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Cultivation of Sprouting Broccoli

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Broccoli (*Brassica oleracea L. var. italica*) is a member of the Cole crop. This group related crops like Cauliflower, Cabbage, Kale and Knol -khol. Broccoli is grown in the cold season for its green flower heads. Broccoli has large flower heads that are usually green in color. Broccoli is a high-quality vegetable for fresh use and one of the most popular frozen vegetables and hotels. It is a highly nutritious crop with high amounts of vitamins (A and C) and minerals (Ca and Fe). Apart from this, it also contains thiamine, riboflavin and niacin. Broccoli is the richest source of protein among Cole crops. High intake of broccoli has been found to reduce the risk of cancer (because it contains the compound glucoraphanin) and may also prevent heart disease. India is the second largest producer of broccoli after China, while the US ranks third. It is also used as a vegetable in many other countries like Spain, Mexico, Italy, France, USA etc.

Origin and Distribution

Broccoli is native to the Mediterranean region. Broccoli is a variety of wild cabbage. Wild cabbage originated along the northern and western coasts of the Mediterranean Sea, where it was apparently domesticated thousands of years ago (Sherry, 1972; Heywood, 1978).

Family

The broccoli is belongs to family 'Brassicaceae' (formerly Cruciferae), also known as the 'mustard family or cabbage family'. The family includes species of great economic importance, providing most of the world's winter vegetables. These include cabbage, broccoli, cauliflower, Brussels sprouts, collards, and kale, Chinese kale, etc.

Major Varieties

Broccoli varieties differ primarily in head size and shape, time to maturity, side shoot production, and disease resistance. Similarly, the other cool-season vegetable, broccoli, also has 'early and mid-season

varieties. Early varieties mature in 50-60 days, while mid-season varieties mature in 60-75 days after transplanting. Three types of broccolis are commonly grown, namely cola berry, sprouting, and purple broccoli (Herbst, 2001).

Calabrese broccoli has large (10 to 20 cm) green heads and thick stalks. Also known simply as 'broccoli', it is grown as a cool season annual crop.

The purple cauliflower head is shaped like a cauliflower, but has smaller flower buds. It is sometimes, but not always, a purple cast at the tips of the flower buds.

The characteristics of some of the improved varieties are as follows

Punjab Broccoli: Its leaves are smooth, wavy and dark green in color. The leaves as well as the sprouts have a slightly bluish tint. Sprouts are compact, attractive and juicy. The main shoots are ready for harvesting in about 65 days after transplanting. Its average yield is 175 quintal hectare-1.

Palam Vichitra: This is an apex broccoli that is medium sized and has dark green leaves with purple stems. The heads are purple and compact, rich in vitamins and minerals. This variety is suitable for cultivation in low hilly conditions. It has an average yield potential of 225 q ha. Other varieties that are suitable for cultivation in low hill conditions are Palam haritica and Palam Kanchan (Singh et al., 2014).

Pusa KTS 1: Medium-tall variety (65–70 cm), dark green waxy leaves, with slightly wavy margins, head solid, main head size and weight about 6.0–15.4 cm and 350–450 g, 90- Matures at 105. day after transplant.

Palam Samridhi: A HYV with large terminal head weighing around 300-400 g.

Gypsy: It is an early variety of broccoli with strong root system for good productivity in poor soil. It produces well-vaulted green heads with medium to small bead sizes. This variety is heat tolerant.

Express: This is a mid-season variety that produces similar plants with dark blue-green heads.

Climate and Soil

Broccoli is a cool season vegetable that grows best in cool and humid climates. It is very sensitive to very low and high temperatures. Broccoli grows best when exposed to an average daily temperature between 17 and 23 °C. Lower than optimum temperature results in delayed maturation and small shoots. Furthermore, it cannot tolerate high temperatures as it produces poor quality sprouts. Broccoli grows best on well-drained, medium to heavy soil with a high organic matter content. It requires moist soil for fast and proper growth. Under dry soil the shoots become more fibrous. It does well in the pH range of 5.0 to 6.5.

Agricultural Practice

Land preparation

Prepare the land for a good tillage by disc plowing followed by one or two harrowing. Include well decomposed FYM @ 20 t ha-1 at the time of land preparation. Broccoli can be sown on bunds or in flat beds. In case of heavy soil, prefer to sow on bunds. The use of organic manure or vermicompost improves plant growth, productivity and improves the water holding capacity of the soil of the field. To prevent the attack of fungal diseases, it is beneficial to sterilize the nursery bed by drenching the nursery bed with formalin @ 1:49 about 15-20 days before sowing the

seeds. After soaking, the seed beds should be covered with polythene for a week. The beds are then reopened and left open for 5-6 days to avoid the harmful effects of formalin on the seeds. Standard procedure to be followed for nursery raising.

Planting season

The best time for sowing seeds in nursery is mid-August to mid-September. Plants are ready for transplanting in the field after a month of sowing in the nursery. Nursery sowing is recommended at the right time to avoid bolting and buttoning.

Spacing

Row to row and plant to plant spacing of 45 × 45 cm should be followed for successful cultivation of broccoli. However, planting distance varies according to variety, climate and soil.

Seed rate

600-650 grams of seed rate is sufficient for cultivation of broccoli in one hectare area.

Nutrient Management

The need for manure and fertilizer in broccoli depends on the fertility status of the soil. During field preparation, add 20 tons of well-rotted FYM. In addition to manure, apply 100 kg N, 75 kg P_2O_5 and 50 kg K_2O per hectare. Half dose of N and full dose of P and K should be given before transplanting. The remaining half dose of N should be top dressed in two equal parts.

Intercultural Operations

Shallow hoeing should be done in broccoli field with hoe or spade to kill young weeds and provide soil mulch. Since it is a shallow rooted crop, weeding should not be done more than 5-6 cm deep to avoid injury to the roots. Weeding and hoeing should be started as soon as the plants are planted in the field. Four to five weeks after transplanting, the plants should be raised slightly above the soil in the field. For chemical weed control, Stomp 30 EC (Pendimethalin) 2.5 L hectare-1 can be applied one day before transplanting in moist soil condition.

Water management

Broccoli requires adequate soil moisture for uniform and continuous growth of the plants. The first irrigation should be done immediately after transplanting. The first irrigation should be light so as not to damage the newly planted plants. Subsequent irrigation can be given at an interval of 7-8 days in summer and 10-15 days in winter depending on the type of soil and season. The soil should have sufficient moisture at the time of head formation. Dry conditions adversely affect the quality and yield of shoots as they are more fibrous. On the other hand, water logging conditions affect the growth of plants.

Physical Disorder

Whiptail: The newly formed leaves become leathery, irregular and composed only of the middle rib. It is caused by the lack of molybdenum in plants.

Control: Application of molybdenum @ 1-1.5 kg ha-1 before transplanting reduces the incidence of soil disorders. Foliar spray with 0.01% ammonium molybdate solution helps to prevent this disorder.

Browning Head: First, water-soaked areas appear on the bud clusters which later turn pink or rust-brown resulting in rot. The browning of the head is the result of boron deficiency in the plants.

Control: Application of borax or sodium borate @ 20 kg O-1 in soil prevents this disorder. Foliar spray of

0.25-0.5% borax solution is very effective, especially when the deficiency is severe.

Leafy Head: The presence of leaves is present inside the head. This disorder is the result of high temperature as well as green growth due to excess water and nitrogen.

Control: In case of high temperature, apply light irrigation. Avoid indiscriminate use of nitrogen and it should be used on the basis of soil test results.

Large And Rough Buds: Excessively large or open buds as a result of high temperature conditions and delay in harvesting make it unsuitable for consumption.

Control: In case of high temperature, apply light irrigation. Harvesting should be done at the proper stage i.e. when the clusters of buds are green and dense.

Broccoli Buttoning

Buttoning is the premature formation of ahead 2.5 to 10 cm in diameter. Buttoning can occur anytime between seeding and almost mature plant, but usually occurs shortly after transplanting into the field. Generally, foliar growth slows after buttoning resulting in too few nutrients to nourish the curd to marketable size. Losses are usually most severe in the early planted crop during cold, wet seasons, when vegetative growth is affected by:

1. Too much hardening of greenhouse plants
2. Too little hardening of greenhouse plants
3. Low soil nitrogen
4. Low soil moisture
5. continued cold weather (4 to 10 ^{0}C for day or more)
6. Other – diseases, insects, micronutrient deficiency, etc.

Some cultivars, particularly early ones, are more susceptible to buttoning than others.

Plant Protection

The major pests and diseases of broccoli crop are given below:

Major insect pests

Aphids (*Brevicoryne brassica*): Aphids are commonly seen on the underside of leaves. The pale green nymphs and adults suck the cell sap and make the plants dormant. Affected plant parts discolor, become deformed and become weak.

Control: Spraying of Monocrotophos (0.05%) or Malathion (0.1%) at 10-15 days interval effectively controls the aphid population. Insect granular insecticides like Phorate @ 1.0 kg a.i./ha should be applied to the soil to prevent recurrence of the pest.

Cabbage Diamondback Moth (*Plutella xylostella*): This is one of the most serious pests of Cole crops, including broccoli. The green or brown caterpillars feed on the inner leaves by making holes that provide transparent skin patches. Severely affected leaves become completely skeleton zed.

Control: Spraying of Neem based formulation @ 4 ml or Bt product like Delphine 3 g @ 1 g per water gives good control of pest or crop with Malathion (0.1%) or Profenophos (0.25-0.5 kg AI/ha) Spraying gives excellent control.

Leaf Webber (*Crocidolomia binotalis*): It is one of the most destructive pests of cole crops. The eggs are laid in clusters on the underside of the leaves. Green caterpillars web the leaves and live inside the nodular mass. Flowering and pod formation are adversely affected.

Control: Removal and destruction of webbed leaf clusters helps prevent further spread of the disease. Spraying of crop with carbaryl (4%) or malathion (0.05%) is effective.

Major Disease

Black Rot (*Xanthomonas campestris):* This is the most serious disease affecting broccoli. This bacterial disease is common in areas with hot and humid climate. Typical symptoms of black rot are due to localized infection. The resulting bacteria enter the leaves through the natural openings of the leaf margins. Infected tissue turns pale greenish-yellow then turns brown and dies. The affected areas are usually wedge or V-shaped. As the disease progresses, these areas enlarge and severely affected leaves may drop. The veins of infected leaves, stems, and roots sometimes turn black. Infected plants have smaller heads and have reduced quality, making them unsuitable for marketing.

Control: Seed treatment with Agrimycin-100 (100 ppm) or Streptocycline (100 ppm) is effective in controlling the disease. Planting should be done on raised beds to facilitate drainage. Cultivation should be avoided in areas where there have been consecutive crucifers during the past 2 years. Plants should be thoroughly inspected for signs of black rot and affected plants should be removed and destroyed.

Downy Mildew (*Perenospora parasitica*): This disease is very serious in nurseries and may also appear in field planting. During periods of high humidity, light brown powdery spots appear on the undersides of leaves and twigs. The first symptoms observed are small, pale greenish-yellow lesions on the upper leaf surface, which later appear on the lower surface. The spots turn yellow as they enlarge.

Control: All weeds that serve as alternate hosts of the fungus should be destroyed. Spraying of copper oxychloride 0.3 and 0.5% of transplanted plants along with transplanting is effective in controlling the disease. Apart from this, spraying of 'Neem seed kernel' @ 5 ml per liter after 25-30 days of transplanting controls the disease outbreak.

Leaf spot and blight (*Alternaria brassica or Brassiciola*): Small dark yellow spots appear on the leaf surface during the initial stage, which later grows into circular areas with concentric rings surrounded by yellow halos. In severe cases, the entire plant withers.

Control: Seed treatment with hot water (50 ^{o}C for 30 minutes) helps in reducing the incidence of the disease. To control the disease, the crops grown for seed purposes should be sprayed with Captan (0.2%) or Copper Oxychloride (0.5%) at full bloom, pod set, and pre-harvest stage.

Harvesting, Yield and Storage

The stem should be cut with a sharp knife as soon as the sprouts are of marketable size i.e. 10-15 cm. The bud cluster should be green and compact. If harvesting is delayed, the buds may become loose. Sprouts or heads should be picked regularly to ensure quality. In addition, sprouts should be marketed as soon as possible because they cannot be stored for long. After 10-12 days the sprouts are ready for harvesting again. An average yield of 100 - 150 q ha-1 can be obtained from multiple harvesting depending on the variety. After harvesting, its ends should be immediately sorted, graded, packed in baskets and sent to markets. The high rate of respiration leads to a deterioration in

its quality. They should be cooled to 40 ^{0}C and then packed in crates with ice and stored in refrigeration. These can be stored well for 7-10 days at 40 ^{0}C. Broccoli can also be preserved in glass jars after lactic acid fermentation.

Conclusion

Broccoli is a cool weather crop that grow best when expose to an average daily temperature 18 to 23^{0}C. It can be cultivated in the both open field and protective condition as well. It is a highly nutritious crop with high amounts of vitamins (A and C), fiber and minerals. Apart from this, it also contains thiamine, riboflavin and niacin. Broccoli is the richest source of protein among all Cole crops. Broccoli are cancer fighting food that promotes longevity.

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