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Advances in Production Technology of Beetroot

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Introduction



Figure 1.1: Beetroot

Beetroot (*Beta vulgaris L.*) is a very popular herbaceous biennial root vegetable mainly grown for its edible roots and leaves, it is commonly known as Chukander in Hindi, but also has different local names depending on the area, for instance, it is called Bita gacha in Bengali, Bita in Marathi, Beet in Punjab, Salada in Gujarati, Dumpamokka in Telugu, and Bit in Malayalam etc (Kumar, 2015). It belongs to the family Chenopodiaceae (now Amaranthaceae). The chromosome number of beetroot is 2n = 18. It is used as a cooked vegetable, salad, and for pickling and canning.

Origin and distribution

The origin of beetroot (*Beta vulgaris*) can be traced back to the Mediterranean region and the Middle East. It is believed to have originated from wild sea beet, a plant that grows along the coasts of Europe, North Africa, and Asia. According to Campbell 1979, the beet originated from the wild-beet or sea-beet (*Beta maritrima*) which is a native of Europe. The cultivation of beetroot started thousands of years ago, primarily for its leaves, which were consumed as a green vegetable. Over time, people recognized the edible and medicinal

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qualities of the beetroot tuber, leading to its domestication and further cultivation. Ancient civilizations, including the Romans and Greeks, cultivated beetroots for their culinary and medicinal purposes. The root's vibrant red color was particularly valued, and it was used as a natural dye.

From its early origins, beetroot cultivation spread to other parts of Europe and gradually reached other continents through trade and exploration. European colonizers introduced beetroot to the Americas, and it became a widely grown crop in North and South America. In modern times, beetroot is cultivated globally in both temperate and tropical regions. Major beetroot-producing countries include Russia, Germany, France, the United States, Poland, and Ukraine. In addition, it is grown in various parts of Asia, Africa, and Australia. Today, beetroot is consumed worldwide for its culinary versatility, nutritional value, and potential health benefits. It continues to be an important crop, and its distribution extends to different continents, reflecting its adaptability to diverse climates and growing conditions.

According to (Hopf *et al.,* 2000) Mesopotamia in the eighth century is when the beet was first mentioned in writing. Later, the Greek traveler Theophrastus compares the beet to the radish, and Aristotle also makes reference to the plant. It was evident from later English and German sources that beetroot cultivation was widespread in medieval Europe (Hill and Langer, 1991).

It is noteworthy that beetroot is different from sugar beet, while most of people think that they are synonyms of one another which is not the case. The easiest way to differentiate sugar beet from beetroot is its white colour whereas beetroot is commonly dark red, though both are from the same family and sugar-beet is used to manufacture sugar and it contains high sugar content but beetroot cannot be used to extract sugar and is more of a table variety (that is for eating purpose). Sugar beet is not extensively grown in India.

Importance and Uses

Beetroot is a versatile vegetable that offers numerous health benefits and finds various uses in culinary and medicinal applications. Its deep red color, earthy flavor, and nutritional richness make it a popular choice in many cuisines worldwide. One of the key reasons for the importance of beetroot is its high nutritional value. It is a good source of dietary fiber, vitamins (such as vitamin C and folate), minerals (including iron and potassium), and antioxidants. These nutrients contribute to overall well-being and support various bodily functions, including immune health, digestion, and cardiovascular health.

Beetroot is commonly used in salads, juices, and smoothies, adding color, flavor, and texture to dishes. It can be consumed raw, roasted, boiled, or

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pickled, allowing for diverse culinary preparations. In addition to its culinary uses, beetroot has also found application in the food industry as a natural food coloring agent.

Moreover, beetroot has gained attention for its potential health benefits. Research suggests that the antioxidants and betalains present in beetroot may have anti-inflammatory and antioxidant properties, contributing to the prevention of chronic diseases and promoting overall health. It is also believed to support cardiovascular health by helping to maintain healthy blood pressure levels.

Nutritional omposition

Beetroot (*Beta vulgaris*) is a root vegetable known for its vibrant color and unique flavor. It is also packed with essential nutrients. Here is the nutritional composition of beetroot per 100 grams

Table 1: Showing the nutritional composition of beetroot (Sehaj, 2021)

S.No.	Constituents	Amount per 100 g of Beetroot
1	Carbohydrates	9.96 g
2	Fat	0.18 g
3	Protein	1.68 g
4	Water	87.58 g
5	Total Sugar	6.76 g
6	Calcium	16 mg
7	Iron	0.79 mg
8	Potassium	325 mg
9	Sodium	78 mg
10	Vitamin C	3.6 mg
11	Anthocyanin	1.44 - 8.45 mg
12	Carotenoids	1.9 mg
13	Betalins	462 - 838 mg
14	Energy	43 Kcal

Area and Production

Major beetroot-growing states in India are Haryana, Maharashtra, Uttar-Pradesh, and Arunachal Pradesh, while apart from this it is also grown in other states like Punjab, Karnataka, and Tamil Nadu but in small quantities. Beet is grown in an area of approximately 12,500 acres with an annual production of around 900,000 quintals (Natrajan and Veeraragavathatham, 2022).

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Botany

As aforementioned beetroot belongs to the root vegetable family having a tap root system which may extend upto a depth of 3m, characterized by thick and fleshy roots that stores a large amount of reserve food while the root colour varies from orange-red to dark-purplish red depending on the traits of the variety under consideration and also due to the presence of β-cyanins, yellow pigment and β-xanthins. At the same, the interior colour may vary depending on the various environmental and other factors like nutrition etc.



Figure 1.2: Beetroot in a field

Leaves are generally ovate with colour varying from dark green to redish. Leaves grows in close spiral forming a rosette with older leaves on the outside and younger ones taking the inner position. The inflorescence of beetroot is large spike which develops in the second year (biennial crop), flowers are small, not easily noticed and are without corolla, but with green calyx. Flowers are composed of 5 stamens, 3 stigma, they are sessile and grows in the bunch of 3-4 on the inflorescence axis and its secondary branches. The true seeds are small, kidney-shaped and brown in colour with girth of around 3 mm.

Taxonomy

Beet is classified into the following categories

Rank	Scientific Taxonomical Details
Kingdom	Plantae
Class	Magnoliopsida
Order	Caryophllales
Family	Chenopodiaceae
Genus	Beta
Species	vulgaris, petula, maritima
Binomial name	Beta vulgaris

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Soil and Climate

Beetroot is a cool season vegetable crop but it can also be grown in warm climatic condition, with the optimum temperature for development being 18-21°C, however if a temperature range of 4.5-10°C persists for 15 days or more then it may induce pre-mature bolting.

Loam and sandy loam soil are ideal for the cultivation of beetroot. In addition to these it can also be grown on acidic (pH of <5.8 has detrimental effect on yield) as well as alkaline soil upto a pH of 9-10, while the optimum range being 6-7.

Seed, Sowing and Field Preparation

Ploughing of the field should be done at a depth of 15-20 cm, followed by hoeing to get fine-textured soil, one should ensure that the soil surface is smooth, loose and free from clods. FYM or compost application at the last ploughing is very essential, with the depth of the sowing of seed being 2.5 cm for getting a good stand of the crop.

In India beetroot is sown in march to July in hills, September to November in northern plains and in July to November in southern plains, with the seed rate being 8-10 Kg/ha having a spacing of 45-60cm × 8-10 cm so as to get ideal yield of the crop.

Prior to sowing seeds should be soaked in water to soften the seed coat and getting maximum plant from the sown seed, while their treatment with thiram or captan at the rate of 2.5-3 g/Kg of seed helps in controlling fungal diseases like damping off, downy mildew etc.

Commercial Varieties

On the basis of shape of root beetroot are classified into 5 groups flat, short top, round, half long and long. The following cultivars are recommended for commercial cultivation in India

VarietyName	Description	Picture
Detroit Dark red	Perfectly **round** roots, deep red skin, dark blood red internal colour, heavy yielding cultivar matures in 80 to 100 days.	

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Crimson Globe	Roots **globular to flattened**, flesh medium, dark crimson red with indistinct zoning, matures in 90 - 100 days when grown in cool season and 60 - 70 during warm season, large bright green leaves with maroon shade.	
Crosby Egyptian	Roots are **flat globe** with small tap root, internal colour is bright red with some indistinct zoning, has 3-5 leaves with red veins, variety matures in 50-60 days after sowing	
Early Wonder	Roots are **flattened globe with rounded shoulder** and matures in 60-70 days after sowing, has good heat tolerance, suggested for warm season, high yielding variety.	
Ooty 1	Roots are **round**, selection from local type, matures in 120 days.	
Avon Early	Roots are **round to oblong**, matures in 50 - 60 days after sowing, early variety of beetroot, known for its sweet flavor and early maturity	
Ruby queen	Beet is round to oblong shaped, matures in 60 - 70 days after sowing, known for its dep red colour hence used as a natural food colouring ingredient.	

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Ochio Canner	Root are **oblonged**, matures in 60 - 70 days after sowing, specifically bred for its ability to be canned and long storage periods,	
Madhur	Known for its high yield and sweet tender flavor.	
Chioggia	A unique variety known for its characteristic red and white rings in its flesh	

Nutrient Management

In beetroot uninterrupted, balanced nutrient supply is required for the production of roots of highest quality, about 25 t/ha of FYM should be applied at the time of last ploughing. While around 70:110:70 Kg/ha of fertilizers N:P:K respectively should be applied to realize full production potential of the crop. Nitrogen is applied in two split doses so as to maximize the nitrogen use efficiency, that is 50% of N along with 100% of P and K can be applied as basal dressing and remaining dose of N should be applied as top dressing 25 days after sowing. In addition to this 20-25 kg/ha of borax is applied for boron deficient soil because beetroot is susceptible to boron deficiency.

Apart from this, it is advisable to conduct soil testing so as to get the detailed description of the nutrients compositions of the soils, in this way deficient nutrients can be identified and accordingly the amendments can be applied and their toxicity or under application can be ameliorated.

Irrigation Management

A steady supply of water is necessary for rapid seed germination and a high quantity of roots. The crop needs 300 mm of water, which can be provided by 5-7 irrigations throughout the rainy season. Excess water delivery should be avoided. While around 75% of the available soil moisture should be maintained, as this crop requires constant moisture supply as mentioned above.

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Weed Management

According to Das, 2015 weeds cause around 38% reduction in the crop yield among other forms of losses, in beetroot a variety of winter weeds infests reduction in the growth and yield of beetroot. The weed flora of beetroot constitutes annual grassy weeds, broadleaved weeds and perennial weeds which includes *Polypogon monspeliensis, Anagallis arvensis* and *Cyperus rotundus* respectively.

Following are the 2 approaches that can be undertaken to tackle the menace caused by the diverse weed flora in beetroot

A. **Non-Chemical Approach:** In this approach mechanical and cultural methods are used to control weed population, it includes following methods as mentioned below:

1. **Hand weeding**: It may be defined as the process of manually removing the weeds by hands this is a labour, cost and time intensive method of weed control. Weed control efficiency is high but might be uneconomical as in many instances multiple hand weeding might be needed for effective weed control, generally two hand-weedings at 20 and 40 DAS is enough to get satisfactory weed control.

2. **Earthing up:** Earthing up is typically done when the beetroot is about 2-3 inches tall, and involves gently mounding soil or compost around the base of the stem so that only the leaves are visible. The process can be repeated as the plant grows, keeping the root well-covered and protected. This technique helps to increase the size of the beetroot and maintain its sweet, tender flavor. At the same also helps in supressing the weed growth and giving competitive advantage to the beet by shading the weeds. Apart from controlling weeds earthing-up gives a competitive advantage to the beetroot over weeds.

3. **Interculture:** Refers to the cultural practices performed between the establishment of the crop and its harvest. This includes activities such as soil moisture management, nutrient management etc. These are just a few examples of the cultural practices that can be performed during the inter-culture phase of beetroot production. The specific practices used will depend on the local climate, soil conditions, and other factors. It is important to follow proper cultural practices in order to ensure a successful crop and high-quality beetroot.

B. Chemical Approach: In this approach chemicals are herbicides are used to control weed population, it includes following methods:

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1. **Pre-Planting Treatment:** - It is a method of application of herbicide before the sowing of the seeds. For example, Cycloate @ 3 - 4 Kg/ha is effective against annual grasses
2. **Pre-Emergence Treatment:** - It is a method of chemical weed control in which herbicide is applied after sowing but before the emergence of the seedling. For example, Pendimethalin @ 0.75 - 1 Kg/ha is effective against annual grass weed although it also controls broad-leaved weeds.
3. **Post-emergence treatment:** - It is a method of chemical weed control in which herbicide is applied after the emergence of the seedlings or the crop. For example, Diclofop-methyl @ 0.5 - 0.75 Kg/ha is effective against many annual and perennial grass weeds.
4. It is noteworthy that proper spray technology as advised by the experts should be used and under-dosage and over-dosage of the herbicides should be avoided so as to avoid the chances of development of herbicide resistance cases in weeds occupying the field of beetroot.

Physiological Disorders and Their management

1. **Internal Black Spot/ Brown Heart/ Heart rot/ Beet Breakdown:**

   Caused due to boron deficiency in neutral or alkaline soil.



Figure 1.3: Showing Internal Black spot of Beetroot

Symptoms

- Hard and corky black spot are scattered throughout the root
- Boron deficiency first affect young cells and tissues

Management

- Apply boron to the soil in combination with other fertilizers or separately

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- Apply 1Ib/A actual boron on the leaves twice in mid-season, this also provides good control of boron deficiency

  Note: Deteroid dark red variety of beetroot shows less symptoms of B deficiency

2. **Speckled yellow**: This disorder is caused due to deficiency of "Mn". Mn deficiency is very severe in sandy or very alkaline soil.

Symptoms

- Yellowing is followed by necrotic spot which appear in the clorotic zones
- Leaves with yellow blotches between veins tends to cover in summer



Figure 1.4: Speckled yellow disease of Beetroot

Management

Apply boron to the soil in combination with other fertilizers or separately.

Insect pest and their Management

1. **Beet leaf minor** (*Pegomyia hyocyami*): The female adult lays eggs on the underside of the leaves the affected leaves turn pale yellow get distorted and crumpled, such leaves gradually die away.



Figure 1.5: Beet leaf minor in Beetroot

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Management

Spraying the under side of leaf with methyl dematon(0.03%) at the time of emergence of leaves.

2. **Beet leaf hopper** (*Neoaliturus tenellus*): It is the most serious pest of the beetroot because it transmit beet curly top virus that is called curly top disease.



Figure 1.6: Beet leaf hopper in Beetroot

Management

For effective pest control, it is recommended to spray insecticides twice after transplanting. The first application should be done 15 days after transplanting, followed by a second application 30 days after transplanting. You may choose one of the following insecticides for spraying:

- Spraying with dimethoate 0.03% controls the pest effectively.
- Fenitrothion 50 EC: Mix 80 ml of Fenitrothion 50 EC with the appropriate amount of water as per the product instructions.
- Monocrotophos 36 SL: Mix with the appropriate quantity of water following the instructions provided by the product.

Diseases Management

1. **Cercospora leaf spot:** It is a fungal disease caused by *Cercospora beticola.* Symptoms of this disease first appear as individual circular spots that are tan to light brown with reddish-purple borders, the leaves become yellow under highly infected condition.



Figure 1.7: Cercospora Leaf spot in Beetroot

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Management

- 3 or more year of crop rotation can reduce the innoculum load
- Growing tolerant variety to cercospora leaf spot
- Seed treatment with captan or thiram @ 2.5 - 3 g/kg seeds
- Spray carbendazim 150 g + mancozeb @ 2 kg/ha

2. **Downy Mildew:** it is also a fungal disease caused by *Peronospora farinosa*

Symptoms: Causes red rimmed spots on the leaves of beet this disease infects the top of beet root causing discoloration, also infect the flowers and seedball



Figure 1.8: Downy Mildew in Beetroot

Management

- Crop rotation
- Eradication of weeds
- Destruction of volunteer crucifer plants
- Spraying ridomil 0.1% or zineb 0.2% at 10 - 15 days interval

3. **Curly top disease**: This disease is caused by beet curly top virus, while the beet leaf hopper is the vector of this disease. Symptoms of this viral disease include warty leaf viens and twisted leaves, plant becomes stunted.



Figure 1.9: Curly top disease in Beetroot

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Management

- Early sowing of crop
- Dense population of plants and quick growth tends to decrease the incidence of this disease.
- Three spraying of methyl demeton is recommended

Yield and Storage

- Average yield of beetroot is 25 - 30 t/ha
- Beet storage temperature 0 ^{0}C and 90% Relative Humidity

Harvesting and Post harvest Management

When the beets reach a diameter of 3 to 5 cm, they are picked. Typically, the plants are pulled by hand, the tops are cut off, and the roots are cleaned and sorted by size. Mature roots are mechanically collected, detopped, washed, graded, and put in polythene bags. The shelf-life is extended by decreasing water loss during storage and transportation by removing the tops and packaging the food in polythene. With surface fissures, the large beets became harsh and woody, which is undesirable.

Future Prospect

It is clearly evident that Beetroot is a highly nutritious vegetable that is gaining attention as a potential "superfood" due to its high levels of antioxidants, anti-inflammatory compounds, and nitrates, which can help lower blood pressure and improve athletic performance and at the same time can also reduce the neurodegenerative diseases like Alzheimer's disease etc. (Giampaoli *et al.*, 2023, Szyma *et al.*, 2023 and Delleli *et al.*, 2023). Beetroot is also a good source of vitamins and minerals, including folate, potassium, and iron. In terms of future prospects, beetroot is being researched for its potential health benefits in areas such as cardiovascular health and cancer prevention. Beetroot juice and supplements are becoming increasingly popular as a natural way to enhance athletic performance and endurance, and research suggests that beetroot may also have potential as a treatment for conditions such as hypertension and dementia. Another benefit of beetroot is that it is easy to grow and can be used in a variety of dishes, from salads and soups to juice and desserts, which makes it a versatile ingredient in food industry. Overall, beetroot has a promising future as a functional food and ingredient due to its high nutritional value and potential health benefits.

Crop improvement of beetroot is an important area of research for the future, as it can help to increase yield, improve disease resistance, and enhance nutritional

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content. One way to improve crop yields is through genetic modification, which can increase the resistance of beetroot to pests and diseases, as well as improve its tolerance to environmental stressors such as drought or extreme temperatures. This can help to increase the overall productivity of beetroot crops and make them more resilient to changing climate conditions. Another area of research is focused on improving the nutritional content of beetroot. Scientists are working to develop varieties of beetroot that have higher levels of beneficial compounds such as antioxidants, anti-inflammatory compounds, and nitrates. This can help to make beetroot an even more valuable food source for preventing chronic diseases such as hypertension and cancer. Another promising area of research is the potential use of beetroot as a biofuel crop. Beetroot is a good source of sugar, which makes it a suitable candidate for biofuel production. Scientists are working on developing new varieties of beetroot that have higher sugar content, which would make it more efficient as a biofuel crop.

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