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Color Illustration of Diagnosis and Control for Modern Sugarcane Diseases, Pests, and Weeds

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Abstract

Sugarcane is the main sugar crop in China; in the process of promoting the modern sugarcane industry, effective control of sugarcane diseases, pests, and weeds is an important part of "high yield and high sugar" sugarcane cultivation technology. Practice has proven that focus on the management of diseases, pests, and weeds can not only significantly improve sugarcane yield and quality, but can also lead to greater social and economic benefits from sugarcane production.

This book, with clear color pictures and scientifically accurate text, systematically describes the 20 diseases, 40 pests, and 7 natural enemies of pests and weeds that commonly occur in sugarcane production. The content includes details of:

- the occurrence and damage, identification of symptoms, and characteristics of epidemic infections of sugarcane diseases, as well as control measures for these diseases;
- the occurrence and damage, morphological identification, and life cycles of sugarcane pests, and control measures for these pests;
- the parasitic (predation) characteristics, morphological identification, occurrence, and life cycles of natural enemies of sugarcane pests, and approaches to the protection and utilization of these entities; and
- the main weeds in sugarcane fields and their distribution and occurrence, as well as chemical control measures for these weeds.

With its novel content, easily understood subject matter, and characteristics of science, accuracy, practicability, and readability, this book is suitable for use in the sugarcane scientific research, teaching, production, and management communities, as well as being a source for reading and reference by relevant people, such as teachers and students in agricultural colleges and universities.

Introduction

Sugarcane, the main source of sugar, is one of the most important economic crops in the world. In China, sucrose yield accounts for more than 90% of total sugar production, making China the third largest sugar producer in the world after Brazil and India. The sucrose industry has become an important pillar of Chinese regional economic development and the main source of increasing farmers' income and local financial growth in remote areas with minority populations. However, with the development of sugarcane production, there have been changes in agricultural farming systems, and the frequent introduction of sugarcane seedcane and the abuse of chemical pesticides, together with the complicated climate and environment, diseases, pests, and weeds, have often caused great losses to sugarcane production, and the occurrence of these problems is becoming increasingly serious. According to still incomplete statistics, there are more than 1770 kinds of organisms in the world that are harmful to sugarcane; among them are more than 120 sugarcane diseases, more than 1000 types of sugarcane pests, more than 600 types of sugarcane field weeds, and more than 50 types of sugarcane field rats (Chen 1982; The Important Sugarcane Diseases Research Cooperation Group 1991; Rott et al. 2000; Huang and Li 2014 2016). The United Nations Food and Agriculture Organization (FAO) statistics have shown that global crops suffer from diseases, pests, and weeds, with the average yield loss before harvest being 30%–35% (An and Guan 2009). The potential rate of sugarcane production loss caused by harmful organisms was shown to be 15%–30%. In the process of promoting the modern sugarcane industry, variety is the basis; cultivation is the key; and diseases, pests, and weeds are the greatest threat. The management of sugarcane diseases, pests, and weeds is an important part of sugarcane cultivation. Practice has proven that, if we concentrate our efforts on the management of diseases, pests, and weeds, this can not only significantly improve sugarcane yield and quality, but can also lead to great social, economic, and ecological benefits from sugarcane production (Li 2010). Over the years, according to practical production, personnel in Chinese sugarcane research institutes and those dealing with sugar industry technology systems have carried out systematic research on, and have ascertained, the distribution, occurrence, and

characteristics of the decreases and increases of the main diseases, pests, and weeds in different sugarcane areas. Practical integrated control techniques have been summarized and implemented, much basic information and real pictures have been accumulated, a series of accomplishments have been made in these fields, and strong technical support has been provided for the improvement of sugar industry efficiency in China in regard to the reduction of the loss caused by the diseases, pest and weeds and the increase of economic benefits (Lu et al. 1997; Zhou et al. 1999; Wang 2007; An and Guan 2009; Xion et al. 2010; Li et al. 2010, 2013; Li and Huang 2012; Wei et al. 2012; Shan et al. 2014). However, the broad masses of workers and sugarcane growers in China often have difficulty in identifying some sugarcane diseases, pests, and weeds during sugarcane production, and do not know how to control them, thus missing appropriate times for control, eventually causing major disasters and serious losses affecting the development of the sugar industry in this country. Against this background, with encouragement and substantial support from relevant institutions, and combined with findings on the scientific and technological development of sugarcane and the actual production of sugarcane areas in China, we have carefully summarized and sorted many years' scientific achievements and pictorial materials, and finally wrote this book, entitled, "Color Illustration of Diagnosis and Control for Modern Sugarcane Diseases, Pests, and Weeds".

The book targets existing questions regarding the control of diseases, pests, and weeds in current sugarcane production, in order to help the broad masses of sugarcane producers and technicians to understand and grasp the following factors:

- the species and distribution of diseases, pests, and weeds in sugarcane areas, and the damage they cause;
- ways to improve the level of scientific control of sugarcane diseases, pests, and weeds;
- ways to effectively control the occurrence of diseases, pests, and weeds;
- ways to enhance their own capabilities for disaster reduction and prevention; and
- ways to ensure the quality of sugarcane varieties and sugarcane production safety.

This book, with clear color pictures and scientifically accurate text, systematically describes the 20 diseases, 40 pests, and 7 natural enemies of pests and weeds that commonly occur in sugarcane production. The content includes details of:

- the occurrence and damage, identification of symptoms, and characteristics of epidemic infections of sugarcane diseases, as well as control measures for these diseases;
- the occurrence and damage, morphological identification, life cycles, and control measures for sugarcane pests;
- the parasitic (predation) characteristics, morphological identification, occurrence, and life cycles of natural enemies of sugarcane pests, and approaches to the protection and utilization of these entities; and
- the main weeds in sugarcane fields and their distribution and occurrence, as well as their chemical control measures.

The book, entitled "Color Illustration of Diagnosis and Control for Modern Sugarcane Diseases, Pests, and Weeds", is edited by the Yunnan Key Laboratory of Sugarcane Genetic Improvement, Sugarcane Research Institute, and Yunnan Academy of Agricultural Science, and is supported by the Earmarked Fund for Sugar Crop Research System (CARS-170303) and the Earmarked Fund for Yunnan Province Agriculture Research System. During the compiling of this book, some relevant materials and pictures from our peers were referred to and referenced, and we herewith express our sincere thanks to those individuals.

Owing to the limited time taken for the compilation of this book, we hope that the readers will make suggestions if there are some shortcomings and mistakes. We believe this book is suitable for people involved in sugarcane scientific research, teaching, production, and management, as well as for reading and reference by interested people and relevant teachers and students in agricultural colleges and universities.

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Contents

Chapter 1
Diagnosis and Control of Sugarcane Important Diseases

There are more than 120 sugarcane diseases that have been found in the world presently (Chen 1982; Rott et al. 2000), and more than 60 have been reported in China (The important sugarcane diseases research cooperation group 1991; Lu et al. 1997; Huang and Li 2014, 2016). Mastering the disease types, damage, and distribution in the sugarcane area can provide scientific basis for the sugarcane disease-resistance breeding, quarantine of introduced varieties, and disease management and research. Sugarcane production areas in China have drought in winter and spring and hot climate and good rainfall in summer and autumn. With the rise of temperature in spring, in case of cold current as well as the rainfall and temperature decline and the poor management, planted sugarcane in winter and this season are easily infected by pineapple disease and the ratoon crops are easily damaged by red rot disease. Because the whole seedling stage is in the dry season, smut becomes substantial causing sparse breakup. After June, with the high temperature and humidity, eyespot, brown stripe, yellow spot, pokkah boeng, rust, ring spot, and leaf scorch diseases are easily occurring and epidemic. Especially in recent years, introducing seedcanes frequently and transposing seedcanes in sugarcane planting area make some dangerous seedcane-transmitted diseases (ratoon stunting disease, mosaic, smut, yellow leaf syndrome, etc.) which are spread by seedcane between sugarcane areas. Then, caused sugarcane diseases occur commonly and damage more severely; have a serious impact on sugarcane yield, quality, and ratooning capacity; and bring serious hidden trouble to the safe production of sugarcane. In order to scientifically control the spread and damage of sugarcane disease, enhancing the capabilities of disaster prevention and reduction and ensuring the quality of sugarcane variety and safety of sugarcane production in 20 diseases that commonly occur in sugarcane production are systematically described in this chapter with clear-colored photos and scientific, accurate words. The content includes the occurrence and damage, identification of symptoms, characteristics of epidemic infection, and control measures.

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1.1 Sugarcane Pineapple Disease

1.1.1 Occurrence and Damage

Pineapple disease is caused by a fungus, whose sexual stage is *Ceratocystis paradoxa* (Dade) Moreau, belonging to the Ascomycetae (it is seldom seen in nature), and its asexual stage is *Thielaviopsis paradoxa* (De Seynes) V. Hohn. This pathogen has a wide host range. In addition to sugarcane, it can infect pineapple, banana, maize, mango, cocoa, coconut, and oil. Pineapple disease has occurred in China and in almost all countries and regions where sugarcane is grown, and it is an important disease at the sugarcane germination stage. This fungus damages sugarcane seedcane and stump, making them rot, causing necrosis and blocking germination, resulting in low emergence and heavy economic losses (Chen 1982; Huang and Li 2016).

1.1.2 Identification of Symptoms

During storage and sowing, pineapple disease infects from the incisions in sugarcane seedcane to a section of the stump and in the early stage has a characteristic pineapple-like smell. The pathogen spreads along the lesion to the bud, causing the seedcane to die without germinating. The color on both sides of the incision in diseased seedcane is initially red, which then develops into dark spots. The interior tissue turns reddish-brown and contains the black bitumite-like conidia of the pathogen. The diseased tissue rots and then forms a black cylinder, and after a long time, only an emission-like black fiber remains.

1.1.3 Characteristics of Epidemic Infection

The source of primary infection of pineapple disease is mainly the disease-bearing seedcane and soil and other diseased host plants near the sugarcane field. This disease also can be spread by airflow, irrigation, knives used to cut seedcane, and insects. The microconidium germinates easily and is spread by wind, irrigation, and insects to cause repeated infection. Long periods of low temperature and high humidity are the two main factors that lead to severe outbreaks of this disease. Sugarcane fields have sticky, heavy soil, which is plowed immediately after irrigation. After soil preparation and planting, the soil becomes harder, and the seedcane germinates slowly, making it susceptible to infection by the fungus. The cold and rainy weather that occurs after winter and early spring planting of sugarcane, combined with poor soil drainage, also increases disease susceptibility. The ratoon crops that form the seedcane after autumn planting and after harvest in the early

spring can also increase the incidence, resulting in bad stumps. Continuous cropping, transportation, and long-term storage of seedcane also increase susceptibility to the disease.

1.1.4 Control Measures

Currently, a combination of agricultural and chemical control is the most important method to control pineapple disease. Chemical control involves sterilizing the seedcane with a fungicide to protect the incision and reduce pathogen infection. Agricultural control involves the use of good cultivation measures to promote the early germination of seedcane after planting, in addition to early growth and quick tillering after emergence. The control measures include:

1. Planting varieties with improved resistance and choosing disease-free and healthy sugarcane plants as seedcane.
2. Choosing the upside of sugarcane plants, because it germinates quickly and the infection rate is lower.
3. Determining the most suitable period for planting, with an appropriate temperature and humidity after planting (performing the spring planting after the beginning of spring and during the White Dew to Cold Dew periods for the autumn planting).
4. During winter and early spring plantings, sugarcane is mulched with plastic films, which can be used to maintain the temperature and humidity, promote the early germination of seedcane, and reduce the infection and damage by pineapple.
5. Sterilization and soaking treatment of seedcane and sugarcane stump in seriously diseased areas. This can be achieved using 2–3% limewater soaked for 12–24 h or 50% carbendazim wettable powder (WP), 70% thiophanate-methyl WP, 32.5% difenoconazole • azoxystrobin suspension concentrates (SC), and 28.7% metalaxyl • fludioxonil • thiamethoxam flowable concentrate for seed treatment (FS) diluted 1000 times to soaking seedcane for 3–5 min or 600–800 times to evenly spray the sugarcane stump for sterilization (Luo et al. 2013, 2014).

1.2 Sugarcane Eyespot Disease

1.2.1 Occurrence and Damage

Sugarcane eyespot disease is a fungal disease caused by *Helminthosporium sacchari* (van Breda de Haan) Butler (Chen 1982; Rott et al. 2000). The sexual stage of this pathogen has not been found, only the generation of conidia (the asexual stage). In addition to sugarcane, *Cymbopogon citratus* DC and *Pennisetum purpureum* are also hosts of *H. sacchari*. Eyespot disease is a devastating leaf spot disease of

sugarcane. It is widely distributed in cane-growing countries and regions around the world and has occurred in each provincial sugarcane area in China. In the 1970s and 1980s, sugarcane eyespot disease was prevalent in some sugarcane regions in Guangdong and Yunnan (The important sugarcane diseases research cooperation group 1991; Huang and Li 2016). This pathogen is an epidemic under favorable conditions. In addition to affecting the cane yield, eyespot diseases also affect the sugar content.

1.2.2 Identification of Symptoms

Sugarcane eyespot disease mainly infects the leaves and the top of stalks. The water-soaked spots occur on young leaves in the early stage of the infection and expand to narrow lesions after 4–5 days. The lesion is 5–12 mm long by 3–6 mm wide, its long axis parallel to the leaf vein. The center of the lesion is reddish-brown, surrounded by a faint yellow halo shaped like an eye. Subsequently, a necrotic strip occurs at the top of the lesion parallel to the leaf vein and usually extends toward the leaf apex (but rarely to the leaf sheath). Later, the disease spots and disease strips combine with each other, resulting in large-scale leaf tissue necrosis, top rot in young stalks, and whole sugarcane plant death. In appropriate conditions, the lesion produces dark mildew-like conidiophores and conidia of the pathogen. Serious cases of disease usually result in large areas of sugarcane dying and affect the cane yield and sugar content: the weight of stalk, Brix, sucrose content, gravity purity, and recyclable sugar of the susceptible variety Co419 were reduced by 33%, 50%, 70%, 35%, and 60%, respectively.

1.2.3 Characteristics of Epidemic Infection

Conidium produced in diseased plants is the main source of primary infection. Many conidia are produced on the lesion and are mainly transmitted by wind and rain. The conidia fall on the sugarcane leaves and germinate with water or dew. Young leaves are more susceptible than old ones. In suitable conditions for pathogen growth, the pathogen multiplies quickly. The infection cycle is very short – after 5–7 days, the pathogen is matured in the lesion and produces new conidia for repeated infection. Sugarcane eyespot disease occurs easily at high temperature and humidity and also in conditions of lower temperature and high rainfall. Therefore, this disease starts in June and July, and the peak period is in September and October, in China. Sugarcane eyespot disease is often prevalent in areas that have high relative humidity, continuous cloudy and rainy days, and heavy morning dew or sugarcane fields treated with high levels of nitrogen fertilizer. Varieties Co290, Co419, ROC23, Yuetang 57–423, Yunzhe 81–173, Funong 81–745, Mingtang 86–05, Mingtang 07–2005, Liucheng 07–506, Mengzhe 92–246, and Qiantang 3 are susceptible to

eyespot disease. By contrast, varieties Yuetang 86–368, Yuetang 93–159, Yuetang 00–236, Yuetang 55, Guitang 29, Guitang 31, Yunzhe 99–91, Yunzhe 03–194, Yunzhe 05–49, Yunzhe 05–51, Funong 91–21, Funong 38, Funong 39, Mingtang 69–421, Liucheng 05–136, and Qiantang 5 and a series of ROC varieties are resistant (Huang and Li 2016).

1.2.4 Control Measures

The following measures may be effective to control eyespot disease:

1. Choosing a disease-resistant variety is the most economical and effective measure to control sugarcane eyespot disease.
2. Rational fertilization. The application of appropriate amounts of phosphorus and potassium fertilizers, and avoidance of heavy application of nitrogen fertilizer, will enhance the resistance of sugarcane.
3. Effective drainage will remove water from the sugarcane field, which will reduce the field humidity so it is not conducive to the infection.
4. Remove diseased, old leaves and avoid ineffective tillering. These measures can reduce the infection source, improve the wind ventilation and light permeation in the sugarcane field, and reduce the occurrence of this disease.
5. In the early stage, using 40% kitazine emulsifiable concentrate, 75% chlorothalonil WP, 50% captan WP, and 40% dimethachlon WP diluted 500–800 times or 1% bordeaux mixture can have controlling effects.

1.3 Sugarcane Smut Disease

1.3.1 Occurrence and Damage

Smut disease is an important disease worldwide and is also known as whip smut, black powdery disease, and gray bag disease. It is caused by the fungus *Ustilago scitaminea* Sydow, which belongs to the Basidiomycetes, *Ustilago* (Chen 1982; Rott et al. 2000; Huang and Li 2016). This pathogen is a systemic parasite in the host, and in addition to sugarcane, it can also infect *Imperata cylindrica*. The fungus shows varying pathogenicities, and different physiological races exist in different sugarcane areas. The different physiological races show varying pathogenicities to the same sugarcane variety, and different sugarcane varieties differ in their disease resistance to the same smut pathogen. To date, several countries (areas) have reported different physiological races. There are two physiological races in Hawaii (A and B), Brazil has at least two races, Pakistan has five races, and race 1 and race 2 exist in Taiwan and China. Moreover, a new race has been found recently (Gong et al. 1993). Two physiological races, race 1 and race 2, were preliminarily reported

in the Chinese mainland by Xu et al., in 2000; however, there has been no report in the other sugarcane fields in China (Gong et al. 1993). Sugarcane smut disease was initially found in the early stage of sugarcane planted in Natal around 1877. Thereafter, smut became prevalent in the sugarcane production areas in the eastern hemisphere. In 1940, it was found in Tucuman in Argentina and has since spread to sugarcane planting areas worldwide, becoming one of the most important diseases in large sugarcane areas and resulting in great economic losses. The disease caused serious epidemics in Argentina, India, Brazil, Zimbabwe, Louisiana, Cuba, and the Philippines, which endangered their sugar industries (Riley et al. 1999; Schenck et al. 2005). There have been several pandemics in Taiwan and China. In recent years, because of the diversification of planting periods, the frequent introduction of seedcane from abroad and the transfer the seedcane among different sugarcane areas, coupled with the long growth cycle, long-term continuous cropping, ratoon cropping, and vegetative propagation, have caused sugarcane smut disease to occur commonly in the key sugarcane producing areas in China, such as Fujian, Yunnan, Guangdong, Guangxi, Hainan, Sichuan, and Zhejiang. Sugarcane smut disease is becoming more prevalent, especially in the upland areas and ratoon sugarcane fields (Lu et al. 2008).

In the history of sugarcane planting in China, the main varieties, such as Co419, F134, Chuantang 61–408, Guitang 11, and Guitang 12, had to be eliminated because they were susceptible to smut, resulting in serious losses of cane yield and sugar content. The current main varieties, such as ROC22 and Mingtang 69–421, are also highly susceptible to smut and face elimination. To a certain extent, this has restricted the sustainable and stable development of the sugar industry in China. Sugarcane smut is a systemic disease, and its prevalence is closely related to the disease resistance and susceptibility of sugarcane varieties (Lin and Wang 1996; Lin et al. 1996; Xu and Chen 2000; Liang and Liang 2002). The incidence in resistant varieties is less than 10%, whereas in susceptible variety it can be up to 50% or 80–90% during severe outbreaks.

1.3.2 Identification of Symptoms

The most obvious characteristic is a black whip growing from the top of the diseased sugarcane plant, which is called a smut, and ranges from centimeters to tens of centimeters in length. The black whip is unbranched; short ones are straight or slightly curved, whereas long ones are curly and twist downward. There is a heart column composed of the parenchyma and vascular bundles in the center of the black whip, which is white, soft, and brittle in the early stage but gradually turns black and tough in the later stage. A black powder layer appears on the outside of the heart column, which are the chlamydospores of the pathogen. The epidermis of the host appears as a thin silver-white membrane covering the outside of the black powder. As the spores mature, the thin membrane breaks, and the large number of black chlamydospores is dispersed by the wind, leaving the heart column only. Before

producing the whip, the leaves become smaller, narrower, and longer. The top leaf appears light green, sharp, and straight. The stalk is thin with sparse nodes, and tillering increases into clusters, all of which symptoms serve to identify an infected sugarcane plant. In cases of serious disease, many sugarcane plants cannot grow normally, and the number of effective stalks is reduced, causing yield reduction.

1.3.3 Characteristics of Epidemic Infection

Disease-carrying seedcane is the source of long-distance transmission and the source of primary infection in diseased areas. Infected ratoon sugarcane, pathogen-carrying soil, and infected weeds in the field may be the pathogen source in some areas. In the diseased field, chlamydospores are not only primarily transmitted by the wind but also by irrigation water and rainwater. In addition, some insects are also vectors of disease transmission. The chlamydospores fall on the sugarcane buds, germinate with water, and form the infective mycelia. With the germination of the sugarcane buds, the growth point of sugarcane is stimulated to form a whip. The mature mycelia in the whip produce chlamydospores, which are scattered on the sugarcane buds and in the soil to cause repeated infection. In the dry soil, the chlamydospores can live for up to a year. High temperature and humidity are conducive to the germination and infection of this pathogen, and the drought contributes to the accumulation of the chlamydospores in the field. Therefore, a long drought in winter and spring, and a large amount of rain in summer, often results in outbreaks and epidemics of this disease. Waterlogged and low-humidity sugarcane fields and the poor growth of sugarcane plants also contribute to their easy infection with this disease. The occurrence in ratoon is more severe than that in cane plants, and the higher the number of ratoon years, the more severe is the disease. The disease incidence in fields that undergo crop rotation is lower; however, a large amount of the pathogen accumulates in continuously cropped fields, thus increasing disease incidence. In intensively farmed and managed fields, applying more organic fertilizer, and appropriate amounts of phosphate and potassium fertilizer, causes sugarcane seedlings to grow earlier, tiller quickly, and show abundant growth, resulting in lower disease incidence. In sugarcane fields subjected to heavy application of nitrogen fertilizer, the damage is often severe.

The sugarcane varieties Co419, F134, ROC22, Yuetang 89–113, Guitang 11, Guitang 12, Yunzhe 71–315, Chuantang 61–408, Chuantang 3, Mintang 69–421, Liucheng 03–182, Yuetang 42, Yuetang 55, Yuegan 26, Yuegan 46, Guitang 02–351, Guitang 29, Yunzhe 03–103, Yuezhe 03–422, Yuezhe 05–39, Yuezhe 05–51, Yuezhe 06–407, Yuezhe 06–362, Yuezhe06–193, Yuezhe 08–1095, Yuezhe 09–1601, Funong 1110, Funong 40, Funong 09–2201, Ganzhe 07–538, Liucheng 03–1137, Liucheng 07–500, Dezhe 03–83, Dezhe 09–78, and Q170 are susceptible to smut. By contrast, varieties ROC10, ROC16, ROC20, Yuetang 86–368, Yuetang 93–159, Yuetang 96–86, Yuetang 00–236, Yuetang 00–318, Yuetang 39, Yuegan 43, Guitang 02–901, Guitang 31, Yunzhe 99–596,

Yunzhe 01–1413, Yunzhe 03–194, Yunzhe 03–258, Yunzhe 04–241, Yunzhe 06–80, Yunzhe 08–2060, Funong 91–21, Funong 15, Funong 36, Funong 0335, Funong 07–2020, Funong 07–3206, Ganzhe 02–70, Liucheng 05–136, Yunri 06–189, and Qintang 5 are resistant to smut (Li and Huang 2012; Huang and Li 2016).

1.3.4 Control Measures

The following measures may be effective to control smut:

1. Choosing a resistant variety. The severity of smut is closely related to the disease resistance and susceptibility of the sugarcane variety. Domestic and overseas research has shown that the most economical and effective measure to control sugarcane smut is to choose disease-resistant varieties. Therefore, the smut resistance of sugarcane clones is a main target for cultivar selection in several major sugarcane countries and regions in the world, such as America, Cuba, India, Brazil, Australia, France, Taiwan, and China. Currently, smut resistance is one of the goals of sugarcane breeding in China (Xu and Chen 2000; Liang and Liang 2002; Xia et al. 2009). However, because of the varied pathogenicities of smut and the different physiological races, coevolution exists commonly among hosts. The varying pathogenicities and physiologies of smut isolated from different varieties and regions and at different times mean that a variety that is resistant to one physiological race of the smut pathogen may not be resistant to other races. Disease-resistant varieties in one area may not necessarily be resistant to the disease in another area. A variety that was resistant at a certain point in time may become susceptible if there is a change in the physiological race of the pathogen. Moreover, because of the differences between the resistance of varieties and the races, in the field, the speed of spread, the degree of damage, and the use effect of the disease resistance varieties are also different. Therefore, ascertaining the type of physiological races of sugarcane smut pathogen in the sugarcane field, including dominant races and their distribution; the resistance degree to these races of the main cultivated variety, popularized variety, and germplasm; and determining the changing trend of races in the field, can be used to breed resistance in the targeted variety, thereby controlling or preventing the occurrence of smut and avoiding significant economic losses.
2. Treatment of seedcane. Soaking seedcane with 2–3% limewater or soaking seedcane with 52 °C hot water for 20 min can be effective. In addition the use of 40% banzhongshuang WP, 40% Amicarthiazole WP, 25% triazolone WP, 80% mancozeb WP, and 2.5% Pulimeng FS diluted 500–800 times for 10 min can have certain controlling effects. Complete control can be achieved using 50 °C hot water soaking for 2 h.
3. Selecting disease-free or less infected seedcane. On the basis of the above hot water treatment, a disease-free seedcane nursery can be established to plant

disease-free materials. Alternatively, seedcane from disease-free fields can be used to avoid or decrease the damage caused by smut.
4. Clearing the source of infection from the field. Pathogen-carrying dead leaves, residual roots, residual stalks, diseased ratoons, and soil in the field are the main infection sources for subsequent plantings.
5. Strengthening field management. Before planting, sufficient base fertilizer application, irrigation timing, timely fertilization and hilling, and the reasonable application of nitrogen, phosphorus, and potassium fertilizer can be used to promote the healthy growth of sugarcane seedlings and strengthen the resistance ability of the sugarcane plants. In addition, removing diseased plants in time (removing diseased plants before the black whip emerges or while the white membrane of the whip is unbroken), and collecting them together for destruction, will reduce the sources of repeat infection sources and control its spread.
6. Introduce proper crop rotation. Reducing the number of ratoon years in heavily diseased areas, and strengthening the rotation of non-infective crops, such as rice, maize, sweet potato, peanut, soybean, and alfalfa, can avoid the long-term infection by the pathogen.

1.4 Sugarcane Red Rot Disease

1.4.1 Occurrence and Damage

Sugarcane red rot is caused by a fungus whose asexual stage is *Colletotrichum falcatum* Went, belonging to the Deuteromycetes and Melanconiales, and its sexual stage is *Physalospora tucumanensis* Speg. (Chen 1982; Huang and Li 2016). Hosts mainly include sugarcane, sorghum, and Johnson grass. Red rot is a common disease in China and has been reported in all sugarcane planting areas. It can infect sugarcane throughout the growth period. This disease mainly damages stalks and leaf midribs but also infects leaf sheathes and ratoon stumps. The infected leaf midribs generally have little effect on cane yield. However, because a large amount of conidia is produced in lesions, these are the main sources of red rot inocula to infect stalks. When the stalk is infected, the pathogen secretes sucrose invertase, which reduces the gravity purity of juice and the sugar content. Also, the red pigment in lesions creates difficulties for sucrose production. High incidence can affect the cane yield. If the seedcane carries this disease, the buds cannot germinate.

1.4.2 Identification of Symptoms

Sugarcane red rot damages the leaf midribs. Red dots are early symptoms. Then, they expand up and down along the leaf midrib, forming fusiform or elongated red spots. The center of the spots is dry white and produces small black flecks which are