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Seminar on

Drought Management and Improving Sugarcane Productivity

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MANAGING SUGARCANE DISEASES UNDER DROUGHT

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Plant disease epidemics develop as a result of the timely combination of the same elements that result in plant disease: susceptible host plants, a virulent pathogen, and favourable environmental conditions over a relatively long period of time. The chance of an epidemic increases when the susceptibility of the host and virulence of the pathogen are greater, as the environmental conditions approach the optimum level for pathogen growth, reproduction and spread, and as the duration of all favourable combinations is prolonged or repeated.

Impact of plant pathogens on crop growth

Plant pathogens infect plants in the course of their obtaining food for themselves, depending on the kind of pathogen and on the plant organ and tissue they infect, they interfere with the different physiological function(s) of the plant and lead to the development of different symptoms. In foliar diseases there is destruction of leaf tissue, photosynthesis is reduced because the photosynthetic surface of the plant is reduced. Even in other diseases, however, plant pathogens reduce photosynthesis, especially in the late stages of diseases, by affecting the chloroplasts and causing their degeneration. In plants infected by wilt pathogens, stomata remain partially closed, chlorophyll is reduced, and photosynthesis stops even before the plant eventually wilts. Most virus diseases also induce varying degrees of chlorosis and stunting. In the majority of such diseases, the photosynthesis of infected plants is reduced greatly. In advanced stages of disease, the rate of photosynthesis is no more than one-fourth the normal rate. When a pathogen interferes with the upward movement of inorganic nutrients and water or with the downward movement of organic substances, diseased conditions result in the parts of the plant denied these materials. The diseased parts, in turn, will be unable to carry out their own functions and will deny the rest of the plant their services or their products, thus causing disease of the entire plant. For example, if water movement to the leaves is inhibited, the leaves cannot function properly, photosynthesis is reduced or stopped, and few or no nutrients are available to move to the roots, which in turn become starved and diseased and may die (Agrios, 2005).

Photosynthates move through plasmodesmata into adjoining phloem elements. From there they move down the phloem sieve tubes and eventually, again through plasmodesmata, into the protoplasm of living non-photosynthetic cells, where they are utilized, or into storage organs, where they are stored. Thus, in both cases, the nutrients are removed from "circulation." Plant pathogens may interfere with the movement of organic nutrients from the leaf cells to the phloem, with their translocation through the phloem elements, or, possibly, with their movement from the phloem into the cells that will utilize them. In diseases caused by phytoplasmas, as well as in diseases caused by phloem-limited pathogens, they exist and reproduce in the phloem sieve tubes, thereby interfering with the downward translocation of nutrients.

In some virus diseases, particularly the leaf-curling type and some yellows diseases, starch accumulation in the leaves is mainly the result of degeneration (necrosis) of the phloem of infected plants, which is one of the first symptoms. It is also possible, however, at least in some virus diseases, the interference with translocation of starch stems from inhibition by the virus of the enzymes that break down starch into smaller, translocatable molecules. This is suggested by the observation that in some mosaic diseases, in which there is no phloem necrosis, infected, discolored areas of leaves contain less starch than "healthy," greener areas at the end of the day, a period favorable for photosynthesis, but the same leaf areas contain more starch than the "healthy" areas after a period in the dark, which favours starch hydrolysis and translocation. This suggests not only those virus-infected areas synthesize less starch than healthy ones, but also that starch is not degraded and translocated easily from virus-infected areas, although no damage to the phloem is present. When plants are infected by pathogens, the rate of respiration generally increases. This indicates that affected tissues use their reserve carbohydrates faster than healthy tissues. The increased rate of respiration appears shortly after infection and continues to rise during the multiplication and sporulation of the pathogen.

Most fungal pathogens require free moisture on the host or high relative humidity in the atmosphere for spore release or for germination of their spores. Most pathogens become independent of outside moisture once they can obtain nutrients and water from the host. In many diseases, although spores may be released following a short leaf-wetness period, the growth and sporulation of the pathogen, and the production of symptoms, come to a halt as soon as dry, hot weather sets in. All these activities resume only when it rains again or after the return of humid weather. Many root infecting fungi grow fairly well in rather dry environments. Apparently that characteristic enables them to cause more severe diseases in drier soils on plants that are stressed by insufficient water. Vascular wilt pathogens are significantly more severe when the plants suffer from water stress.

Changes in temperature will alter host plant physiology and so modify host resistance. Elevated temperature may cause the breakdown of temperature-sensitive resistance. Conversely, in some crops, there is increased lignification at higher temperatures and this can enhance the level of host resistance to pathogens. Some diseases can be aggravated by stresses induced by extremes such as drought. Some fungal pathogens cause severe disease when host resistance is affected as a result of drought. Whereas certain pathogens remain latent or endophytic in healthy plants, but in hot, dry summers it can rapidly invade vascular and bark tissues and cause disease.

Status of sugarcane diseases

Sugarcane diseases are constraints to crop production all over the world, and no country is immune to the destructive influences of plant pathogens and pests. About 240 diseases of sugarcane caused by fungi, bacteria, viruses, phytoplasma and nematodes have been reported from all over the world (Rott *et al.*, 2000). In spite of all the efforts of breeding for disease resistant varieties, sugarcane is becoming more and more prone to many diseases and pests. The disease incidence is increasing at an alarming rate and the yield decline due to diseases continues every year in sugarcane. As per the ISSCT report, every year sugarcane diseases cause the loss of several millions of dollars. About 10-15% of the nation's sugar produced is lost due to diseases. Among them red rot, smut, wilt and pineapple disease (sett rot) are the important fungal diseases. Bacterial diseases like leaf scald disease (LSD) and ratoon stunting disease (RSD) are found to cause considerable yield loss in some countries. Also gumming disease and red stripe are known to cause damage in certain regions. Among the viral diseases mosaic is prevalent in almost all the countries; however its severity is felt more in American continents. Under Indian conditions, though mosaic occurs nearly 100% in the field, its impact on cane growth / yield is not appreciated. Besides these, grassy shoot caused by phytoplasmas is also a potential disease, which can cause considerable damage to sugarcane production. In addition, yellow leaf disease (YLD) has become a major constraint in many countries. Many promising varieties were removed from cultivation in the past since they succumbed to new pathogenic variants of red rot with more virulence. Also slow build-up of many non-fungal diseases in sugarcane causes decline in varietal performance and results in varietal deterioration. In this presentation disease management in sugarcane is briefly described in relation to the prevailing drought situation in different parts of the country.

Red rot

Currently red rot is in a contained state in the region. However, varieties such as CoC 24, CoSi 6, CoV 09356 *etc.*, recorded the disease in varying intensities in different districts. The causative fungus *Colletotrichum falcatum* is a facultative saprophyte i.e. it cannot survive in the soil for long periods without host substrate. The pathogen is primarily transmitted through sett borne infections and soil borne inoculum surviving in host debris and secondary transmission occurs through rain / irrigation water, rain splash or to some extent through air. Any changes in the environment will affect its perpetuation in the environment.

Survival of red rot pathogen in the absence of the host is influenced by various environmental conditions which may affect saprophytic ability and also formation of resting structures of by *C. falcatum*. Various workers have reported that dry or drought period during the growing season favours severe attack of red rot. Singh *et al.* (1991) studied this aspect of the problem by creating four types of moisture conditions after planting of sugarcane setts in artificially infected soil. The moisture treatments consisted of: (1) No irrigation after 2 months of germination (one irrigation was avoided between 20th May and 25th June), (ii) four irrigations at 25 days interval starting from 30th day after planting, (iii) Maintenance of moist conditions from one month after germination, and (iv) normal irrigations during pre-monsoon followed by flooding during July to September, given to the plant crop only. Maximum red rot incidence (70%) was observed when one irrigation after two months of germination was avoided. It is possible that moisture stress predisposes the plant to the attack of the pathogen and promotes formation of more dormant / resting structures by the fungus due to moisture stress (Singh et al., 1985). Secondly, presence of more dead parenchyma cells seems to facilitate the spread of the pathogen in stalk tissues. But with the formation of more dead cells due to water stress, the resistance offered by the host cells against the spread of the red rot pathogen appeared to be minimum which accelerated the invasion of the pathogen. The fungus surviving in dormant stages on young plants or infected sugarcane debris gets favourable environment upon commencement of rain at the end of June in subtropical conditions to sporulate and produce numerous acervuli loaded with conidia, which may cause fresh infections. However, formation of dormant infections in ratoon does not differ significantly with moisture levels.

Under Nigerian conditions the disease has been a concern to rainfed cultivation of sugarcane. Olufolaji (1989) reported that under experimental conditions red rot infection levels were higher in those treatments watered at wilting point than those watered regularly. His field trials also showed similar impact of drought on red rot incidences, where, the disease infection levels in rainfed plots were significantly higher than in the normal irrigated plots from the 7^{th} to 12^{th} month after planting with terminal disease infections of 45.6% and 21.8%, respectively.

Yin and Hoy (1997) investigated the effect of stalk desiccation on red rot under controlled conditions and in the field, and to evaluate the resistance to red rot of commercial sugarcane cultivars exposed to stress under Louisiana conditions. Field experiment results demonstrated that stalk desiccation occurring during the fall at the beginning of bud germination, and growth of vegetatively propagated stalks can increase the detrimental effect of red rot on shoot population in the following spring. Without desiccation, disease did not adversely affect spring shoot populations of seven cultivars in two seasons. Stalk desiccation alone resulted in shoot population reductions in some cultivars. However, the lowest shoot population always occurred in plots where inoculated, desiccated stalks were planted. The desiccation treatment was intended to induce drought stress in treated stalks. The authors claimed this is the first demonstration by experimental means that the severity of red rot of planted sugarcane could be increased by drought stress. Desiccation apparently can increase disease symptom severity in sugarcane stalks. Environmental stress conditions also may determine the extent to which red rot affects bud germination and shoot development, survival, and regrowth in the spring. Visible symptoms of desiccation, including stalk shrinkage that results in longitudinal wrinkling of the rind and internal internode discoloration, were evident in the ends of stalks. In preliminary experiments, conidia were introduced into internodes at the ends of stalks. Desiccation treatment appeared to increase disease severity, but the discoloration associated with desiccation interfered with disease assessment. The effects of stalk desiccation on disease severity could be greater in the ends of stalks, but disease was increased even in the center portions of inoculated, desiccated stalks.

In summary, desiccation increased disease severity in stalks of some cultivars more than others. However, in field experiments, red rot and desiccation together had a synergistic effect on spring shoot population reductions for all cultivars, except for one cultivar that was very sensitive to desiccation. The results have implications for research efforts to control red rot and on-farm management of the disease. Observational evidence suggests red rot is favoured by both excessive and deficient soil moisture, and by low temperatures. These factors can adversely affect sugarcane growth, but have much less effect on the pathogen. However, the possible relationships between different types of stress and sugarcane red rot severity are poorly understood. Timing farm cultural practices to avoid or minimize drought stress at and after planting should reduce red rot severity and improve plant cane stands.

Smut

Smut caused by *Sporisorium scitamineum* (Syn: *Ustilago scitaminea*) has assumed serious proportion in different parts of the country. With the introduction of smut susceptible cv CoA 92081 (87A298) in Andhra Pradesh and Tamil Nadu, the disease gained epidemic status. The pathogen is primarily sett-borne and secondary transmission occurs through air. The smut whips produce millions of teliospoes and they are easily spread through the air and reach throughout the field. The survival of sugarcane smut teliospores in the field is an important factor in the epidemiology of the disease and is important when developing strategies to limit the spread of the disease in the fields. Dry weather during the tillering phase appears to predispose the plants for smut infection. It was found that higher average temperatures favour more rapid spread of smut in the Herbert and Mackay areas in Australia. It can take up to three years for smut symptoms to develop in some varieties. Infected plants may not exhibit symptoms, but ratooning can induce symptom development in latently infected plants. Teliospores of the smut fungus had completely lost viability after 12 weeks in soil at 30% and 20% soil moisture. In soil at 10% moisture, teliospores survived for up to four months. Approximately 25% of teliospores remained viable in soil with 0% soil moisture after six months. These results suggest that teliospores of sugarcane smut can only survive for a few months at high soil moisture level (>10%) or when buried in soil. However, teliospores of the smut fungus have potentially greater longevities when maintained in dry environments (Bhuiyan *et al.* 2009). The smut symptoms developed faster and the symptoms were more severe in the September to November planted clones compared to the March to May planted clones under Australian conditions. Sugarcane plant growth and smut fungal growth are both restricted by temperatures below 20–24 °C. The temperatures around 31°C would be more ideal for sugarcane and smut fungal growth during the summer months. The summer conditions are also ideal for secondary spread of smut and secondary smut symptoms, smut whips on side-shoots and young tillers, were observed under this temperature conditions. The history of sugarcane smut epidemics suggested that disease severity is associated with hot and dry growing conditions.

It is clear that the disease will attain more severity during hot summer accompanied by drought. Hence there is an urgent need to protect the crop from the disease if susceptible varieties are under cultivation. Our studies have clearly proved that spraying of propiconzole (0.1%) contains the disease if spraying is done well before whip emergence.

Wilt

Among the various fungal diseases wilt caused by *Fusarium sacchari* has the maximum impact due to environment factors. The pathogen survives in the soil for many years. The surviving inoculum initiates infection in sugarcane when favourable environmental conditions set-in. Moisture stress during summer months coupled with high day temperature and low humidity may favour increase in wilt incidence. Sarma (1971, 1976) conducted detailed studies on the epidemiology of wilt in peninsular region by planting Co 419 in months from June to September and subjected to moisture stress. It was found that June (40%) and July (20%) planted *adsali* crops were highly susceptible to wilt, as compared to those planted in August. The extent of wilt was 8.2% when crops are not subjected to moisture stress, while it obtained a maximum of 45% when crops are subjected to moisture stress. It was established that moisture stress, particularly during March to May, coupled with high day temperature and low humidity appeared to lower the resistance of plants, accelerating their susceptibility to invasion by wilt pathogen.

Yellow leaf disease (YLD)

The disease is caused by Sugarcane yellow leaf virus (SCYLV), is a new disease reported in the recent years. There are also reports of sugarcane yellow leaf phytoplasmas (ScYP) causing the disease. The symptoms appear initially on matured leaves three through five usually in maturing plant or ratoon crop. The symptoms could be very clear after 5 to 6 months of crop growth. On the leaves, the symptom appears as yellowish midrib on the lower surface. The yellowing may be confined to midrib region or the yellow discolouration may spread laterally to adjoining laminar region parallel to midrib up to a distance of 2.0 cm. Reddish discolouration of midrib and laminar region is also noticed in certain varieties. In most susceptible varieties, typical yellowing of midribs and laminar region is noticed on upper surface of the leaves. Finally symptoms of necrosis of discoloured laminar region from leaf tip to bottom and subsequent drying of entire leaf is noticed. This virus is transmitted from plant to plant by aphids in a persistent, circulative and non-replicative manner. The virus particles are ingested with the sap when aphids feed on infected leaves, and aphid species *Ceratovacuna lanigera, Melanaphis sacchari, Rhopalosiphum maidis,* and *R. rufiabdominalis* are known to be vectors of SCYLV (Viswanathan et al., 2012). However, *M. sacchari* has been shown to be the most efficient aphid vector of SCYLV when compared to *R. maidis*, and *R. rufiabdominalis*.

In ratoon crop the intensity of the disease will be much higher than in plant crop. The disease incidence in sugarcane is found aggravated by the poor maintenance of the crop in the field. It is observed that infestation with internode borer, flowering, drought conditions, Striga infestation, and infection with other pathogens such as ratoon stunting, grassy shoot etc. favour early expression of the disease. The sugarcane varieties showing mild symptoms usually record normal cane growth. In severely infected clumps cane thickness and stalk height are significantly affected. Severe infection of the disease leads to shortening of internodes in the top. This effect culminates in bunching of leaves at the top. Usually such infection results in drying of entire clumps. Severe infection of SCYLV leads to reduced juice quality and sugar recovery. Combined infection of SCYLV and ratoon stunting bacterium in sugarcane causes severe stunting than their infection alone (Viswanathan, 2002; 2004). The disease occurs in epidemic form on most of the cultivated varieties and it adversely affects cane productivity in the tropical region. The disease infection may result in 25-30 % loss to cane and juice yield in popular varieties (Viswanathan, 2012). Virus-infected varieties recorded significant reductions in growth / yield parameters, such as stalk height, stalk thickness and number of internodes. Plant growth reductions were found to be 42.9, 42.3 and 38.9% in YLD-susceptible varieties CoPant 84211, Co 86032 and CoC 671, respectively. In addition to reductions in stalk weight, height and girth, YLD also reduced juice yield in the affected canes up to 34.15% (Viswanathan *et al.* 2014).

Impact of the disease on sugarcane growth and varietal degeneration has been well established. The author has observed severe incidences of the disease in the fields suffering from moisture stress in different states. Daugrois et al. (2011) conducted detailed studies on the disease epidemiology in Guadeloupe and they found aphid dispersal within the field increased regularly and rapidly and within 22 weeks, aphids were present on 88% of the plants in the first trial and on all plants in another two trials. Aphid dispersal in the field, expressed by an increasing number of plants colonized at least once by aphids, had a significant impact on SCYLV incidence. A correlation was found between aphid dispersal within the field and SCYLV incidence, indicating the importance of the rapidity of first arrival of aphids and their dispersal under humid tropical climatic conditions. Because rapidity of aphid dispersal seemed to play a major role in SCYLV incidence, they explored environmental data to identify key factors involved in aphid population dynamics in a humid tropical location such as Guadeloupe. Climate conditions have an effect on aphid populations in continental temperate locations. Warm temperature has a beneficial effect on aphid populations, whereas rainfall has a negative effect. They found a significant negative correlation between cumulative rainfall in the early stage of the sugarcane crop and aphid dispersal in the field. Because aphids can only land on plants, main alate aphid immigration occurs during the first stages of plant growth and until the soil is covered by the leaf canopy. Because tropical rain can disturb aphid flights, rain most likely impacts alate aphid immigration in the field and reduces aphid dispersal in humid tropical conditions.

YLD spread was random during the first 3 months after transferring healthy plants to the field. These random virus infections are mainly due to primary infections that originated from outside the field and are transmitted by alate aphids. Secondary infections resulting in aggregated diseased plants are observed later when the plant canopy covered the field, allowing apterous aphid migration within the field over short distances (Edon-Jock et al. 2009). Because secondary infections originate from primary infected plants, the level of primary infection is critical for SCYLV spread by aphids. The amount of rainfall at the beginning of sugarcane growth in the field impacted aphid dispersal. Consequently, rainfall also impacted sugarcane field contamination by SCYLV. They found a highly significant correlation between the number of virus infected plants and the cumulative rainfall observed during the first six weeks of plant growth in the field. Absence or low rainfall during early plant growth resulted in a high level of SCYLV infection, especially in highly susceptible sugarcane variety SP71-6163. Under high aphid pressure due low rainfall, the incidence of SCYLV in different varieties increased by an additional 45–65%. This is the first time that high variation in sugarcane infection by SCYLV is explained by variation in climatic conditions, and especially rainfall during alate aphid immigrations.

It is certain that drought affects normal growth of the plant and additional virus infection causes more diversion of nutrients/energy for its multiplication that result in severe retardation of the growth. Such scenario has been noticed during the drought. Although such detailed studies are conducted under Indian conditions we need to quantify the loss caused by SCYLV and other viral diseases during drought or other stress conditions.

Other diseases

It was reported that higher rate of pineapple disease infection occurred at low soil moistures and at temperatures of 28-32 °C and it was considered that dry soil conditions had a clear effect on the incidence of the disease. Similarly mosaic disease is aggravated by the host and dry conditions. The viruses associated with the disease viz. Sugarcane mosaic virus (SCMV) and Sugarcane streak mosaic virus (SCSMV) systemically infect the plants and cause pronounced effect on crop growth and vigour during moisture stress. Author has witnessed different varieties such as Co 740, CoC 671, Co 7219, CoJ 64, CoS 767 exhibiting very severe symptoms of mosaic during peak summer combined with drought.

Disease management vis-a-vis drought

The various types of diseases on sugarcane determine the quality, quality and stability of crop yield. Long duration coupled with its vegetative propagation, high sugar accumulation and practice of ratooning makes the crop easily succumbs to the diseases in the field. The pathogens are not only reducing the yield but also cause the deterioration of the variety due to their accumulation in the stalk over the time. Overall, it is established that drought increases the severity of the diseases caused by fungal and viral pathogens. Hence priority should be to go for planting disease-free planting materials and maintain the field under highest hygienic conditions.

Healthy nursery programme

Infected planting materials are responsible for the primary spread of the disease in the field. Hence, going for the disease-free setts would reduce the risk of disease introduction to disease free areas. Lack of awareness on seed cane health and ignoring quarantine regulations resulted in introduction of diseases, their epidemics and varietal degeneration in the country. To increase sugarcane productivity, supply of healthy seed canes is to be ensured in the field. As vegetative propagation in sugarcane favours harbouring of the pathogens causing red rot, smut, wilt, grassy shoot, leaf scald, YLD and RSD in the setts, adequate care should be taken while selecting seed canes. Since it is difficult to detect incipient infections of red rot pathogen in seed-pieces, it is recommended to take the planting material from a disease free crop. Any crop with more than 5% smut or as high as 2% grassy shoot incidence is unsuitable for seed purpose. For red rot, if there is any infected clump in the field the plot is to be rejected for seed. It is advised to select always a disease free area to raise the seed crop.

The scientific principle involved in heat therapy is that the pathogens present in seed materials are inactivated or eliminated at set temperatures not deleterious for the host tissues. Aerated stream therapy (AST) is advocated to eliminate sett borne infections of GSD and RSD. Any fault in the AST unit may adversely affect the sett germination. Hence functioning of the heating unit and temperature control systems, proper volume and circulation of the heating medium and proper loading of the cane within the treatment chamber are to be monitored time to time. Treated setts should always be treated with fungicides (Carbendazim 0.1%) to reduce the entry of soil pathogens through cut ends. Since operations in AST need critical care and handling this treatment is recommended only for raising primary seed in three tier seed nursery programme. The treated setts should always be planted in factory farm for better monitoring. In place of the thermotherapy meristem-culture derived seedlings can be used in three tier seed nursery programme to get disease-free seedlings.

Virus elimination through tissue culture techniques

Since many of the viruses are systemically infecting sugarcane, virus elimination through meristem-tip culture is being followed in many countries. In vitro culture techniques employed for virus elimination involve indirect morphogenesis. However, clonal fidelity is not assured when plants regenerate via a callus stage. Some viruses can be effectively eliminated from infected plants owing to their mode of replication and their mechanism of movement within the plant. Meristem tip culture is the most widely used method to eliminate the virus / phytoplasma. This technique takes advantage of the fact that many viruses are unable to replicate in this region. Transfer of the meristem dome, together with one or two leaf primordial, to a culture medium and development into a plantlet may lead to the elimination of a virus. Successful elimination of sugarcane mosaic virus and Fiji disease virus in sugarcane through apex or bud culture has been reported earlier.

Studies conducted to eliminate the SCYLV and SCYP by tissue culture from infected sugarcane plants in Mauritius found that the tissue culture derived regenerated plants were remained free from the respective pathogens over a period of one year in the glasshouse, confirming that the pathogens had been eliminated by tissue culture. Also attempts made from CIRAD, achieved virus elimination of 92 %, however they got only 64 % disease free plantlets. Hence stringent seed indexing methods have to follow while screening of the regenerated plantlets. The potential for eradicating pathogens via rapid regeneration of plants directly from leaf roll discs was explored in South Africa. The technique, NovaCane®, has been used successfully to remove SCYLV from sugarcane. Plantlets were transferred to seedling trays after ten weeks and acclimatized in the glasshouse. Two months later, tests for the presence of the disease causal agents in selected plants were performed by RT-PCR for SCYLV and it was found that the process eliminated SCYLV. In addition, this process enabled elimination of bacterial pathogens from diseased sugarcane plants while simultaneously enabling large-scale micro-propagation. As disease eradication was not 100% effective, they have suggested that donor plants require conventional screening for the presence of known causal agents prior to micro-propagation.

Detailed studies were conducted at SBI, Coimbatore to eliminate Sugarcane yellow leaf virus (SCYLV) from infected sugarcane. Meristem culture combined with viricide Ribavirin has effectively eliminated the virus and reverse transcription polymerase chain reaction (RT-PCR) is being used routinely to index the tissue culture materials (mother plants or seedlings) for the virus. Production of SCYLV-free seedlings has ensured supply of YLD-free planting materials to the growers fields and such fields showed renewed vigour in the crop. Overall, virus elimination through meristem culture combined with molecular diagnosis has been demonstrated as a viable strategy to manage YLD, which occurred in epidemic form in sugarcane in the recent years.

All the tissue culture seedlings supplied form the institute are indexed for the viruses. In addition, SBI offers virus-indexing service to tissue culture production units in the country and many laboratories are utilizing the service. Multiplication of virus-free planting materials in the nurseries ensures crop vigour in the field. Detailed studies conducted in the factory areas in Tamil Nadu revealed that adopting tissue culture derived YLD-free nurseries resulted in better crop stand with good vigour. Such fields recorded higher yields compared to the YLD infected crops in the same region. There is also apprehension from the factories that the virus-free crop would acquire virus through aphid vectors subsequently. Yes, it would happen in the field. However build-up of virus titre in the disease-free plants would take about 5-6 years. By the time it is due for new seed through the seed cycle and the fields are to be replaced with fresh seed. Hence this approach is sustainable to manage sugarcane from non-fungal diseases and to prevent varietal degeneration.

Ratoon management

We notice more damages caused by the diseases in ratoons than plant crop due to different reasons. Inoculum level of systemic pathogens causing red rot, smut, GSD, LSD, RSD, mosaic etc. gradually increases and result in severe expression of diseases in ratoon crop. Combined infection of two diseases such as RSD and mosaic or RSD and YLD adversely affect the crop growth and such effect is more pronounced in ratoons. Also establishment of ratoon crop in the field is severely affected by pathogen infection in plant crop. Similarly more accumulation of pathogen in ratoons facilitates acquiring higher virulence in the pathogens. In the previous years, the popular sugarcane variety Co 419 lost its prominence due to its susceptibility to RSD, mosaic and YLD. Higher RSD pathogen load favours YLD and entire foliage become yellowish and slowly crop degenerates and dries. This situation was found more in ratoons, due to high pathogen load/vigour. Since multi-ratooning of sugarcane has several advantages it is being followed in many they have suggested that donor plants require conventional screening for the presence of known causal agents prior to micro-propagation.

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Emerging new diseases

Factory personnel's traditional wisdom is that only red rot and to some extent smut cause significant damage to sugarcane. However other diseases also inflict loss to the crop depending on the situation. Recently many diseases have emerged as serious ones in different states. YLD has spread to epidemic form in some varieties. Although mild infections of the disease do not cause much crop loss continuous use of seed from such fields lead to severe disease outbreak. Similarly, problems of wilt, RSD and GSD have been ignored in certain pockets, as there was no previous history of their severity there. Due to introduction of new varieties or change in cultivation pattern, minor diseases become severe. Hence, we have to keep a constant vigil on the emerging diseases in the region and immediately suitable management practices are to be taken up to avert future losses.

Avoidance of predisposing factors

Sugarcane is more prone to vagaries of nature, unlike short duration crops, which has the advantage of evading the critical drought stress period. Different biotic and abiotic factors aggravate many sugarcane diseases viz., different borers, sucking pests, drought (or) water logging. The diseases like sugarcane wilt and YLD are severely aggravated by drought as well as water logging. Likewise, RSD is also influenced by low or excess moisture stress. The infestation of internode borer (or) striga favours wilt outbreaks in different regions. Hence, these types of predisposing factors are to be minimized. Added to the abiotic stress induced by drought, the weakened cane gets more prone to diseases like wilt and smut in sugarcane. However, still sugarcane can withstand certain degree of moisture stress, as it has remarkable ability to recover and put up normal growth when it is released from stress either through rainfall or irrigation.

Conclusion and future perspectives

Sugarcane diseases perpetuate in the sugarcane ecosystem and cause damage to the crop depending on the prevailing environmental conditions. The disease severity is aggravated when the crop suffers from other stress conditions. The drought situation prevailing in the state is unexpected and continuous drought for the last three seasons in the region indicates the possible climate change effects. This needs detailed investigation. As discussed earlier diseased sugarcane suffers more during drought situations; hence the industry needs to follow an integrated disease management in sugarcane to avert losses caused by the diseases.

The fungal diseases like red rot, smut and wilt were responsible for the elimination of many elite commercial varieties in the past in different epidemics. Additionally many of the non-fungal diseases contribute to decline in their performance due to 'varietal degeneration'. Lack of awareness on seed cane health and ignoring quarantine regulations resulted in introduction of diseases, their epidemics and varietal degeneration in the country. Hence sugar industry may follow strict quarantine norms when they bring new varieties from unknown sources or destinations. This would prevent introduction of new diseases which are not reported in the region from other zones or countries.

Growing disease resistant varieties is the mainstay in disease management in sugarcane and introduction of disease resistant varieties after red rot or smut epidemics has saved sugar industry during several occasions. However, sugarcane varieties vary in their potential against different diseases and any elite commercial variety may not possess tolerance against all the major diseases. Hence to sustain the productivity in such varieties alternate management strategies need to be followed to contain the disease losses.

Although YLD has created a havoc to sugarcane cultivation in the country and SBI has evolved strategies to manage the disease through meristem culture combined with molecular diagnosis of the virus. Hence, need of the hour is to establish YLD-free nurseries in different sugar mills to reduce disease severity. Wherever appropriate conventional seed nursery programme through aerated steam therapy needs to be followed to reduce severity of GSD and RSD.

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