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Review Article

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Sugarcane Grassy Shoot (SCGS) Disease - An Overview

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ABSTRACT

Sugarcane (Saccharum officinarum L.) is one of the important agro industrial crops of the tropical and subtropical countries of the world. India being a world's larger consumer as well as the second largest producer of sugar country requires sugarcane production on large scale. To fulfill this demand large of amount of seed material is to be exchanged from one location to another, but, as most of the sugarcane diseased are seed borne, new diseases have also been introduced to new location from its centre of origin in the past history. Similar to other major diseases of sugarcane, phytoplasmal diseases are also of economic importance and cause various biochemical changes in the plants. Phytoplasma has been reported to be associated with grassy shoot disease of sugarcane which causes significant losses in sugarcane yield and sugar recovery. It is very important to identify the disease at earlier stage to avoid its further spread and to develop effective control measure strategy. The identification of the disease based on the symptoms developed by infected plants is not always specific and can be confused with those caused by biotic and abiotic agents. With the use of various serological and molecular techniques, phytoplasma can easily be detected at early stage. These diagnostic techniques could play a vital role in supply of healthy sugarcane seed material. Keeping in view the economic importance of this disease, the present review summarizes the symptoms expression, mode and source of infection, transmission, biochemical aspects and detection methods of casual pathogen and disease management.

Keywords: *Sugarcane, Sugarcane Grassy Shoot Disease, Disease Incidence, Insect-vector Transmission, Symptoms*

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is one of the important commercial cash crops of the tropical and subtropical countries of the world. Sugarcane provides raw material for production of sugar, jaggery, khandasari and other byproducts and also used for preparation of compost (Bagasse + trash), press mud, alcoholic beverages and variety of chemicals. Bagasse has been used as a raw material in paper industry (Anon, 2000).

Worldwide sugarcane occupies an area of 26.52 million hectare with a total production of 1877 million tonnes (Anon, 2018). India is the second largest producer of sugarcane next to Brazil and it is the second important industrial crop of the country.

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The area under sugarcane is 4.79 million ha with productivity of 74.4 t/ha, sugarcane production is 355 million tonnes (Anon, 2018). Uttar Pradesh, Maharashtra, Karnataka, Bihar, Tamil Nadu, Anthra Pradesh and Telangana, Gujarat, M.P. and Chhattisgarh, Haryana, Uttarakhand and Punjab are the major sugarcane growing states of India.

Sugarcane is vegetatively propagated and this crop stands in the field for a year or more, it is prone to several diseases caused by many fungal, bacterial, viral, phytoplasmal and nematode pathogens as well as abiotic factors right from planting to harvest (Matsuoka & Maccheroni, 2015).

At present, India is self sufficient in sugar production but due to increase in population size and for export to earn foreign exchange, demand for sugar is growing every year mainly. To fulfill increasing demand of sugarcane for sugar and its raw material, large amount of sugarcane seed material is transferred from one area to another and as majority of diseases of sugarcane are seed borne it also lead to the introduction of several new pathogens (Shruthi, 2011). Sugarcane diseases, red rot, whip smut, wilt, pineapple disease, ratoon stunting, wilt, rust, mosaic, white leaf and grassy shoot are of great concern (Agnihotri, 1983). Among the disease, phytoplama diseases of sugarcane are gaining importance nowadays because of their non specific symptoms and serious economic losses especially caused to the ratoon crop (Tiwari et al., 2012).

Plant-pathogenic phytoplasmas (formerly called mycoplasma-like organisms [MLOs] are nonculturable, wall-less prokaryotes of the class *Mollicutes* with a small genome size ranging from 530 to 1350 kilobases (kb) (Marcone et al., 1999). Phytoplasmas are phloem-limited plant pathogens which resides almost exclusively in the sieve tube elements and classified as a member of the 16Sr XI-B group. Phtoplasmas are associated with plant diseases and are known to cause diseases several hundred plant species (McCoy et al., 1989, Lee et al., 1998, Seemuller et al., 1998). The symptoms shown by infected plants include, whitening or yellowing and reddening of the leaves, reduced leaf size, shortening of the internodes leading to stunted growth, smaller leaves and excessive proliferation of axillary shoots resulting in a witches'-broom appearance, virescence, phyllody, sterility of flowers, loss of apical dominance, decline and death of plant (Lee et al., 2000, Nasare et al., 2007).

A number of sugarcane diseases have been associated with phytoplasmas, some of which are region or country specific. Among them, two major phytoplasmal diseases are sugarcane grassy shoot (SCGS) and sugarcane white leaf (SCWL) (Sdoodee, 2001) found in many Asian countries including India (Rao et al., 2005). However, there is no report on occurrence of the SCWL disease in India except a report from Karnataka undertaken due to great confusion about the identity of the SCGS and SCWL disease occurrence due to similar type of symptoms produced by two diseases (Shruthi, 2011).

ECONOMIC IMPORTANCE

Phytoplasmas are known to cause diseases in several hundred plant species, including many important food, vegetable, and fruit crops; ornamental plants; and timber and shade trees (Bertaccini & Duduk, 2009). The list of diseases caused by phytoplasmas is increasing year by year and many newly diseases are emerging. SCGS and SCWL have been reported from many Asian countries *viz.*, Bangladesh, India, Iran, Malaysia, Nepal, Pakistan and Sri Lanka, Myanmar, Sudan, Thailand (Bhansari & Shukla, 1985, Corbett et al., 1971, Nakashima & Murata, 1993, Vishwanathan et al., 2000, Rishi & Chen, 1989, Singh et al., 2002, Srivastava et al., 2003). Sugarcane grassy shoot (SCGS) is one of the most important diseases of sugarcane in India. Rao and Dhumal (2002) reported that SCGS disease is very important next to fungal diseases. In India, SCGS disease has been reported from Punjab, Uttar Pradesh, Haryana, Bihar, West Bengal, Madhya Pradesh, Andhra Pradesh, Karnataka and Tamilnadu (Vasudeva, 1955). Disease was first observed by Barber (1919) and reported by Chona et al. (1958)

from Belapur (Maharashtra). The grassy shoot disease has been reported to contribute losses of 5 to 20 per cent in main crop and these losses are up to 100% in ratoon crop (Rao et al., 2008, Marcone et al., 2004, Vishwanathan & Rao, 2011). Primarily SCGS infected plants are limited in number, but incidence increases by upto 60-80 per cent in ratoon crops through secondary spread by insect vectors (Srivastava et al., 2006).

SYMPTOMOLOGY

SCGS disease is characterized by the production of a large number of thin, small, slender, adventitious tillers from the base of the affected stools, giving the plant a bushy appearance bearing pale yellow or chlorotic leaves which remain thin, narrow, reduced in size (Chona et al., 1958, Sarosh et al., 1986, Rishi & Chen 1989). Formation of white leaves by leaf chlorosis and proliferation of tillers, excessive tillering and stunting of the plants gives the plant a grassy appearance (Nasare et al., 2007) and hence the name grassy shoots disease. Affected plants do not produce millable canes. If the attack is light, one or two weak canes may be formed. Most of the stools die after monsoon. The severely diseased clumps remain stunted and may produce one or two weak canes. The disease is particularly pronounced in the ratoon crop give the appearance of a field full of perennial grass.

TRANSMISSION

The vector(s) responsible for the natural spread of SCGS have not been identified. there According to some reports, the disease primarily spread by infected seed setts while secondary infection may involve insect vectors especially leaf hoppers, plant hoppers and psyllids from the family *Cicadellidae*, *Fulgoroidea* and *Psylloidea* in a persistent propagative manner (Vasudeva, 1960, Singh, 1969, McCoy et al., 1989, Srivastava et al., 2006). However, these reports have not been confirmed. Also, there are reports on transmission by three different species of aphids (currently named *Rhopalosiphum maidis* (Fitch), *Melanophis sacchari* (Zehntner) and *Melanophis sachhari* forma *indosacchari* (David)) as well as by *Proutista moesta* (Westwood), a fulgorid (Chona et al., 1960, Edison et al., 1976).

The leafhopper has been reported to transmit SCGS phytoplasma in India). In India, sugarcane grassy shoot disease has been reported to be transmitted by leafhopper (Edison, 1973, Rishi & Chen, 1989, Tran-Nguyen et al., 2000, Singh et al., 2002, Srivastava et al., 2006). Singh et al., (2002) and Srivastava et al., (2006) reported that nymphs of leaf hopper *Deltocephalus vulgaris* were more efficient than adults in transmitting the SCGS phytoplasma.

Mechanical transmission through cutting knives etc. is doubtful though transmission through dodder plant (*Cuscuta campestris*) has also been reported. The disease increases in successive ratoon crops.

DETECTION METHODS

SCGS can be detected by using 4', 6-diamidino-2-phenylindole (DAPI) stain technique in thin sections of infected tissues (Seemuller, 1976, Sarindu & Clark, 1993). DAPI binds AT-rich DNA preferentially, so that phytoplasmas, which possess AT rich genone (Lee et al., 2000, Hogenhout et al., 2008, Sugio et al., 2011) localized among phloem cells, can be visualized in a fluorescence microscope. This is a simple and rapid technique and not much expensive permit a rapid and precise localization of phytoplasmas both in fresh and dried samples (Musetti et al., 1992), and not only in leaf or stem tissues, but also in roots and petioles (Favali et al., 2004). However, it is limited when the population of pathogen is very low in the effected tissues.

ELISA technique employing polyclonal or monoclonal antibodies is another method used for identification of phytoplasma. Antisera are successfully used in ELISA tests for detecting their respective homologous phytoplasma antigens in crude tissue extracts of diseased sugarcane. For the detection of SCGS, polyclonal antisera have been produced against partially purified antigen preparations from affected sugarcane plants (Sarindu & Clark, 1993, Viswanathan, 1997, 2001).

However, due to cross-reactions with plant host proteins and non specific background reactivity and lack of sensitivity this technique have not been widely employed in phytoplasma detection and identification (Seemuller et al., 1998, Adams et al., 2001).

The powerful nucleic acid based technique based on polymerase chain reaction (PCR) has widely been employed in several laboratories for detecting many different types of phytoplasmas. PCR provides a highly sensitive, simple, specific and quick and cheap detection of phytoplams over other methods. Conventional detection of phytoplamss is based on universal phytoplasma-specific primers (Ahrens & Seemullar, 1992, Davis & Lee, 1993, Deng & Hiraki, 1991, Firrao et al., 1993, Seemullar et al., 1994). Phtoplasma group-specific primers have also been designed, directed to ribosomal and/or non-ribosomal DNA sequences (Bertaccini & Martini, 1999, Gunderson et al., 1994). Since phytoplasmas occurs in low titre, a nested PCR assay is often required for diagnostic purposes (Anderson et al., 1998, Gunderson & Lee 1996; Heinrich et al., 2001). In infected plants of sugarcane the phytoplasma numbers are so low that infections could be detected only through the highly sensitive nested PCR assay (Tran-Nguyen et al., 2000, Aljanabi et al., 2001). Although nested PCR technique may increases sensitivity and accuracy, also it increases the risks of cross –contamination (Nejat & Vadamalai, 2013).

Advances in various molecular diagnostic techniques based on DNA hybridization, amplification and sequencing have been widely used for the detection and classification of phytoplasma isolates (Bertaccini et al., 1990, Klingkong & Seemuller, 1993). Sequence analysis of rDNA of the phytoplasmas conducted by Nakashima et al., (1996) revealed the closer similarity between SCWL phytoplasmas and the rice yellow dwarf (RYD) phytoplasmas. SCWL phytoplasmas also showed relateness to the sugarcane grassy shoot phytoplasmas.

BIOCHEMICAL ASPECTS

SCGS pathogen severely alter protein metabolism in the diseased plants. Amino acids and amides levels are elevated in the diseased leaves in comparison to disease free plants. Arginine accumulation patters also differs between albinoid and healthy leaves (Singh & Singh, 1966, Jaiswal & Bhatia, 1971). Total chlorophyll content in diseased plants is reduced upto 20-40% during the disease infection (Shukla et al., 1988). Increased concentration of protein amino acids in healthy leaves suggests the interception of free amino acids incorporation into proteins in diseased leaves due to impaired photosynthesis and insufficient chlorophyll. In addition, the inadequate carbohydrate supply leads to degradation of protein into free amino acids.

Disturbed photosynthetic activity in the infected plant, affects the respiration ratios which in turn affects the carbohydrate metabolism. Non reducing sugars, total sugars and starch decreased whereas reducing sugars increase in diseased plants. Increase in total water soluble carbohydrates and reducing sugars content in diseased leaves is due to the enzymatic conversion of carbohydrates into simple sugars by the pathogen. SCGS infection impared the activity of sucrose synthatase and sucrose phosphate synthatase and stimulated the activity of invertase (Dhumal & Nimbalkar, 1982).

The activity of peroxidase, polyphenol oxidase and ascorbic acid oxidase increased manifolds following SCGS infection (Dhumal & Nimbalkar, 1982). The increase in peroxidase activity is a defense mediated response to the disease and is attributed to the oxidation of phenolic compounds to quinones which are toxic to the pathogens. The organic acid metabolism is also severely altered in SCGS affected leaves. Higher citric acid: maleic acid ratio is recorded in the diseased leaves due to more accumulation of organic acids. Mineral compositions (Potassium, Phosphorus, Sodium, Iron, Zinc, Copper, Nitrogen, Magnesium) is largely affected in diseased sugarcane leaves.

CONTROL

The primary method for the disease control is prevention of disease rather than treatment.

As the disease is seed transmissible, use of healthy, certified, disease free seed setts

should be use as planting material. Moist hot air treatment (MHAT) at 54°C for 4 hours inactivates the causal organism though other modes of heat treatment are also effective. Rogue out the diseased clumps regularly and do not keep ratoon of the diseased crop. Phytoplasma infection is also known to be transmitted by insect vector, therefore, it is important to control them.

CONCLUSION

The intensity of phytoplasmal diseases of sugarcane is increasing and becoming more widespread and are of considerable economic importance. SCGS diseases seem to occur in all parts of south-east Asian region and cause huge economic losses. The infected seed material is the main source of spread of the diseases. Majority of sugarcane disease are seed borne, so, during exchange of large amount of sugarcane germplasm, the many new diseases of sugarcane including those caused by phytoplasma have been introduced in the past from one area to another. Therefore, it is very important to identify and manage the disease. But, the identification of the disease is mostly relied on the symptoms expression by the plants which are influenced by various factors. With the use of multiple and advanced strategies based on biotechnology and molecular techniques, phytoplasma can easily be detect at early stage. These diagnostic techniques could play vital role in supply of healthy and pathogen free sugarcane seeds. However, there is a still need to identify and develop a rapid assessment and quicker diagnostic methods and procedures to develop successful control measure strategies for this pathogen.

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