

Sugarbeet

diseases and its management

Dinesh Singh¹, Priyam Vandana¹, Bana Sravani², Ashutosh K. Mall³ and A D Pathak³

ICAR - Indian Institute of Sugarcane Research, Lucknow 226 002, Uttar Pradesh

Sugar is produced in more than 100 countries of the world including India. With the introduction of sugar beet in 19th century, sugarcane has been replaced by sugar beet as the main source of sugar in continental Europe and in the process of shifting in several other countries. Presently 40% of the world supply of sugar is from sugarbeet. Sugarbeet is considered as temperate crop; however, it is cultivated in wide range of climatic condition due to its wide adoptability to different atmospheric condition. Sugarbeet contains sucrose up to 21% whereas sugarcane contains sucrose up to 14% only. The sugarbeet root yield varied between 5000 and 9000 kg/h under different climatic conditions. Sugarbeet is used as human food, livestock feed and for industrial uses such as in alcohol, pharmaceuticals, and baker's yeast. This crop also has several medicinal properties. There are several factors which affect its yield in which only sugar beet diseases are contributing 20 to 50% yield loss and recoverable sugar reduction is up to 50% as per the disease pressure. Numbers of bacterial, fungal and viral diseases are reported that responsible for deterioration of sugarbeet crop either in the field condition or during storage. In this publication, importance of sugar beet and its contribution in worldwide sugar production along with the main focus on sugar beet diseases and its management is being discussed.

Key words: Diseases, Management, Root rot, Sugarbeet

Sugarbeet (*Beta vulgaris*) is a member of *Chenopodiaceae* family with its wild relative *Beta vulgaris* subsp. *maritima*. Its chromosomal number is $2n=18$. Sugarbeet is a recently introduced crop to India therefore, has mostly exotic varieties. The varieties are mostly from Germany, Russia, USA, UK, Denmark, etc. Some varieties have also been evolved in the country especially from IISR, Lucknow. *Pant S 1*, *Pant S 2*, *Pant S 3*, *Pant S 10*, *Pant composite 6*, *Pant composite 3*, *composite 1*, *IIST composite 1*, *IISR 2*, *IRSR composite*, *Rajendra Sakarkand 35*, *Rajendra Sakarkand 43*, *Sree Bhadra* and *Sree Rathna* are the suitable varieties for all growing regions of India. Out of number of varieties, *Pant S 1*, *Pant S 10*, *IISR Composite 1* and *IISR 2* are the varieties suitable for saline soil. The

optimum population of sugarbeet is 100,000 to 106,000 plants in one hectare area. Ridge sowing and flat-bed sowing method are the two common methods of sugarbeet sowing for which recommended row-row spacing is 50 cm plant to plant spacing is 20 cm.

As per report it is originated from white Silesian beet from Middle East, which was used as fodder by past growers (*B. vulgaris* subsp. *maritima*). Sugarbeet is the foremost and essential sugar crop in many of the western industrialised countries, including some parts of developing

Table 1. Area, production and productivity trend of top ten sugarbeet producing countries

Country	Area (h)		Production (tonne)		Yield (t/ha)	
	2006	2016	2006	2016	2006	2016
United Kingdom	527,554	455,760	34,064,000	33,457,880	64.57	73.41
Egypt	78,317	254,991	3,904,970	13,323,369	49.86	52.25
Iran	185,888	101,211	6,709,113	5,536,914	36.09	54.71
Netherlands	82,781	70,722	5,414,100	5,502,200	65.40	77.80
Belarus	105,760	95,952	3,978,474	4,278,359	37.62	44.59
Czech Republic	60,958	60,736	3,138,326	4,118,356	51.48	67.81
Belgium	82,912	55,504	5,666,621	4,021,110	68.35	72.45
Japan	67,400	59,700	3,923,000	3,189,000	58.20	53.42
Serbia	71,581	44,237	3,188,905	2,683,860	44.55	54.51
Italy	91,230	32,297	4,769,614	2,046,297	52.28	63.36

Source: FAOSTAT, 2016

countries like India and China.

Russia, France, the United States, Germany, and Turkey were the world's five largest sugarbeet producers. During the period from 2008 to 2012, sugarbeet production increased by 2.5% per year reaching 272 million tonnes. France and United States shared 13% of total world production followed by Russia (12%). According to 2013 world records, Russia ranks first in sugar beet production accounting 39,321,161 metric tonnes to total 250,191,362 metric tonnes produced in the world. On an average world produces 58.2 t/ha. The best average root yield was obtained 39 t/ha from India. Cultivation of sugarbeet over 6,000 acres was recorded in Punjab during 2012-13. Salt affected soils in the country is estimated to be around 6.7 million hectare in India and sugarbeet has an edge in salt affected areas which may be the future area for the crop.

Medicinal Value of Sugarbeet

Sugarbeet is a source of vitamin A, vitamin C, iron, minerals, carotenoids and dietary fibres. A decoction prepared from the seed of sugarbeet used as a remedy for tumours of the intestines. The juice or other parts of the plant help in the treatment of tumours, ulcers, leukaemia and other forms of cancer such as cancer of breast, oesophagus glands, intestines, lung, rectum, spleen, stomach and uterus. Beet juice can be recommended as a remedy for yellow jaundice, anaemia and alleviate tooth ache. Beet juice promotes a healthy complexion and prevent falling hair. It is also recommended for treating headache and vertigo as well as all affections of the brain.

Qualitative and quantitative development of sugarbeet

During nineteenth century, cultivation of sugarbeet was broadly adopted by the farmers of India and China, due to introduction of bolting resistance varieties like Gauguin and Degas. On the other hand, India witnesses wide range of weather conditions across a vast geographic scale and varied topography. Therefore, many breeding procedures

like selection and crop improvement practices, the present cultivated sugar beet are developed. North-east monsoon favours the cultivation of sugarbeet in India. Growers in Tamil Nadu usually sow in October or November as to coincide with monsoon and harvest after 5-6 months depending on the purpose. Tropical sugarbeet varieties namely Pasoda, H1 0064 and Doratea are suitable for cultivation in Tamil Nadu, but at present Cauvery, Indus and Shubhra are widely adopted for cultivation. Other popular varieties grown all over the world are Aimanta, Trinta, Saracen, Opta.

At the time of discovery of sugarbeet, the extraction of sucrose percentage was only 5-6% whereas presently it has reached up to 20% due to improved varieties. Sugarbeet gained many advantages over sugarcane in case of sugar content (12-21%), sugar purity (85-90%), and in sugar recovery (12-14%) which is higher than that in sugarcane. It can be grown in wide varying temperatures and also requirement of water is less than that of sugarcane. Moreover, sugar beet can be used in crop rotation. Sugar beet is mainly cultivated for commercial production of sugar and bio energy. Whereas, it is also grown for its fresh and tender leaves which we refer as Swiss chard. Though leaves are little bitter in taste but people prefer it in soups mostly in Mediterranean countries. Also as a table beet, we use it as a vegetable in our daily needs. Sometimes it is purposefully cultivated for feeding livestock. Depending on the purpose of cultivation, growing period varies. It is generally grown annually for sugar production because sugar is accumulated at end of first year in taproots. If taproots (crop) is left unharvested in the field, it flowers and produces seed in the next year. So, for seed production it is grown as biennial. Sometimes they are even grown as perennial in hilly areas but the species differ with respect to growing period such as *B. trigyna*, *B. lomatogona*, and *B. macrorrhiza*. Main product processed from this cash crop is white sugar, which is obtained from the underground,

white, fleshy, storage root that forms nearly 20% of total weight of sugar beet, based on variety and environmental conditions, sugar content varies, with an average of 16%. More than half of the beet includes water and rest filled with dry matter. Sugar is an important component of this dry matter, which also includes pulp and molasses as their by-products. Pulp is the waste product formed during diffusion step in processing, where the strips of beet are removed after extracting sugar from them. These are pressed and used in animal feed. Whereas during centrifugation step, syrup left at the centre after crystals separated from them are called as molasses. This is used as substrate in alcohol production. Apart from these, sugar beet is also used in preparation of jams, syrups, alcohol and even in curing some of the diseases related to liver and can be used for diabetics.

Processing of Beet

In 1799 with the invention of method of extraction of sugar from the beet roots, first sugar beet mill was established in 1802 by Mr. Archard in Cunern, Germany. Later on, in 1879 a commercial factory started for the production of sugar from sugar beet.

Harvested sugar beet transported to processing unit quickly because postharvest deterioration is a limiting factor for sugar deterioration. Harvested beets are transported either by tractors or trucks to near by units. Processing of sugarbeet generally takes place in important steps like diffusion, carbonation, filtration, evaporation, crystallization, and centrifugation. Before processing, beets are cleaned and washed by using beet washer to eliminate soil, stones and other impurities present on it. Later on, minute dust particles like sand and mud are removed along with metal bits by using magnets. After eliminating all the impurities the fresh and cleaned beets are passed through slicers on conveyor belts. These slicers make the passing beet in to thin slice for easy processing of beet and for maximum sugar extraction. In general the sliced beet



Fig. 1. Healthy crop (a) and (b) single plant of sugarbeet

portions are called as cossettes. These cossettes are passed into next level called diffusion, where hot water is passed in opposite direction to the cossettes. Diffusion takes place in large cylinders. The product that comes out from diffusion cylinders is called as raw juice and the by-product formed is called as pulp which is dried to reduce the moisture and pressed to form pellets, that is used for livestock.

Raw juice is processed by eliminating the impurities present in juice such as sulphate, phosphate,

citrate in the next stage of carbonation. Here, two carbonation tanks are used for complete removal of impurities. After complete carbonation of juice, it is filtered by using various filters and also sulphur dioxide is passed through it to prevent blackening of juice colour. After filtration, the juice is passed through evaporators to increase the sugar content by evaporating the moisture present in it. The mentioned process is subjected for five to six evaporators to reduce the moisture content. Product obtained

after evaporation is called as thick juice that contains 50-65% of moisture. Next stage involved is crystallization. Thick juice obtained is passed through crystallizers to form mother liquid, which is thick sugar syrup. This is processed to form massecuite by using vacuum pans. The massecuite contains mixture of sugar crystals along with syrup mix. In order to separate these crystals from syrup we use centrifugation process, where centrifuge separates sugar crystals. The sugar obtained will be of low quality with



Fig. 2. Flowering stage of sugarbeet (a and b)

undesirable colour and impurities. So they are again boiled at high temperatures and passed through crystallizers to remove further impurities.

The by-product obtained after boiling is called as molasses, which is used as animal feed and also for ethanol production. Sugar crystals are again washed and passed through coolers and dryers. After cooling, it is sent to the storage in large bins for further packaging process.

Diseases affecting sugarbeet

Sugar beet crop suffer from many diseases either in field or during storage. Out of these rust, beet powdery mildew, *Cercospora* leaf spot and *Rhizoctonia* root rot are the major and most important diseases in all beet growing areas. They reduce the quality of product besides reducing the yields. There are nearly 30 fungal and bacterial diseases that affect the crop.

Cercospora leaf spot (*Cercospora beticola*)

Symptoms

The predominant symptom of this disease is small, circular, light brown leaf spots with dark border either of reddish purple or dark brown on the surface of the leaf. Sporulating structures are present at its centre. Under favourable condition, sporulation increases which turn the spot into dark brown. These spots coalesce with each other turning entire leaf into yellow and finally brown colour, which later dries and collapse. High humid conditions such as irrigating the field frequently favour the disease. If the day



Fig. 3. *Cercospora* leaf spot of sugarbeet

temperature is around 30°C and the night temperature is around 15°C coupled with 90% relative humidity for 2 days can absolutely favour the pathogen to initiate disease. Generally, residues from previously infected crop, or pathogen carried on seed and alternate hosts acts as primary sources of inoculum. Wind and splashing rain can cause dispersal of fungus from infected to other susceptible sugarbeet plants which spreads and causes secondary infection.

Management

- Early control on appearance of disease symptoms should be implemented as the fungus damages the leaves, which reduces the photosynthetic activity of the plant thereby reducing the yield. It also reduces the sugar content of beet.
- Avoid planting or sowing of sugar beet in the season that favours the pathogen growth such as cultivating in early spring, which initiate pathogen growth. So late planting can reduce the infection.
- Avoid using sugarbeet variety that are susceptible, growing the crop close to infected field, shelter belt and even near to the water source.
- Some pathogenesis related proteins like chitinase glucanase and also styramine and phytoalexin which are referred as antifungal proteins are isolated from sugarbeet and cloned to protect the plant from *Cercospora beticola*.
- **Chemical control:** Fungicides belonging to benzimidazole and triazole class as well as organotin derivatives and strobilurins can control *Cercospora* leaf spot. Fungicides like headline 2.09 EC, Proline 4SC, Inspire XT and Topsin 4.5F can effectively manage the disease. Avoid using fungicide from same class or from class of fungicides where fungicide resistant is established. Use recommended dosage of fungicides in order to have effective control.
- **Biological control:** An isolate Bac J, from *Bacillus mycoides* bacterium that lives in phyllosphere of plant like flower leave, stem, fruit, which is non-pathogenic to plant, reduces

nearly 65% of *Cercospora* leaf spot infection on sugar beet.

Powdery mildew (*Erysiphe betae*)

Symptoms

Powdery mildew is identified easily due to its distinct symptom that first appears on lower surface of leaf in the form of white powdery small spots, later, it can rapidly spread to the entire plant making greyish white appearance. It is generally seen on leaves but under favourable atmospheric condition it can spread to stem due to production of large number of spores. Infected parts turn yellow and finally dark brown in colour. This disease is air borne in nature and due to which covers large area in a short time. Loss in sugar yield (20 to 35%) can occur, if the disease is not controlled. This disease is generally seen in arid climate. Average temperature is 20 to 22°C and 30% relative humidity is the favourable condition for disease development. High temperature reduce or check the fungal growth as well as its spread.

Management

- To reduce this infection, use sprinkler system for irrigation which reduces humid conditions as compared to surface irrigation.
- **Chemical control:** Sulphur fungicides such as Microthiol, Disperss and Micro Sulf can be used for powdery mildew management.
- Copper sulphate fungicides are used in common to control this disease.
- Recent fungicides such as Gem,



Fig. 4. Powdery mildew of sugarbeet

Headline and Quadris, belonging to strobilurin class can be used to manage powdery mildew. Other fungicides such as Proline (150 a.i./h), Inspire (364-512 a.i./h) and Eminent (385 a.i./h) are also found effective for powdery mildew management.

- Application of fungicides should be repeated if symptom reappear and application of fungicides before harvest is of no economic benefit.
- Apart from chemical, neem oil (3-4%) and silicon treatment (1 g/l) is also effective in controlling powdery mildew.
- In case of organic farming, potassium bicarbonate (2-8 kg/h) is used as fungicide.
- Genetic resistance is developed in host plant by introduction of *pm3* allele against the disease.

Dampingoff (*Pythium ultimum*)

Symptoms

This disease is generally seen in seedlings stage. Characteristic symptom of disease is soft, brown rotted tissue. Appearance of plant is similar to nitrogen deficiency, where plants are often stunted or become chlorotic. Under moderate infections plant wilt, and reduce plant population. In case of severe infections it leads to plant collapse and death. Root tips of diseased plant appear as brown. Round, thick-walled spores could be seen in root cells. Excessive soil moisture followed by heat stress is prerequisite for development of this disease and also with optimum temperature of 30°C. In heavily infected sugarbeet crops, low sugar concentration is noticed.

Management

- Avoid overirrigating, especially during periods of high temperature that favours the pathogen growth.
- Rotation with non susceptible crops like wheat and maize can reduce pathogen potential and prevent infection to the crops.
- *Chemical control*: Soil disinfestations with methyl bromide are common practice in greenhouses to control this disease.
- Preventing sowing in fields with the history of this disease can eliminate

the infection.

- *Biocontrol*: In case of bio control, *Pseudomonas* antagonists are found to be superior to *Bacillus* antagonists in controlling damping off in sugarbeet.
- Chaetomin has been identified from *Chaetomiumglo bosum*, having antagonist effect against *Pythium ultimum*. Therefore, soil application of *Chaetomium globosum* is effective against this disease.

Beet rust (*Uromyces betae*)

Symptoms

Initially small circularred-orange or brown raised pustules are found on both sides of the leaf and also on leaf stalk surrounded by a yellow halo. In case disease prolongs for long period under severe condition, pustules coalesce with each other resulting in drying of leaf and finally death of plant. Rust infected plants are found to be stunted and chlorotic in nature. Rust of sugar beet typically causes 2 to 5% of yield reductions; however, in severe cases it can have a greater impact. Nitrogen fertiliser, high humidity and high temperature above 20°C favour the development of pathogen.

Management

- Cultivation of resistant variety is best preventive method for disease management. Use disease free seed for sowing of the crop to get maximum yield.
- Following crop rotation with non hosts (maize, barley, cotton and alfalfa) can reduce the infection.
- *Chemical control*: Fungicides such as Escolta (cyproconazole + trifloxystrobin) effectively manage the rust.
- *Bio control*: The bio control agent *Bacillus subtilis* QST 713 provides approximately 76% control of beet rust.

Bacterial leaf spot (*Pseudomonas syringae* pv. *Aptata*)

Symptoms

Water soaked spots are characteristic symptom for bacterial diseases. The spot is initially very small with 1mm in size on leaf

surface. As disease progresses, spots increase in to 3 to 8 mm diameter. Later changes its shape from circular to ellipsoid along with black or dark brown borders. Spots will be so clear that can be visible from both the sides of leaf. Bacterial colonies are formed at the centre of spot. As the disease progress the leaf spot joins together and finally forms dead areas in the infected parts. Temperature around 30°C is appropriate for infection. Wet and cool climate with high soil moisture favours disease development.

Management

- Sprinkler system of irrigation instead of surface irrigation reduces humidity at soil surface and suppresses the disease.
- Removal of infected debris help in preventing disease to the new crop.
- High seed densities and raised bed planting reduce the chance of infection.
- *Chemical control*: It is not effective against this disease; however, copper fungicide can reduce disease if applied at early infection stage.

Root and crown rot (*Rhizoctonia solani*)

Symptoms

Disease is initiated with the root tip, infection leading to appearance of dark colour oval lesions that spread and cause damage of entire bulb. The infected plant has brown leaves which dries and fall-off on severity. As disease progresses infection occurs to entire plant resulting in heavy losses. Rotting generally occur when moisture and humidity is high. Under wet condition the pathogen is



Fig. 5. Root and crown rot of sugarbeet

more aggressive and thus the disease is more severe.

Management

- Crop rotation with non hosts like wheat and barley that does not harbour *R. solani* 2-2 IIIB or 2-2 IV, will reduce the inoculum pressure of field.
- Drainage is recommended in rot infected field to suppress pathogens growth in the soil.
- Summer deep ploughing and crop rotation with maize increase sugar yields.
- **Chemical control:** Nearly 50% of disease can be controlled by spraying Azoxystrobin and Tebuconazole fungicides. Fungicide should be applied at particular depth and at suitable soil temperature for its effective result. Resistant variety should be used for planting in a disease infected field.

Ramularia leaf spot (*Ramularia beticola*)

Symptoms

Distinct light brown spots are seen on surface of leaf with dark reddish brown margin surrounding it. Sporulation take place at the centre of spot which give silvery appearance. On severity leave die by necrosis. High precipitation cause the spread of disease especially during monsoon period.

Management

- **Chemical control:** Fentinhydroide is recommended as a foliar spray with repeat application after 20 days to manage the disease. This application increase yield by 4% as compared with other crop where it is not applied.
- The disease can be effectively managed by application of the chemical like Difenoconazole and Pyraclostrobin to nearly 90%.

Downy mildew (*Peronospora farinosa* f. *sp. betae*)

Symptoms

The disease is noticed in crops grown for seed production. Forty five percent crop loss is reported by the disease. Initially light green spots appear on foliage which later turn

into greyish moulds that is seen on lower and upper surface. Under severity spots coalesce, dry and resulted to fall off of leaf. It also cause crown infection and bulb distortion. Cool and humid weather condition with an appropriate temperature range of 7.2°C and 15°C favours the epidemic of the disease.

Management

- Planting crop at recommended spacing, both for seed and root crops, can avoid the severity of disease.
- **Chemical control:** Excess nitrogen application on crop should be avoided in disease prone area.
- Fosphite sprays at 20 days interval can reduce the disease.
- Trilogy@ 0.5-1% or Dithane DF rainisohield at 7-10 days interval can be used to eliminate the disease.
- Use of resistant varieties like Druzhba MS34 and E87-87 should be planted under disease prone weather condition and area.

Alternaria leaf spot (*Alternaria brassicae* and *Alternaria alternata*)

Symptoms

Alternaria brassica causes circular lesion covered by dark brown or black boarder with sporulation at the centre where as *A. alternata* causes interveinal chlorosis on leave. This disease appear under moist, cool condition.



Fig. 6. *Alternaria* leaf spot of sugarbeet

Management

- It is a minor disease and does not require much concentration. Use of fungicides and seed treatment can eradicate the pathogen and save the crop.
- Under epidemic condition application of 2-3 spray at 15 days interval is recommended for effective management of this disease.

Beet tumour (*Urophlyctis leproides*)

Symptoms

The disease is seen on leave in the form of small greenish galls which later become brown. These galls when dissected reveal the spore of pathogen.

Management

- Uproot the infected plant and burn it to check the secondary spread.
- Planting of resistant variety under disease prone area is the best possible management of disease.

Scab (*Streptomyces scabies*)

Symptoms

Development of round or oval, rough, corky surface on the roots and turn brown to black in colour. They infect even the deeper tissues when disease advance. It is most common in calcium-rich soils. Improper drainage and excess of nitrogen fertilizer favour the pathogen.

Management

- Avoid planting in streptomyces scabies sick soils.
- Planting of resistant varieties like Sandra KWS and BTS 3325 is the best management of disease.

Crown gall (*Agrobacterium tumefaciens*)

Symptoms

Corky, rough, brown coloured overgrowth called as gall is noticed on the root which grow faster than root. Even on foliage small galls are produced. On severity gall increase in size in both foliage as well as root.

Management

- Removal of infected plants and destroy to check the secondary spread of disease.

- Planting of resistant variety and seed treatment with antibiotic is recommended.

Violet root rot (*Rhizoctonia crocorum*)

Symptoms

Reddish purple mycelia growth on roots prominently. Infection starts from tip of the root and spreads to entire plant. Foliage becomes purple colour with the progress of disease and later plant wilts on severity of disease. Infection is superficial initially and later deepens. The disease appears in patches in the field, few plants get infected. Alkaline soils, high temperature and poor drainage favour the development of this disease with the presence of primary inoculums of pathogen.

Management

- Infected root should be removed and destroyed.
- Deep summer ploughing and proper drainage can help to reduce the attack of disease.
- Crop rotation with cereals for more than 3 years can prevent the disease.
- Acidic soil favours the disease development, therefore, lime amendments (5-7 g/kg of soil) to the soil is advisable for management of disease.
- Efforts should be made for the development of resistant varieties. Early maturing varieties can escape the disease.
- Early harvesting is recommended for the diseased crop.

Aphanomyces root rot (*Aphanomyces cochlidioides*)

Symptoms

Disease develops symptom in two stages. Initially black root of seedlings phase and later on chronic root rot phase. A symptom of black root is firstly seen on seedling stem close to the soil level. Black water soaked lesions are visible on the stem which later spreads to the above stem portions of the plant. Main characteristic symptom is stem becomes thin and thread like structure. In case of chronic phase, root is affected mainly at the tip. First visible symptom under this phase is

scorching and brittling of leaves, which finally leads to drying of foliage and death under severe condition cases. Root distortion and scarring are general symptoms seen under chronic root rot phase. Warm and wet soils with 25°C temperature favour disease development.

Management

- Avoid planting in field with the history of this disease.
- Over irrigation favours the disease development in the field; therefore, use of sprinkler system reduces the severity of disease.
- Control weed population of Pigweed, Kochia, and Lambs quarters (alternate host of the pathogen) is effective to escape the crop for this disease.
- Use plant growth-promoting Rhizo bacteria (10^6 - 10^7 cfu/ml) (PGPR).
- Use of resistant/tolerant varieties (BTS 470 or Hornet) is the best method for management in the disease prone areas.
- Seeds treated with Hymaxazole (10 g a.i./kg of seed) fungicide can control the disease.

Charcoal rot (*Macrophomina phaseolina*)

Symptoms

Initially, the plant wilted, and leave soon turned brown and died. Diseased plant will be observed in patches in the field. Brown-black lesions were observed in the external part of the root crown. In the disease development, yellow-mustard coloured lesions occurred internally. In advanced stage of disease, masses of sclerotia formed in rotted cavities and root became mummified.

Management

- Diseased plant should be removed and destroyed.
- Plant growth promoting cultural practices (weeding, harrowing and application of PGPR microbes) are recommended to minimize the plant stress which will reduce the risk of charcoal rot disease development.
- Reduce plant populations (15-20%) and optimize fertility levels, especially phosphorus to reduce disease impact on yield.

- Following crop rotation with wheat for two years or more in the history of charcoal rot field to reduce inoculum.
- Plant disease resistant varietie daphna for the best management of disease.

Fusarium yellows (*Fusarium oxysporum f. sp. betae*)

Symptoms

In general, *Fusarium* mainly infect root portion. This disease is identified when foliage shows chlorosis especially near main vein of leaf. It is generally notified on older leave, sometimes young leaf shows the infection in severe cases. Drying of leaf occurs in later stage of disease. They may sometime recover at night and during dry day. Roots show dark brown vascular discoloration when cut open as pathogen infects root cells internally. Disease external symptoms on root are not found and should be identified only based on foliar symptoms. High soil moisture with optimum temperature of 24°C leads to appearance of this disease. Infected beet parts come in contact with the healthy plant lead to disease spread.

Management

- Soil fumigation and soil solarisation is recommended for the management of this disease.
- Proper irrigation and crop rotation eliminates the pathogen development and disease development.
- Early planting will also help in disease control by escaping pathogen development.
- Controlling weed hosts like Pigweed, Kochia and Lambs quarters which harbours pathogen have good effect on pathogen control.
- Fusarium yellows-resistant variety Sabatina KWS should be plant in disease prone area.

Rhizomania (Beet necrotic yellow vein virus)

Symptoms

Symptoms are similar to that of Aphanomyces root rot disease, but

unlike in *Aphanomyces* symptoms are very distinct on root than on foliage. Rhizomania is a 'crazy root' itself states that it has profound effect on root. Infected root become stunted because the growth of main root is stopped and proliferation of secondary roots start. Large masses of these roots give 'bearded' appearance which is the significant symptom of the disease. Foliage of crops seen yellowish and chlorosis were noticed. As compare to *Aphanomyces*, leaf scorching is not seen in this disease. Sometimes vein banding occurs on leaves which on severity spreads and turns entire leaf yellow and later dries-off. Upright leaf posture is notified in rhizomania infected fields. Moist wet soils and high humidity favours for this disease initiation and *Polymyxabetae* helps in dispersal of the virus.

Management

- Crop rotation and use of sprinkler can manage the disease to significant level.
- Using of resistant cultivars is the most effective management of disease. CZ25-9 is a resistant to rhizomania and having high sugar content.
- A combination of cultural practices to interfere in vector's life cycle will help to minimize yield reduction due to disease.

Beet curly top (Beet curly top virus)

Symptoms

This is the first viral disease discovered in sugarbeet. Major losses noticed several time due to the virus in America as this disease mainly affects the leaf portion. Distinct symptoms are identified through curling and rolling of leaves upward and downward. Other symptoms like yellowing, distortion and mottling are generally associated with it. Galls or blisters are characterised symptoms of the disease. Young seedlings when infected die immediately. As pathogen affects mainly phloem tissue, root necrosis is seen in the form of concentric rings when cut horizontally. Having irrigation, change of planting time leads to immediate attack of this

disease. Leafhopper (*Circulifer tenellus*) insect play role in dispersal of virus in persistent manner.

Management

- Eliminate and destroy the infected parts of the crop to prevent its spread to the other field.
- Avoid planting beet in the areas already infected with the disease.
- Vector control and prevention of alternate weed hosts like Brassica spp., *Erodium* spp. and *Plantago* spp. can control disease.
- Planting of resistant varieties in virus-prone area is only the best management.

Soil borne mosaic virus (Beet soil borne mosaic virus)

Symptoms

Primarily symptom of this disease is visible on leaf veins, where chlorosis is restricted as vein banding. Distortion of leaf and mottling symptoms occur simultaneously with the early symptoms. As disease become severe it spreads to other leaf area and finally turns entire leaf in to yellow. Proliferation of lateral root is also a symptom but is very rare. It is found that the disease occurs in association with rhizomania where root symptoms are much clear than that of foliar symptoms. Warm and saturated soil water favours the disease. The disease requires effective vector for dispersal of virus (*Polymyxa betae*).

Management

- Avoid over irrigation or surface drainage which favours suitable conditions for pathogen to develop.
- Crop rotation with non hosts (paddy and maize) and soil solarisation can reduce disease development.
- Management of vector can control disease from spreading.
- Use of resistant varieties is the only the best remedy for the management of the disease.

Beet yellows virus (Beet yellows virus)

Symptoms

It is the most common virus causing beet yellowing disease.

Symptoms appear as yellowing of the leaves between the veins which can spread through the entire leaf. Leaf becomes thick and even mottling symptoms are seen. Necrosis is the common symptom seen in this disease as virus infects phloem tissue especially companion cells, sieve elements and parenchyma. Viruses like beet yellows virus, beet mild yellowing virus and beet chlorosis virus is transmitted by aphid (*Myzus persicae*).

Management

- Carefully cultural operations may be done it may cause infection on healthy plants.
- Crop rotation may reduce inoculum build-up in the soil and thus reduce the chance of infection.
- Seed treatment by using imidacloprid 17.8 SL can help in controlling disease development by killing the insect vector.
- The elimination of over wintered beets plants in root crop fields, clamps, seed crop fields or escapes, can reduce the incidence of virus.
- Early planting and high plant population can the yield loss from BYV.

Latent rosette (rickettsia like organism)

Symptoms

Significant symptoms are noticed on leaves where leaf turns yellow and later brown with its tip turning black. They form rosette shape leaves and also 'witches' broom symptom is clearly identified. As disease advances leaves dry and fall off. Adults and nymphs of the beet lace bug, (*Piesma quadratum*) act as vectors.

Management

- Use the disease-resistant varieties for the management of disease.
- Crop rotation with cereals for three years breaks the inoculum build-up in the area and reduces the chance of infection.

Low sugar syndrome (Phytoplasmas and bacteria of genus g-3)

Symptoms

Occurrence of this disease reduces

sugar content approximately by 5%. Symptoms are seen on leaves where they exhibit chlorosis followed by necrosis. The characteristic symptoms of this disease are production of many narrowed chlorotic leaves and 'honey-brown' discoloration of vascular bundles when roots are split open.

Management

- Use of disease-resistant varieties like Senada KWS and Landon.

Postharvest diseases

The postharvest diseases cause major loss of sugarbeet as they cause rot development due to increased respiration, reduce of sucrose content and attacks the several pathogens as storage temperatures are favourable for them. Depending on the temperature of storage, beets rotting varies such as *Botrytis cinerea* is grown when temperature is nearly 8°C and when temperature raises and becomes more than double, downy

mildews of oomycetes and *Fusarium* noticed. *Phoma betae*, *Lesconostoc mesenteroides* and a large number of *Penicillium* species develop in storage beets deteriorating its quality. *Penicillium* is noticed only when they find wounds as a source of entry in to the tissue. *Botrytis* infection can be identified easily as they cause rotting with greyish colour spores over it and *Phoma* infection is characterised typically by the appearance of 'V' shaped rotting when the beet is cut open. *Erwinia* and *Phytophthora* also cause roting storage beets. All the storage rots in general cause reduction in sucrose content making it unfit for consumption which highly reduces market value.

Management

- Avoid mechanical damage during harvesting of the crop. Measures should be taken to prevent damage to the beets.
- Root exposure to direct sunlight

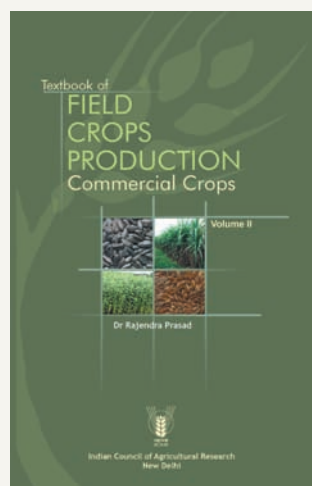
and prevailing wind should be minimized.

- Frost damaged crops should not be stored along with healthy ones.
- Storage temperature should always be maintained at 4°C and harvesting temperature of the crop should be below 13°C.
- A relative humidity of 95-98% should be maintained.
- All the harvested beets should be placed in properly spaced piles in order to have good air circulation which prevents the initiation of disease.
- Bio control of these diseases is recommended by using like *Saccharomyces* (Agrauxine or Epi-Agri) which effectively reduces disease.

²Department of Mycology and plant pathology, BHU, Varanasi, U.P. ³Division of Crop Improvement, ICAR-Indian Institute of Sugarcane Research, Lucknow, U.P. Corresponding authors' e mail: 1970dinesh@gmail.com

Textbook of Field Crops Production – Commercial Crops

(Volume II)



Availability of high-yielding varieties/hybrids and increased irrigated facilities have resulted in the development of production-intensive cropping systems in several parts of India, and this has catalyzed further agronomic research based on the cropping-system approach. Many changes have also taken place in the crop-production technologies. And this necessitated the revision of the earlier publication brought out in 2002. The revised textbook is in two volumes: First is covering Foodgrains and second is on Commercial Crops.

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