

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

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

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

RADISH



Fig. 14. Radish

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

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

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

Botany

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

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

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

Breeding

Radish is a cross-pollinated crop. The commonly adopted procedures for breeding are mass selection, recurrent selection, hybridization and heterosis. The F₁ hybrids are produced by single crosses, or double crosses. Transgression of useful traits is possible by wide interspecific crosses between *Raphanus* and *Brassica* species by protoplast fusion and genetic engineering. These aspects are important for developing commercial cultivated species of the crop. Some studies on pollen morphology and physiology in radish have been reported. Different useful strains of Asiatic types have been reported from different regions of the country. A good number of temperate and Asiatic varieties were also introduced and some of them have been grown as commercial varieties for decades, but their seed production has been possible only in Kashmir, Kullu Valley and Nilgiri Hills. Usually the Asiatic types are more pungent than the temperate ones. Attempts have been made to improve upon the Asiatic strains by crossing with the exotic varieties to obtain new varieties with root qualities of temperate types and ability to produce seeds in the plains. An important achievement in this direction has been the release of the new radish variety 'Pusa Himani'. Emphasis has also been laid on developing varieties resistant to diseases. 'Arka Nishant', is the variety developed at IIHR, Bengaluru in 1972 which produces high yield with the better quality roots in the southern region. Male sterile line has also been used for hybrid seed production in other countries. In radish Ogura sterile cytoplasm is widely distributed in wild Japanese radish (Nath *et al.* 2002).

Improved cultivars

Asiatic cultivars

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

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

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

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

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

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

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

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

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

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

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

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

European cultivars

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

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

Climate and soil

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

Cultural requirements

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

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

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

Intercultural operations

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

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

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

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

Pest and disease management

Diseases

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

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

Insect pests

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

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

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

Harvesting and yield

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

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

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

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

Seed production

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

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

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

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

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

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

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

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

TURNIP

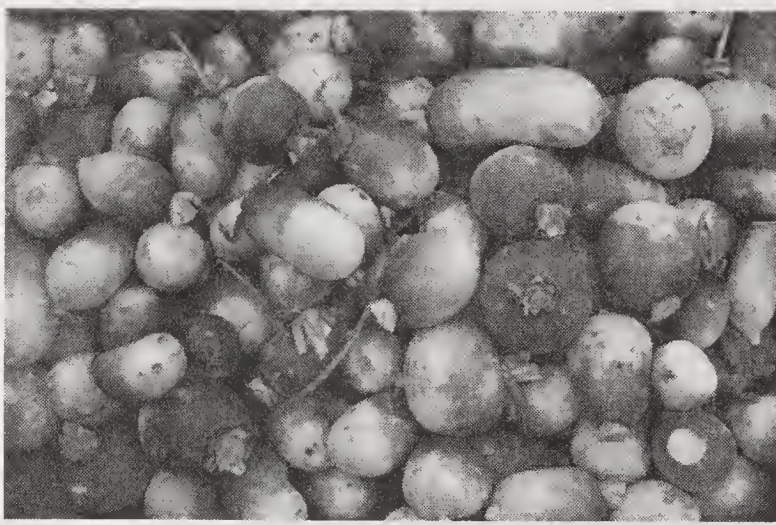


Fig. 15. Turnip

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

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

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