish plant. During the early stages of growth, radish plants need to be kept moist but not waterlogged. Over-irrigation can lead to waterlogging, which can cause the roots to rot and result in plant death. In the later stages of growth, the frequency of irrigation can be reduced as the radish plants become more drought tolerant.

When irrigating radish, it's important to avoid wetting the foliage, as this can encourage the growth of disease-causing organisms. Drip irrigation or micro-irrigation systems are effective methods for irrigating radish as they can be used to deliver water directly to the root zone of the plant. This helps to conserve water and reduce the risk of disease. It's also important to ensure that the soil around the radish plants is well-drained, as standing water can also lead to root rot and plant death. If the soil is heavy or clay-like, it may be necessary to incorporate organic matter such as compost or peat moss to improve drainage. In conclusion, proper irrigation is a crucial factor in the growth and development of radish plants. Adequate and appropriate irrigation helps to provide the right amount of moisture to the root system, while avoiding waterlogging and disease. It's important to be mindful of the weather conditions, soil type, and stage of growth when irrigating radish to ensure optimal growth and yields.

Weed Management

Regular weeding should be done to control the seasonal weeds. Generally, two to three weedings are done to keep the field weed free throughout the growing season. Light hoeing can also be done to facilitate the proper root growth.

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Intercultural Operations

1. Thinning

Thinning is the removal of excess seedlings which is an important operation to maintain desired plant population. It also reduces competition for light, water and nutrients between seedlings. It is done twice to provide proper conductive conditions. In first thinning the diseased and weak seedlings are removed to a distance of 3 to 4 cm between seedlings and in second thinning excessive seedlings are removed to a distance of 6 to 8 cm within the row.

2. Earthing up

Long rooted radish types often have green shoulders because the spreading roots tend to push through the soil's surface and get exposed to the sun. Additionally, the area that has been exposed to the sun develops a harsh texture, which is not at all a desired character. So, to prevent the root shoulders from excessive heat and greening effect of sunrays proper earthing up is essential. This is done during the early stages of crop when roots start developing. Soil required for covering the root should be taken and placed at the base of the plant**. Sandhu (1986)** reported that one weeding and one earthing is needing during early crop growth for better development of the roots.

Physiological disorders and their management

1. Pithiness

Symptoms: It is characterised by the formation of air spaces in the root, which will eventually leave it spongy, dry, and hollow. Such roots are poor in quality and unfit for consumption.

Causes: Pithiness is governed by genetic factors. It increases markedly with the increases in plant age due to delay in harvesting. It is seen both in field and in storage.

Management: Timely harvest of roots without any delay. Excessive fluctuations in the climate should be avoided. Avoid drought stress or excessively high temperature at the end of the crop growth.

2.Forking

Symptoms: It is a condition where vertical growth of the root is inhibited and results in forking. It is an undesirable character as it deteriorates the quality and market value of the roots.



Causes: It is a feature of clay and hard soil. Presence of unrotten organic matter or any plant refuse causes forking by inhibiting downward growth of roots.

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Management: Application of fully decomposed organic matter. Growing of radish in deep, well drained loamy soils. Cultivating resistant varieties like Punjab Safed, Arka Nishanth

3. Splitting



Symptoms: Cracks are caused in the roots of radish which results in splitting.

Causes: Heavy rainfall after a long dry spell. Wide difference in temperature in later stages of root development. Boron deficiency also causes splitting. It is a problem in large rooted varieties

Management: cultivating of resistant varieties like IiHR-1-1, Arka Nishanth

4. Freezing injury

Radish is susceptible to freezing injury. Ryall and Lipton (1972) reported that freezing followed by thawing causes the injured tissue to appear translucent. In severe cases, root softens, loose moisture quickly and shrivel. Parsons and Day (1970) stated that in red radishes the pigment oozes out of the roots with moisture, leaving them yellowish and bleached.

5. Akashin

Symptoms: The growth of the root is checked.

Causes: It is majorly caused due to Boron deficiency. It is also induced by the fluctuation of day and night temperature as well as by low soil moisture.

Management: Borax spray

Major insect pest and their management

1. Aphids: *Myzus persicae*, *Brevicoryne brassicae*, *Lipaphis erysimi*

Aphids are the most destructive type of sucking pest of radish crop. It attacks all the crop plants of Brassicaceae family and survives on the alternate host around the year. It attacks both seedlings and mature crop. They suck sap from the ventral surface of the tender leaves reducing the plant vigour and yield. They excrete honeydew on which sooty mould develops and hinders the photosynthetic activity. It attacks crop at seedling stage, flowering stage and pod formation stage. In case of severe infestation, the plants are completely devitalised, leaves and shoots curl up, become yellow and finally die. Cloudy and humid conditions favour the multiplication of aphid population.

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Control

- Remove and destroy the plant portion attacked by aphids.
- Spray the crop with water with pressure.
- Spray the crop with systemic insecticides @ 0.1% Metasystox, Rogor etc

2.Mustard sawfly: *Athalia proxima*

It is one of the common pests of radish and turnip. It attacks crop in both vegetative and flowering stage. The grub feeds on leaves and fruits and make holes by biting them thus damaging the crop. It attacks crop late in the growing season.

Control

- In small areas, hand-picking of larvae is done.
- Dusting the BHC @ 25 to 30 kg/ha is recommended.
- Spray the crop with Carbaryl 0.1% Malathion 0.05% or Dichlorovos 0.05%.

3. Flea beetle: *Phyllotreta* sp.

This may be the most serious pest in some areas. It damages the crop during vegetative stage by biting the leaves and making circular holes in them. It becomes very active in sunny days during the spring months.

Control

- Phyto-sanitary conditions should be adopted.
- Alternate host should be removed from the surroundings.
- Spraying the crop with 0.1% Malathion or 0.4% Sevin at 15 days interval.

4. Root lesion nematode:*Pratylenchus penetrans*

For controlling the population density of root lesion nematode, *Avenastrigosa* was considered to be the most effective antagonist plant.

Major diseases and their management

1. Damping off: *Rhizoctonia solani*, *Pithium* sp. *Fusarium* sp. and *phytophthora* sp.

Fungus attack the crop at seedling stage. In pre-emergence damping off, before the seeds emerge from the soil surface in the early stages of germination, the growth points are killed. In post emergence damping off, due to collar rotting

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and rapid shrinking of cortical tissue of hypocotyl, the infected seedlings fall down on the ground.

Control

- Long crop rotation should be followed
- Good drainage is required.
- Seed treatment with any copper fungicide like Agrosan GN, Thiram or Foltaf @ 2g/kg of seed or hot water treatment at 50°C for 30 minutes before sowing.
- Soil drenching with 0.1% Captan solution when attack is observed.
- Shallow sowing of seed to give the seed a better aerobic condition.
- Avoid overcrowding of seedlings by manual thinning.

2. Alternaria blight

It is a common disease in rainy season. Fungus affects every part of the plant like leaves, stem, pods and seeds. Slightly raised lesions first appear on leaves, stem, pods and seeds. These lesions enlarge many times as they get older. Concentric rings develop in the necrotic tissue giving a target board like appearance. The disease is seed borne. The infected seeds germinate poorly (Mc Lean, 1947), and hot water treatment or any fungicidal treatment will not improve the germination. Warm, moist, cloudy weather and abundant soil moisture conditions favours the occurrence of this disease.

Control

- Use of disease-free, good quality seed.
- Follow long crop rotation.
- Seed treatment with any copper fungicide like Agrosan GN, Thiram, or Foltaf @ 2g/kg of seed.
- Spray the crop with Blitox 0.4% blitane 0.5% captan 0.3% or Bavistin 0.1% to control the disease.

Yield

Yield varies from cultivar to cultivar. Average yield of Asian cultivars ranges from 15 to 20t/ha and European cultivars ranges from 5 to 7 t/ha.

Harvesting and post-harvest Management

Generally, harvesting is done by lifting the roots up and to facilitate this, light irrigation is given a day before harvesting. Radish reaches maturity 25 to

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60 days after sowing depending upon the variety. Early maturing European varieties take 25 to 30 days and Asiatic varieties take 40 to 60 days to reach maturity after sowing. Roots become bitter and pithy if harvesting is delayed. The harvested roots are washed, graded and tied in bundles and transported for marketing. The radish should ideally, be of uniform and similar shape for the variety, well formed, smooth, firm but of tender texture. It should also be free from harvest damage, decay, disease or insects. Bunched radish tops should be fresh in appearance and turgid. Radish cannot be stored at room temperature for more than 2-3 days. However, in cold storage, O topped radish if packed in a polybag with few holes for aeration, can be stored at 0 ^{0}C with 90-95 % relative humidity for about 2 months. Chandra *et al* (2018) found that HDPE film packed roots at 0 degrees Celsius exhibited longer shelf life (more than 2 months).

Modern Technology relevant to vegetable crops

Protected cultivation is one of the modern technologies which creates a favourable environment for the sustained growth even in adverse climatic conditions. This becomes relevant to the farmers of small land holding to produce more crops especially in during the off season when the prices are higher. Protected cultivation has very high entrepreneurial value and profit maximisation leading to local employment. Precision application of water and nutrients is possible through drip fertigation to attain very high crop water and nutrient use efficiency. Hasan *et al* (2019) stated that to reduce the postharvest losses of vegetables, drying of the produce can be done. Drying of vegetables through conventional approaches like sun or open-air drying found a slow process and may lead to the inferior quality product due to contamination. Various advanced drying techniques such as solar, microwave, vacuum, infrared, freeze, oven drying, and different hybrid drying technologies have been developed around the globe as being successfully used for various vegetables.

Rooftop gardening of root vegetables

Rooftop gardening of root vegetables using modern technology is a growing trend in urban areas as people look for ways to grow their own food in limited spaces. With the advent of new and improved tools, materials, and techniques, rooftop gardening has become an increasingly accessible and sustainable option for growing a variety of crops, including root vegetables. One of the key modern technologies used in rooftop gardening is hydroponics, which is the practice of growing plants in water rather than soil. This method not only saves space, but it also eliminates the need for soil, which can be heavy and take up valuable real estate on a rooftop. Additionally, hydroponic systems

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can be designed to be highly efficient and controlled, ensuring that the plants receive the exact amount of nutrients, water, and light they need to grow.

Another important technology in rooftop gardening is the use of smart systems and automation. For example, there are sensors that can monitor moisture levels in the soil and automatically water the plants when necessary. There are also systems that can track sunlight exposure, temperature, and other environmental factors, and adjust accordingly to provide the optimal growing conditions for the plants. Finally, the use of efficient, compact, and lightweight containers for growing root vegetables is another key aspect of modern rooftop gardening. These containers can be easily transported and set up on a rooftop, allowing even apartment dwellers to get in on the action.

In conclusion, rooftop gardening of root vegetables using modern technology offers a unique solution to the challenges faced by urban farmers, providing a way to grow fresh, healthy food while also reducing the environmental impact of traditional agriculture. With the right tools, techniques, and materials, anyone can start their own rooftop garden of root vegetables and enjoy the benefits of growing their own food in an urban setting.

Future Prospect

Radish is an important crop that is widely cultivated for its edible root, which is high in vitamin C and other nutrients. It is a fast-growing crop that can be harvested in as little as 4-6 weeks, making it an ideal crop for use in intercropping systems, rotation with other crops, or as a catch crop. It is a versatile crop that can be grown in a variety of soil types and climates and is relatively easy to cultivate. In terms of future prospects, crop improvement efforts are focused on developing new varieties of radish that are more resistant to disease, pests, and extreme weather conditions. This can be achieved through traditional breeding methods, such as crossbreeding, or through the use of modern biotechnology techniques, such as genetic engineering. Additionally, research is also being conducted to improve the nutritional content and taste of radish. For example, breeding radish varieties with high levels of antioxidants or other beneficial compounds, or developing radish varieties with a sweeter or milder flavour. Another important future prospect for radish is the use of precision farming techniques. These techniques, such as precision nutrient management and precision irrigation, can help farmers optimize the use of resources and improve crop yields. Precision farming technologies can also help farmers to minimize the use of chemical inputs, such as fertilizers and pesticides, which can help to reduce costs and environmental impact. In addition, radish is also a great crop for biofortification, for example, breeding radish varieties with high levels of micronutrients such as zinc, iron, and vitamin A, to help combat

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nutrient deficiencies in developing countries. This will be especially important in regions where nutrient deficiencies are prevalent and where traditional food sources may be limited or unavailable. Overall, radish is a valuable crop with many potential uses, and ongoing research and development efforts are likely to continue to improve the crop and its potential in various field. Radish is a versatile crop that can be grown in a variety of soil types and climates, and is relatively easy to cultivate. With the right research and development, radish could become an even more important crop in the future, helping to feed a growing global population and improve the nutritional health of people around the world.

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