Symptoms and their Assessment of Sugarcane Pokkah Boeng

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Abstract— *Sugarcane (Saccharum officinarum L.) is one of the main important commercial crops, mainly grown in tropical and subtropical countries in the world, because these areas provide suitable conditions for obtaining the best yield and productivity. Sugarcane is affected by many pathogens such as fungi, bacterial and viral diseases and fungal diseases are increasingly being affected internationally, affecting the quantity and/or quality of harvested crops. Among the fungal diseases, pokkah boeng have become the main problems faced by sugarcane growing countries, causing serious yield losses. However, there are many reports of an outbreak of the disease, which looks spectacular, but it caused trade and industrial losses. In this review we highlight the importance of sugarcane and the symptoms of the Pokkah Boeng disease tend to develop during period of rapid crop growth.*

Keywords— Sugarcane, Pokkah Boeng, Symptoms, Pathogen, Fusarium.

I. INTRODUCTION

Sugarcane (*Saccharum officinarum L.*) is one of the most important commercial crops and the primary producer of sugar in the world, accounting for around 70% of the world's overall sugar supply. Sugarcane is cultivated primarily for sugar, which is an important cooking material in the modern world. Sugarcane is a member of the *Poaceae* family which consists of six perennial grass species of the genus *Saccharum L*. It is a long-term crop of 10-12 months, so it is susceptible to a number of diseases, and the importance of diseases as a restrictive factor in the development of sugar cane has been widely established. A substantial number of diseases have a major effect on the production of sugar cane **[1]**. This is partially due to their nature, reproduction, cultivation and management methods.

The crop has an unparalleled record of dealing with new diseases, some of which have caused major losses or more widespread. The increase in sugarcane land used as a commercial crop is expected to cause more disease problems in many countries. The losses caused by these diseases may vary from place to place and depend on the type of crop. Therefore, these diseases cannot be ignored or neglected due to their impact on the quality and quantity of sugarcane.

Disease is one of the major problems affecting sugarcane productivity. Sugarcane disease not only caused a decline in production, but also had a major impact on variety development plans. The fungal pathogens of sugarcane are known to spread to different continents and different sugarcane varieties. Many primitive noble canes are susceptible to some serious diseases, but their hybridization with wild canes improves their toughness. Among fungal diseases, pokkah boeng has become a serious problem for sugarcane-growing countries, which can lead to severe yield losses.

When the plant grows rapidly, Pokkah boeng may become obvious during wet periods. However, the plants can be restored and have little effect on yield. In particular, resistant varieties may affect the disease resistance or resistance of plants to pathogens, and moderate safety in controlling plant diseases should be considered. Planting healthy seed materials/using drug-resistant materials and following comprehensive disease management measures is the best way to prevent the occurrence of diseases **[2]**. This chapter initially briefly introduced the economic importance of sugarcane. Subsequently, the pokkah boeng of sugarcane is described in detail, including its disease symptoms and pathogens. Biological control has become the ultimate long-term solution to the problems of sugarcane pokkah boeng because it is safer than chemical pesticides and is considered to be less polluting to the environment. However, due to severe constraints, the above-mentioned disease control measures cannot be implemented, so some alternative sustainable strategies are necessary.

II. SYMPTOMS

Fungal infections may typically cause noticeable signs of abnormal development, patterns and colors, but non-biological issues can cause normal, stable symptoms. Pathogens can also be present on symptoms such as fungal growth, bacterial exudate, etc. The magnitude of symptoms varies with the species' propensity and the environmental factors that regulate the growth of the organism. The symptom is easy to recognize because it affects the top of the plant and the young leaves begin to chlorosis. The death of host cells and tissue is triggered by constant activation of environmental factors. This

contributes to the development of symptoms that may result in damage or death to the whole plant or portions of it. The initial sign is easy to recognise because it involves the top portion and the chlorosis region at the base of the young leaf. If the fungus is confined to the leaves, the plant will normally recover, else internal ladder-like lesions can occur in the stem [3]. Heavily infected plants showed a malformed or damaged top and stalk may occur in highly susceptible varieties.

2.1 Chlorotic Phase

Severely infected plants exhibit top deformities or damage, and stalks can occur in highly susceptible varieties. The earliest symptom of Pokkah boeng is the appearance of green leaf disease on the roots of young leaves, occasionally occurring in other parts of the leaves. It is often seen that the bottom of the affected leaf is narrower than the bottom of a normal leaf. The first sign of Pokkah boeng is the green state toward the base of the young leaves, which rarely occurs in other parts of the leaves. The roots of affected leaves are usually narrower than the roots of normal leaves. Ladder like shaped lesion on the spindle-shaped leaves is obviously yellow, the spindle is wrinkled, twisted or tangled, red streaks appear, the leaves become shorter and the young leaves are deformed. As the leaves mature, irregular reddish stripes and spots will appear in the chlorosis part.

2.2 Top-Rot Phase

The most advanced and severe stage of Pokkah Boeng is the top rot phase. Leaf infection sometimes continues downward and penetrates into the stem through the growth point. In the late stage of infection, the entire root of the spindle and even the growth point showed leaf deformities, and the spindle blades were obviously wrinkled, twisted and rotted. Red spots and streaks also appeared. In the late stages of the disease, decay will appear. The growth points are killed and the plants die.

The young spindle was killed, and the entire upper mold died. Leaf sheaths may also chlorosis and develop reddish asymmetric necrotic areas. The reddish tissue forms a stepped lesion, usually with darker edges. These lesions sometimes penetrate the surface of the peel. Sometimes, pathogens also attack the spindle and move down from there to the end of the stem, causing the top to rot. The decayed apical rot is through the rot of the spindle leaf, obvious red streaks and white spore clumps, necrosis and bud sprouting. The spots and flow channels combine to form large red-brown wilted tissues. Later, irregular red streaks and spots are formed in the chlorosis part, forming a lens or diamond-shaped hole **[4]**. The top part of the stem is severely damaged.

2.3 Knife-Cut Phase

The symptoms of knife-cut stage are observed in association with the acute phase of the disease characterized by one or two or even more transverse cuts in the rind of the stalk /stem in such a uniform manner as if, the tissues are removed with a sharp knife. Usually, the infection occurs evenly on top of the sugar cane, which is obviously the cause of the spread of the disease. This is the exaggerated stage of the typical stepped lesions of pokkah boeng disease. The infection in the spindle sometimes continues down to the stem, and dark red stripes may be found to extend across multiple internodes. When the leaves are peeled off, a large horizontal cut is formed on the stem. As the name suggests, the most obvious function of pokkah boeng is to deform the top of the sugar cane. The earliest symptoms appear on young leaves, which are chlorosis to the base, twisted, wrinkled, narrower and shorter than normal leaves. Irregular reddish streaks may appear in the fading area. If the infection is limited to the leaves, the plant usually recovers little and is damaged [5]. However, the infection may progress to the stem, where internal and external ladder-like (knife cut) lesions may appear. The most serious damage occurs when the fungus penetrates the growth point, which may die and cause the top to rot. Infection is achieved by washing air-borne spores between partially unfolded leaves to the roots of the spindle during rapid growth in hot conditions, and then rain or irrigation. Then, the spores germinate and infect the young tissues of the spindle [6]. Pokkah boeng disease shows several post-inflection points in morphology, anatomy, biochemistry and physiology. The occurrence of Pokkah boeng disease is more pronounced in the dry season followed by the humid season. Under these conditions, leaf infections develop rapidly, and even resistant varieties sometimes show typical leaf symptoms. It is generally observed that when conditions favorable for plant growth occur, the affected plants recover from the disease. The infection of this disease is caused by spores or ascospores.

Pathogens enter the host tissue through any damage caused by insects or borers or natural growth cracks. The severity of symptoms varies with changes in drug susceptibility and environmental conditions, and determines the development of pathogenic organisms. After entering, the infection line will develop normal hyphae, which will grow in the host tissue for a period of time, and then come out of the cells and reach the outer surface, forming the cervix. Upon close inspection, the

deformed leaf blade showed extensive damage on the leaf base, resulting in white plaques, blackening of the affected lamellar area and extensive black vein necrosis.

Rain and heavy dew will usually wash the nodules and microspores that develop between the nodes, and the spores will stay around the nodes behind the leaf sheath. Due to severe PB infection, the extension of intermodal transportation in the affected straw area has been drastically reduced. Depending on the severity of the PB, at most five or six nodes show shortened nodes. Spores germinate, mycelium forms bud scales, roots are primitive or leaf scars, and then enters the plant tissue. Associated with the increase in *fusarium* are several cultural practices that may contribute to the increase in the disease: maximum farming, high nitrogen fertilizer, high plant populations, and continuous cropping. In the process of fungal penetration and growth inside plants, *fusarium* protease and mycotoxins play a complementary role in host defense inhibition and intracellular colonization of spikelets, and play a strategic cooperative role in the process of ear and core colonization.

III. MEANS OF DISPERSAL

The pathogen of the disease is spread by moving spores from one place to another by air currents **[7]**, and will settle on the leaves, flowers and stems of plants **[8]**. For spores to take off, it depends on the environmental conditions, which requires different propagation strategies **[9]**. The fungus splashed by rain is based on the "puff" and "tap" mechanisms, which cause dry spores to spread into the air, and the spores are usually bent like *Fusarium* **[9]**. Pokkah boeng disease of sugarcane may also be transmitted from seeds contaminated with fungi **[10]**. The spread of spores depends on various environmental conditions and may require different spreading strategies. However, many have active or passive means of diffusion in the atmosphere and are common among settlers of aerial plant parts, where they can cause diseases of great economic significance. Infection usually occurs through the spindle along the edge of a partially expanded leaf. The spores that enter the spindle germinate and grow into the internal tissue of the spindle leaf. **[11]** reported that adults of the and sugarcane stem bore can also transmit fungi. The top bore worm is called Chilo spp. It usually results in leaf deformation and shortening, which is similar to leaf deterioration and shortening caused by pokkah boeng disease.

IV. CAUSAL ORGANISMS

Although the disease is caused by *Fusarium*, there is some controversy about the species **[12]**. In Malaysia, the pathogenic organism of Pokkah boeng is called *Fusarium moniliforme var. Subglutinans* **[13]**.**[2]** studied the morphological and pathogenicity of different isolates of *F. moniliforme* associated with pokkah boeng disease collected from various places in Maharashtra. According to reports, the causative organism of Pokkah Boeng disease belonging to the Section Liseola is *Fusarium sacchari* found on sugarcane in Asia **[13]**. **[12]** proved the association between *F. sacchari* and pokkah boeng disease in their work. Pathogens can be spread by air currents **[4,5]** and airborne spores will colonize the leaves, flowers and stems of plants **[8].** The curved structure of the large conidia of *Fusarium* species is easily scattered by rain.

V. CONTROL MANAGEMENT

Spraying different fungicides, such as Bavistin (1 g l-1 water) or Blitox (2 g l-1 water) or copper oxychloride or Dithane M-45 (3 g l-1 water), can effectively reduce pokkah boeng disease **[15]**. Spraying 2 to 3 times every 15 days can reduce the propagation of pathogens, thereby reducing sugarcane yield and quality loss. Therefore, paired rows or larger planting intervals are necessary to promote plant protection operations. When they are observed, the sticks showing the highest decay should be driven out of the field immediately. Planting healthy seed material/using drug resistance and following comprehensive disease management practices is the best way to prevent disease from occurring **[2]**.

Only disease-resistant varieties can be controlled. Generally, the resistance of the seedlings to pokkah boeng is tested by injecting a suspension of the conidia of G. fujikuroi conidia into the leaf spindle 10 cm below the highest visible leaf joint. In most breeding institutions, susceptible new varieties are discarded in the selection process, which provides sufficient control **[1]**. In addition, the fungus *F. moniliforme* can be spread horizontally through airborne spores or crop residues, and vertically through seed blocks. For these seeds, it is important to use resistant varieties and apply fungicides. Both control methods are limited. Therefore, it is important to develop novel and environmentally sound strategies to control this and other sugarcane diseases. Burkholderia isolates from sugarcane plants are essential for further isolation of these isolates for biological control of pokkahboeng and other sugarcane diseases. Because of the high frequency of Burkholderia in endophytic bacteria from sugarcane plants and its strong growth inhibitory activity against *F. moniliforme*, these isolates are potential candidates for disease control.**[16]** The endophytic bacterial community associated with sugarcane has multiple genera and has the potential to promote plant growth and control disease.

VI. POTENTIAL UTILIZATION OF SUGARCANE

Today, sugarcane agriculture has become an important economic activity in more than 100 countries especially in developing economies. Sugarcane is responsible for raw sugar production worldwide **[17]**. Dryness, winter, and chemical maturity all slow down growth and increase sugar concentration. In addition, chopped sugarcane stalks are widely used as cattle feed, especially during dry seasons when pastures are unavailable for grazing. Sugarcane is considered the first generation of biofuel crops. The world's demand for sugar is the main driving force for sugarcane agriculture. In addition to sugar, products extracted from sugar cane include witch falernum, molasses, rum, cachaça, bagasse and ethanol.

It is one of the most efficient photosynthesis in the plant kingdom. This is a C4 plant that can convert solar energy into chemical energy. The sugarcane pathway-C4 or dicarboxylic acid pathway-also functions in other species and appears to have some unique anatomical features. It has been recognized as an important energy crop and has recently been enhanced by large-scale production of sugarcane-based ethanol from molasses and directly from cellulose. Bagasse is the fibrous material remaining after crushing sugarcane. Generally, for every 10 tons of sugarcane crushed, 3-4 tons of wet bagasse are left. It has a high moisture content, usually 40% to 50%, and is usually stored before further processing. Molasses is another important by-product of the sugar industry. The mother liquor remaining after the crystallization of sucrose cannot economically recover more sucrose from it. Due to the total sugar content of molasses, it is a valuable raw material for the production of many value-added products. The main products that can be produced from molasses are breweries, acetic acid, fuel alcohol, biogas from sewage treatment, cattle feed, ethanol, Baker's yeast, lactic acid, citric acid, etc. Ash and filter mud are also used as fertilizer. Boiler ash is "scrubbed" from the mill stacks, and the filter residue/filter cake is the residue left after sugar clarification. In the early stage, the processing of press mud posed a problem in the sugar mill, not only related to the processing volume, but also related to the sugar processing volume. Now, due to technological advancement, pressed mud is widely used as fertilizer as well as wax and compost industry. In many countries, many sugar manufacturing units have transformed themselves into sugar agricultural industrial parks, producing various chemicals and practical products from sugar cane. In southern China, a typical subtropical climate region, the epidemic of pokkah boeng disease is more serious, which seriously threatens the production of sugarcane plantations and the huge losses of the sugar industry. The growth of susceptible varieties led to significant losses of pokkah boeng in the humid climate followed by the dry season. Carry out appropriate planning and environmental risk assessments to expand sugarcane into new areas, improve land use practices to reduce soil erosion and nitrogen pollution, properly protect streams and riparian ecosystems, prohibit sugarcane burning practices, and fair working conditions for sugarcane cutters. Due to the production of sugar, the chemical composition of the ethanol is usually available. It can be used as a biofuel substitute for gasoline and is widely used in Brazilian cars. It is a substitute for gasoline and may become the main product of sugarcane processing instead of sugar. Molasses-based industries mainly produce edible alcohol, acetic acid, fuel ethanol, cattle feed and many pharmaceutical products for use in distillers. The pressed mud-based industries mainly produce fertilizer, wax and compost industries as animal feed.

VII. CONCLUSION

From the sugarcane samples exhibiting Pokkah boeng symptoms, a phytopathogenic fungal strain belonging to the complex of Fusarium and *Gibberella fujikuroi complex* was isolated through morphological and molecular techniques, which may be *Fusarium verticillioides*. The existence of this pathogen is unknown. Therefore, this report opens the door to different viewpoints, such as researching the biology of the pathogen and the diseases it produces, and formulating mitigation and control strategies to avoid economic losses and food contamination problems produced by the fungus and its impact on the health of consumers, all of them of highly importance for the industry and public health.

REFERENCES

[1] Rott, P., Bailey, R.A., Comstock, J.C., Croft, B.J. and Saumtally, A.S.A guide to sugarcane disease. CIRAD. ISSCT. Montepellier: CIRAD publications services; **2000**, p. 339.

[2] Patil, A.S., Singh H., Sharma, S.R., Rao, G. Morphology and pathogenicity of isolates of Fusarium moniliforme causing Pokkah Boeng disease of sugarcane in Maharashtra. Microbial Diversity: Modern Trends. **2007**, 234-263.

[3] Blackburn, F. Sugar-Cane. Longman, New York, NY, USA. **1984**, 414p.

[4] Martin, J.P., Hong, H.L and Wismar, C.A. Pokkah boeng In Sugarcane Diseases of the World. Vol. 1, Elsevier Publ. Co. New York,**1961**, pp. 247-57.

[5] Ricaud, C., Egan, B.T., Gillaspie, A.G and Hughes, C.G. Diseases of Sugarcane; Major Diseases. (Elsevier Science Publishers, Amsterdam: The Netherlands)(Eds)**1989**.

[6] Suma, S. and Jones, P.A Guide to Sugarcane Diseases. CIRAD and International Society of Sugar Cane Technologists, Montpellier.**2010,**pp. 226–230.

[7] Martin, J.P., Abbott, E.V and Hughes, C.Sugarcane disease of the world. Vol., 1.Elsevier publishing Co. Amsterdan, **1961**, 542p.

[8] Raid, R.N andLentini, R.S.Pokkah boeng. In R.A. Gilbert (Eds.) (Online). Florida Sugarcane Handbook.**1991** (Accessed 6th April 2005).

[9] Burgess, L.W. General ecology. In: Nelson PE, Toussoun TA,Cook RJ (eds) Fusarium: diseases, biology and taxonomy. The Pennsylvania State University Press, University Park, PA, **1981**,pp225–235.

[10] Deacon, J.W. Fungal Biology (4th ed.).**2006**,United Kingdom: Blackwell Publishing Ltd

[11] Narendra, D.V and Setty, M.V.N. Seed mycoflora of sugarcane and their importance in nurseries. Seed Research, New Delhi, v. 7, n. 2, **1979**,p. 145-150 .

[12] Bourne, B.A. Studies on the dissemination of sugarcane disease. The Sugar Journal 16: 19.**1953**.

[13] Govender, P., McFarlane, S.A and Rutherford, R.S.Fusarium species causing pokkah boeng and their effect on Eldana saccharina walker (lepidoptera: pyralidae). **2010**, Proc S Afr Sug Technol Ass 83: 267-270.

[14] Siddique, S. Pathogenicity and aethiology of Fusarium species associated with pokkah boeng disease on sugarcane. **2007**, Thesis, University of Malaysia, Malaysia.

[15] Patil, A.S.Studies on pokkah boeng and pine apple disease of sugarcane in Maharashtra with their economic losses in yield and quality of sugarcane. **1995**, Final Project Report. Pune: ICAR, VSI.

[16] Kamal Singh, R.P.Knife cut disease of sugarcane in India. Sugarcane Pathologists' News Letter 1979, 23: 34. 44.

[17] Mendes, R., Pizziarani-Kleiner, A.A, Araujo, W.L and Raaijmakers, J.M. Diversity of cultivated endophytic bacteria from sugarcane: genetic and biochemical characterization of Burkholderia cepacia complex isolates. Appl Environ Microbiol,**2007**, 73: 7259–7267.

[18] Contreras, A.M., Rosa, E., Perez, M., Langenhove, H.V and Dewulf, J. Comparative Life Cycle Assessment of four alternatives for using by-products of cane sugar production.Journal of Cleaner Production , **2009**,17:772–779.