X. DISEASES IN SUGARCANE CROP

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Werner Ovalle*

INTRODUCTION

In general, crop diseases can affect processes such as photosynthesis, respiration, and circulation of water and sap in the vascular system, absorption of water and nutrients from the soil. Consequently, there are decreases in the production of the plant component of interest, such as for man, as grain, plant biomass or other, for example sucrose in the sugarcane case. Therefore it is important to keep the crop free of diseases, which can be achieved either by the application of chemicals or by the use of resistant varieties. In sugarcane, in most countries of the world, the diseases control in sugarcane is focused on the use of resistant varieties and Guatemala, is not the exception.

More than 126 diseases have been reported for sugarcane in 109 different countries (Chinea *et al*., 2000), and in Guatemala 24 have been identified (unpublished data). Taking into account the incidence, severity, effect on production, and discard of varieties with good production potential when are free of disease, it has been determined that in Guatemala the most important diseases are: ratoon stunting, smut, leaf scald, brown rust and orange rust. The second largest group is composed by: mosaic, red stripe and yellow leaf (leaf yellowing) and the third group: pokkah boeng, purple spot, yellow spot and chlorotic tripe.

Studies on the disease effect on sugarcane production like ratoon stunting, have been made in CENGICAÑA. It was found that production decreases depending on the resistance of the varieties, but in average of nine varieties losses were significant. In plant sugarcane the loss in cane yield was 7.88 percent, in first ratoon, 16.47, in the second, 21.38, in the third, 23.2, and in the fourth, 20.9, (Ovalle and Garcia, 2008). These results are an illustration of what diseases can mean in the production, and the importance of maintaining disease-free sugarcane fields.

Below is a description of symptoms, transmission, the importance to our country, and control methods for these and other common diseases in the Guatemalan Pacific sugarcane zone.

*Agr. Eng., M.Sc., Plant Pathologist at CENGICAÑA. www.cengicana.org

FUNGAL DISEASES

Smut

Causal agent: ***Sporisorium scitamineum*** **(Syd.) M. Piepenbring =** ***Ustilago scitaminea*** **H. Syd & P. Syd**.

Symptoms: The main symptom of smut disease is a whip-like structure that develops at the apex of infected stalks (Figure 1). The structure is formed by a center with corky appearance, which is initially covered by millions of spores (chlamydospores), which together present a black color. That is why the common name of the disease, because it looks like coal dust (smut) (Martin *et al*., 1961). The whip-like structure is covered by a thin silver-gray membrane, which while breaking, releases spores (Ramallo and Ramallo Vázquez, 2004). After the release of spores the structure can remain as a corked appendage. The structure has no ramifications, and depending of the variety it is variable in thickness and the length varies from a few centimeters to over a meter (Chinea *et al*., 2000). It can also be straight or curved.

Before the whip emergence, the infected stems may show abnormalities and can be thinner, flattened rather than cylindrical and the leaves of the infected plant are reduced in size and width, taking a position in which the insertion angle of the stem is reduced (more upright than normal) (Ovalle, 1997; Vázquez de Ramallo and Ramallo, 2004).

In susceptible varieties, infections of the stalk pieces used as seed can produce dozens or even hundreds of thin stalks that produce stools with "grassy" appearance and eventually develop whips in their tops.

Secondary infections can cause the development of small lateral whips type "lalas or side shoots" (called lalas to anticipated growth of lateral buds) on stems with normal development (Martin *et al*., 1961).

Transmission and spread: The transmission and spread of the disease occurs when wind or rain release the spores and carry them to the neighbor plants or neighboring fields (Chinea *et al*., 2000). The spores germinate and infect the buds, the infection can remain dormant until the next cycle when the pieces of stalks are used as seed in other fields, or produce the appearance of side whips in the same cycle (Ovalle, 1997) where infection occurred.

Importance: Smut disease is considered one of the most important diseases in sugarcane, because of this potential to cause losses of production, which has impacted various sugarcane producing countries. In Guatemala severe losses

occurred in the eighties in varieties like CP57-603 and B49-119, forcing the substitution by resistant varieties.

Control: The recommended method for smut disease control is the use of resistant varieties (Tokeshi, nd)

Figure 1. Typical whips of *S. scitamineum* on infected stem tops

Brown rust

Causal agent: *Puccinia melanocephala* H. Syd. & P. Syd.

Symptoms: The first symptom of this disease is the appearance of small elongated yellow spots which are visible on both surfaces of the leaves. The spots change to brown color with a thin yellowish-green halo (Hughes *et al*., 1964). The size of the spots is variable and lesions have been observed from 2 millimeters to 30 or 40 millimeters. Later, when the development of the pustules starts, slightly elongated bulges are observed beneath the epidermis of the lower leaf surface. Generally, these bulges break up to release the spores (urediospores) which, when ripe, are brown in color (Fig. 2). After a period of active sporulation, lesions darken until reaching a blackish tone and sporulation stops. Most lesions occur at the tips of the lower leaves. When the variety is susceptible, and environmental conditions are favorable to the pathogen, the lesions coalesce (come together) and large areas of dead tissue are produced which can completely dry the leaves.

Transmission and spread: It happens in a very quickly form and when the epidermis of pustules breaks, the spores are carried out to other plants and other fields by wind and rain (Ovalle, 1997). The spores require a thin layer of water on the leaf surface for at least six hours, for optimal germination (usually on the underside of the leaf). Optimum temperature for germination is 21° C. (Magarey *et al*., 2004).

Importance: The importance assigned to brown rust, varies in different countries. In Guatemala it is considered very important, because recently there have been outbreaks of the disease on previously resistant varieties, such as CG97-97, CP73-1547 and PR75-2002. This disease is the reason to discard the highest amount of varieties in the selection program.

Control: The recommended method is the use of resistant varieties, however, because sudden breaking of resistance is usual, then fungicide application is recommended, while the susceptible variety is replaced by a resistant one.

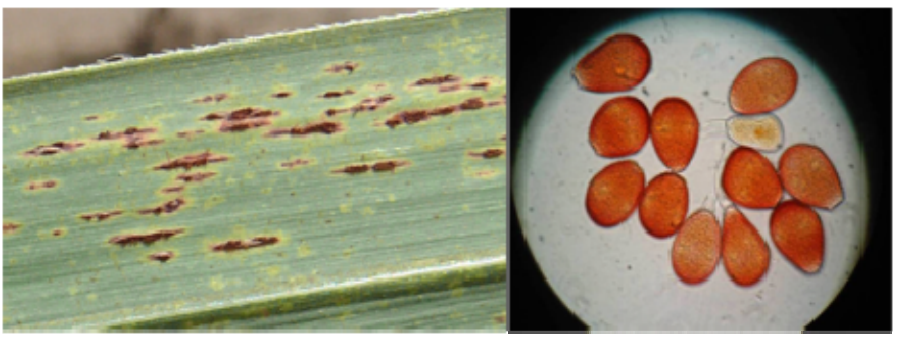

Figure 2. Lesions caused by *P. melanocephala* on the underside of a leaf. Uredospores in a microscope view

Orange rust

Causal agent: *Puccinia kuehnii* (Kruger) Butler

Symptoms: The first symptom of this disease is the appearance of yellow lesions, small and elongated, developing a pale yellowish-green halo when enlarged (NORTH AMERICAN PLANT PROTECTION ORGANIZATION (NAPPO), 2007). After enlarged, the lesions turn from yellow to orange-brown or orange when pustules open to release the spores (Figure 3). The pustules tend to occur in clusters or spots on the underside of leaves and are most abundant in

the apical zone. One characteristic which distinguish orange rust from brown rust, is its tendency to produce additional infections in the middle and basal areas of the leaves in pustule patches. Another difference is the size and shape of the lesions, which are larger and more elongated in brown rust that can be distinguished only by the experience of repeated observations. The color of the lesions does not allow differentiation, in old lesions. Adequate differentiation is achieved only by observing the spores under the microscope. The behavior of infections is different in both rusts, since forfor brown rust infection occurs in young states of the plant (up to 5 or 6 months) and after the, symptoms of the disease disappear. In orange rust, lesions have been observed with active and abundant sporulation until maturity of the plant and even on necrotic tissue and during dry seasons.

Transmission and spread: The transmission and spread, occurs when the epidermis of the pustules breaks and spores are carried out to other plants and other fields by wind and rain. The spores require Relative Humidity values above 98 percent and the optimal temperature for germination is 21°C. (Magarey *et al*., 2004).

Importance: In Guatemala, the disease is considered of high importance, since its arrival to the country caused major changes in varieties composition. The most important variety CP72-2086 decreased from 66 percent to 30 percent in three years; and the variety CP88-1165 increased from 5 percent to 35 percent in that period, with consequent expenses for these changes. In addition, the disease caused discarding of many varieties in different stages of CENGICAÑA´s selection program.

Control: The recommended method is the use of resistant varieties, however, in countries like Australia and the United States, application of fungicides is recommended while the susceptible variety is replaced by a resistant one.

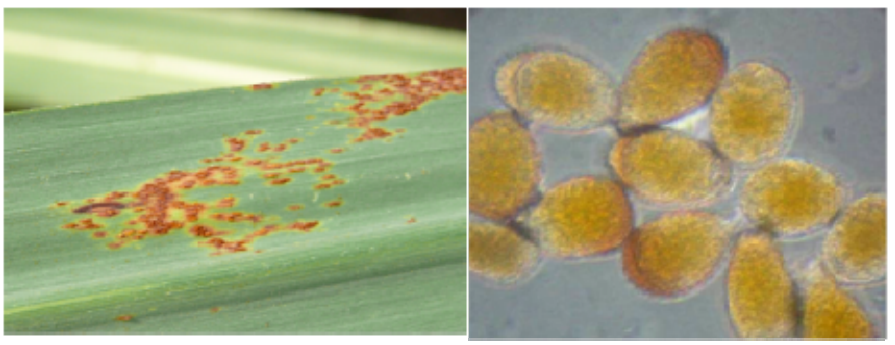

Figure 3. Lesions caused by *P. kuehnii* on the underside of a leaf. Uredospores in a microscope view

Pokkah boeng:

Causal agent: *Gibberella moniliformis* (Sheldon) Wineland
***Fusarium moniliforme* Sheld. Snyd et Hans**

Symptoms: Initially symptoms of the disease are manifested in the stalk apex, subsequently it can be seen on lower positioned leaves, when the stalk continues growing. Symptoms ranging from discoloration (chlorosis) of unopened leaves , which are whitish or yellowish (Figure 4), until the death of the apical meristem (this is not common). Other symptoms of intermediate intensity are deformations of unopened leaves, wrinkled or entangled, therefore the opening and expansion is difficult. In other cases, a whitish or yellowish discoloration in the basal part of the young leaves is seen, and red stripes are projected that can be confused with those caused by red stripe disease (*Pseudomonas rubrilineans*). During periods of high relative humidity, the base of the apical leaves may show areas of necrotic tissue, redish-brown in color and when, the sporulation occurs (Ovalle, 1997) (Figure 4). Sometimes, the infection causes malformations of the stalks, which vary in intensity and the stalks can show superficial or deep horizontal cracks. When the variety is susceptible, the disease can cause death of the apical meristem and side shoot development (lalas).

Transmission and spread: The transmission of the disease takes place mainly by the transfer of spores by wind (Martin *et al*., 1961).

Importance: Despite the above symptoms, the disease rarely causes effects on production. It is common, in the varieties growing in Guatemala, sometimes with alarming symptoms that then disappear, with minimal or no effect on the production.

The disease is more severe when the weather conditions are very hot and dry, and after a rainy period that cause high environmental humidity ((Martin *et al*. 1961).

Control: The recommended control method is the use of resistant varieties.

Figure 4. Symptoms of *F. moniliforme* in stalk tops. Tissue necrosis where sporulation of the fungus occurs

Purple spot

Causal agent: *Dimeriella sacchari* (B. de Haan) Hansford

Symptoms*:* Purple spot disease is characterized by the formation of irregular leaf spots, light red in color at the beginning and then dark, from 2 to 10 millimeters in diameter (Figure 5). Symptoms begin in the lower leaves and progress over time toward the younger leaves. This means that in later stages, severity is higher in lower leaves. Sometimes the spot is not solid and is formed by a series of very fine parallel red lines following the direction of the secondary veins (Ovalle, 1997). When environmental conditions are favorable, the fungus produces perithecia (globosely structures covering spores) on the spots surface on the underside of leaves. These resemble small black balls that can be seen with a magnifying glass. In dried lower leaves, spots can be clearly seen but reddish-brown to black in color. The disease is favored by high humidity and high temperature periods. InThis is the reason why in Guatemala appears towards the end of August and develops its maximum level in September (Ovalle, 1997).

Transmission and spread: Like most fungal diseases, transmission and spread take place through spores produced in the lesions. The spores are carried out by wind and rain.

Importance: The disease is considered non-significant despite being a disease observed in all varieties grown in Guatemala. However, it can become important since variety CP88-1165, which is rapidly expanding, shows more severe purple spot infections than other varieties and has shown effects on plant growth in slow drainage areas.

Control: The recommended method is the use of resistant varieties

Figure 5. Lesions caused by D. *sacchari* on the leaf surface

Yellow spot

Causal agent: *Mycovellosiella koepkei* (Krüger) Deighton

Symptoms: The disease can be seen as yellow spots on the leaves, from 2 to 10 mm in diameter, irregularly shaped, which can show reddish colors at maturity (Ovalle, 1997) (Figure 6). If there are suitable conditions (high humidity mainly) the fungus sporulates mainly on the underside of the leaf, developing a woolly, whitish or greyish growth (Martin *et al*., 196). When spots become reddish, the woolly growth differences the spots from those caused by purple spot. In susceptible varieties and suitable conditions for infection, the spots can come together and cover large areas of the leaf. In these cases the leaves may distort and become prematurely detached from the plant. Yellow spot could be confused with the expression of genetic spots, which are usually yellow. Both can be distinguished because those of genetic origin are smaller (as freckles) and show no sporulation, regardless of the moisture and temperature conditions.

Transmission and spread: The transmission from plant to plant and spread from one field to another occurs in periods of high relative humidity, when high

sporulation occurs and spores are splashed by rain and carried out by wind (Martin *et al* ., 1961).

Importance: The disease is considered of minor importance in Guatemala, as in the currently used varieties, it appears in advanced stages of plant development.

Control: The recommended method is the use of resistant varieties (Ramallo and Ramallo Vázquez, 2004).

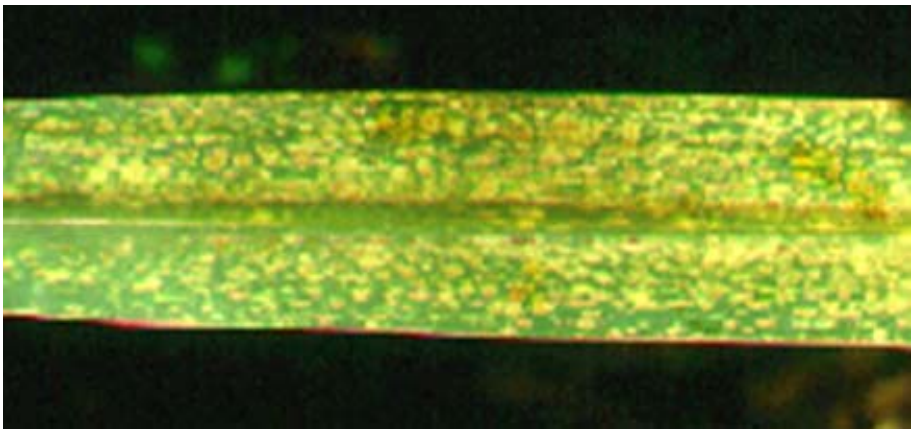

Figure 6. *M. koepkei* lesions on the leaf surface

Rot of basal stem, sheath and root

Causal agents: *Marasmius sacchari* Wakker y *M. stenospilus* Montagne

Symptoms: The distinctive symptom of this disease is the mycelium development in the basal leaf sheaths and in basal portion of the stalk (Tokeshi, sf, Hughes *et al*., 1964). Mycelial growth is noticed more easily by separating, the sheaths of lower leaves from the stalks which exposed show a whitish growth on both surfaces. It seems that sheaths are glued or attached to the stalk; this is due to mycelial growth between the two surfaces. If humidity and temperature conditions are high, development of reproduction structure occurs, which is characterized by an umbrella-shaped structure, white in color with a yellow to light-brown center, from 2 to 4 cm in diameter, with long bases of 2-7 cm (estipites) (Tokeshi, nd), (Figure 7). Usually the reproduction structure grows very close to or on the soil surface (Hughes *et al*., 1964). These structures produce and release large amounts of spores from the underside. In severe

infections the stalks and attached leaves die, and a brown rot is shown at their basis. Sometimes it may occur in complete stools.

Transmission and spread: The fungus is maintained as saprophyte in crop residues (Hughes *et al*., 1964) and it is transmitted through the mycelium and spores developed near the ground level. The spread from one field to another occurs by the use of contaminated tools infected seed.

Importance: This is a minor importance disease. In Guatemala, infections have been observed in areas with slow drainage and mainly in flooded areas.

Control: It is a weak pathogen that causes infections under abnormal plant development conditions. If good conditions to the plant growth are maintained, especially in terms of adequate soil drainage in areas of high humidity, the fungus will not be able to cause damage.

Figure 7. *M. sacchari* reproduction structures. Cogumelos (umbrellas) abundant in the basis of stools. Detail showing stipites (the long base of Cogumelos -arrow-)

Sooty mold

Causal agents: *Capnodium* sp. *and Cladosporium* sp.

Symptoms: The condition known as Sooty mold is presented in plants infested with pests such as West Indian Canefly or "Coludo" (*Saccharosydne saccharivora*), Leafhoppers (*Perkinsiella saccharicida*) and Ribbed scale (*Orthezia* sp.) and sometimes Yellow aphid (*Sipha flava*), which exude sweet substances that serve as substrates for the fungus growth. The symptom can occur on leaves, sheaths and stalks; and is visible by blackening of those organs

(Figure 8). The identifiable feature is that such blackening is removed when it is rubbed with the nail, because the structures of the fungus cannot penetrate the plant tissue and only form a superficial, thin black crust. Although fungi *Capnodium* sp. and *Cladosporium* sp. are not plant parasites, they can cause developmental disorders, as they interfere with the photosynthesis process, blocking sunlight penetration and gas exchange by blocking the stomata (Chinea *et al*., 2000).

Transmission and spread: These occur through spores (ascospores or conidia depending on the causing fungi) that are carried out by the wind and rain. Spores can also be carried out by pests of insects when they move from affected to healthy areas.

Importance: In recent years sooty mold importance increased because of infestations by West Indian Canefly or "Coludo"(*Saccharosydne saccharivora*) and Ribbed scale (*Orthezia* sp.) .
Control: Control is obtained by eliminating pests that secrete sweet compounds. Farmers are recommended to use products with the lowest impact on the environment.

Figure 8. Blackening of the leaf surface by superficial development of *Capnodium* and / or *Cladosporium*, causing agents of Sooty mold

Dry top rot

Causal agent: *Ligniera vasculorum* (Matz.) Cook

Symptoms: The disease called dry top rot begins with the drying of tips on top leaves. After the entire surface of these leaves dry, the top internodes are shortened and wrinkled, and the whole stalk dries dried (Comstock *et al*., 1994) (Figure 9). When the stalk has not yet dried,, longitudinal cuts show a color change in some of the vascular bundles, a salmon tone (Comstock *et al*., 1994). Infections usually occur on developed stems which the losses can be severe. Infections with the symptoms described were seen in Guatemala, but no signs were found (spores) to allow confirmation of the causal agent.

Transmission and spread: Transmission is by infected soil and spread by infected seed pieces.

Importance: Considered of little importance due to its low incidence in commercial varieties at the present time.

Control: Use of healthy nurseries is recommended.

Figure 9. *L. vasculorum* infection symptoms in sugarcane stalks

BACTERIAL DISEASES

Leaf scald

Causal agent: *Xanthomonas albilineans* (Ashby) Dowson

Symptoms: The characteristic symptom that gives the disease its name is death of leaf tissue with burning appearance at the tips, which are curved up or down. The disease presents different symptoms depending on the form of the disease. Two possible phases or forms are:

Chronic Phase: The characteristic symptom of the chronic phase is the presence of fine lines about 0.5 mm wide and well-defined edges, that develop in secondary veins of leaves forming sharp angles with the midrib (called pencil lines) (Martin *et al*., 1961; Ovalle, 1997). In most cases, lines are long and initially white to yellowish (Figure 10). Later, the pencil lines can present red sections intercalated with yellowish sections (Martin *et al*., 1961). Such infections come from the stalk and through the leaf midribs. Most resistant varieties show only this symptom when inoculated, without effects on production.

Sometimes the lines arise from infections which start at the leaf edges through the hydathodes. In these cases the lines tend to be wider and with irregular edges.

Another symptom of the chronic phase is the growth of side shoots (lalas), which develop from the base or from the middle part of the stalk. In most cases the lalas decrease in size from the bottom to the top of the stem (Martin *et al*., 1961; Tokeshi, nd; Vázquez de Ramallo, and Ramallo, 2004) (Figure 10), unlike the lines developed as a result of chemical ripening, such as fluazifop butyl and Glyphosate or by any damage to the apical meristem. In these cases the side shoots develop first from the superior buds and then the upper lalas are larger, and the size of the rest decreases along the stem. The lateral shoots induced by leaf scald may or may not display "pencil lines", chlorosis or burning of leaves. Finally, there may also be young shoots (suckers) with etiolated leaves (white to cream in color due to the lack of chlorophyll and chloroplasts) (Martin *et al*., 1961).

In the internal part of the stalks a change in color of the vascular bundles, may occur which are presented light-red at the beginning and dark red (almost black) at the end (Figure 10). The development of the color change is initiated at the nodes and extends to the internodes (Martin et al., 1961).

Acute phase: When this phase is presented, the stems may suddenly wilt and change from the normal color to a dark red, causing sudden deathwithout other symptoms (Martin *et al*., 1961)

Transmission and spread: Transmission occurs primarily through the use of infected "seed" pieces and contaminated tool during field works or at harvest (Martin *et al*., 1961). However, the transmission and spread may also occur by the combination of strong wind and strong rain, which can break the infected tissue of stalks allowing exposure of the bacterium, which is dragged by water and wind. (Autrey *et al*., 1991). This type of transmission has also been linked to infections that occur through the hydathodes in the guttation process.

Importance: In Guatemala, this is an important disease due to environmental conditions (severe rainy periods and severe dry periods) that favor its spread and expression.
In addition, leaf scald has caused the elimination of some commercial varieties of high potential of production.

Control: Use of resistant varieties is recommended. Some varieties with high potential of production (as CP73-1547 and CP72-1312) that have shown soft leaf scald infections (less than five percent) are still used successfully by applying appropriate hot water treatment to eliminate the infections (immersion of seed pieces in stream water at room temperature for 48 hours, followed by immersion in water at 50°C for three hours) (Steindl, D., 1971; Frison and Putter, 1993).

Figure 10. Side shoots on a stalk, induced by *X. albilineans* infection. "Young" pencil line on a leave. Color changes of vascular bundles in an infected stem

Red stripe

Causal agent: *Acidovorax avenae* subsp. *avenae* (Manns) Willems *et al.* = *Pseudomonas rubrilineans* (Lee *et al.*) Stapp

Symptoms: The Red Stripe of sugarcane can produce symptoms on leaves and at the apex of the stalks. Infections in the leaf-blades cause the symptom that gives the disease its name. Infections appear as red lines of different intensity, depending on whether they are recent or old, with well-defined edges and with a width from less than one millimeter to two millimeters (Figure 11). The lines may be short or long in size, but generally, they are long, sometimes occupy the entire length of the blade; and may occasionally fuse to form bands of red tissue. In high humidity and high temperature periods, the causing bacterium exudes on the underside of leaves and on the site of the bands or stripes. When dry, these exudates leave dry rubber flakes. Sometimes when strong winds occur, the leaves are broken and divided into strips.

Infection of the tips of the stalks kills the growing point and cause drying of young leaves. In these cases, a wet, soft rot, with disagreeable and characteristic odor occurs (Figure 11). The death of the growing point induces budbreak of lateral buds and growth of "lalas" (Martin *et al*., 1961).

Transmission and spread: They occur when bacterium exudes on the underside of the leaves, which coincides with high humidity periods. If strong

rains and winds occur, the bacterium is spread by splashing and drag, and penetrates through leave wounds (Martin et al., 1961). The bacterium does not circulate through the vascular bundles of stalks; and therefore it does not spread through the seed.

Importance: Currently, the red stripe is of relative importance in Guatemala, because among the major varieties only CP72-2086 is severely attacked during the growing phase in low slow drainage and ponding areas.

Control: The recommended method is the use of resistant varieties. It has been observed that some varieties show susceptibility and resistance in young states from 7 or 8 months of age, lost stem infection recovery, issuing new stems.

Figure 11. Symptom of red stripe on a leaf and on the growing point of a stalk

Ratoon Stunting Disease

Causal agent: *Leifsonia xyli* subsp. *xyli* (Davis *et al*.) Evtushenko

Symptoms: This is one of the most difficult diseases to diagnose with certainty in the field, because its symptoms are vague and can be confused with those produced by other abiotic agents (CENICAÑA, 1995). When plants are infected, there occurs a progressive reduction in sugarcane production through the harvests; this effect gave the name to the disease. Such reduction is due to the obstructions of xylem vessels caused by the bacterium, resulting in lower growth (shortening of internodes and decrease of diameter –notice in Figure 12, ten healthy stalks and ten infected stalks–). Besides, diseased stools may produce fewer stems (CENICAÑA, 1995; Ovalle and Garcia, 2008). In some varieties, there are reddish small lines (1-2 mm), at the base of the internodes in longitudinal sections of diseased stalks (CENICAÑA, 1995) (Figure 12).

Transmission and spread: It mainly occurs through infected seed pieces and infected cutting tools and tillage.

Importance: It is considered one of the most important diseases worldwide. It has been found infecting all varieties growing in Guatemala, and it has been demonstrated that it causes significant effect on production. (Bailey and Bechet, 1995; Ovalle and Garcia, 2008).

Control: Hot water treatment of seed pieces is the most used control method. In Guatemala, five hydrothermal treatments were evaluated (Ovalle *et al*., 2001), and the best results were found by dipping seed pieces in hot water at 51°C for 10 minutes, followed by reposing at room temperature for 12 hours, and finally immersion in hot water at 51°C for one hour. However, good results were also obtained by direct immersion of the seed pieces in water at 52°C for 30 minutes, which is a simple treatment. Besides the use of healthy seed, control of ratoon stunting, should include cleaning of the cutting and field work tools. This is done with chemicals and good results have been achieved with Vanodine 1% (Victoria, *et al*., 1985; CENICAÑA, 1995**).**

Figure 12. ***L. xyli*** **infection effect on stems. Reddish lines at the basis of an infected node**

VIRAL DISEASES

Mosaic
Causal agent: *Sugarcane mosaic virus* (SCMV), *Sorghum mosaic virus* (SrMV)

Symptoms: This disease is characterized for causing decrease in the number and size of chloroplasts in certain areas of the leaves, leaving other areas without apparent damage. This causes the characteristic symptom of mosaic with normal green areas on a background of lighter green to yellowish (Figure 13), with patterns that vary depending on the virus strain (Martin *et al.*, 1961), the variety (Koike and Guillaspie cited by CENICAÑA, 1995), and sometimes, temperature and other growing conditions. Sometimes only limited chlorotic stripes on normal green are observed. In common cases, chlorotic areas on the normal green predominate, with varying intensities and patterns. The mosaic symptom may or may not be associated with a decrease in normal growth (Brandes, cited by Martin et al., 1961). The mosaic is most evident in young shoots (1-3 months) and in the apical leaf basis (Cook, cited by Martin *et al.*, 1961). In some varieties changes in color of the stem bark can be seen (Tokeshi, nd) similar to those seen on leaves.

Transmission and spread: The virus is transmitted in the seed pieces and also through the aphids *Rhopalosiphum maidis* and *Hysteroneura setariae* (CENICAÑA, 1995) and *Toxoptera graminum.*

Importance: Currently, it is considered without commercial importance in Guatemala, even though one of most planted variety (CP72-2086) usually shows high infection by this virus, without effects on production.

Control: The use of resistant varieties is the recommended method (Vázquez de Ramallo, and Ramallo, 2004). It has been observed that some varieties have symptoms in the seedling stages but without development effect, thus, they are considered tolerant to the disease.

Figure 13. Mosaic virus effect on growth. Leaf infection symptoms

Yellow leaf

Causal agent: *Sugarcane yellow leaf virus* (SCYLV)

Symptoms: Symptoms of this disease begin with yellowing of the leaf midrib, in leaves +3 to +5, evident on the underside (+1 leave is the first leave with fully visible neck at the apex. Count down to name the following leaves). At the beginning it appears pale yellowish and after it turns like egg yolk color (Figure 14). In some varieties, the upper face of the midrib takes a pinkish or reddish color. Following, the leaves tips dry, and on susceptible varieties the dry area advances on the entire leave. Plants may or may not show, an effect on growth (stunting), depending on the susceptibility of the variety. In severe cases, which rarely occurs, death of the apical meristem is observed; and adventitious roots emission at the apex of the stem (which was described by Witteveen, P., in 1969 in Tanzania, in what he called "yellow wilt" but it has many similarities in symptoms, so it is probably the first description of the yellow leaf disease). Any type of stress is associated with the manifestation of the symptoms of the disease, mainly by drought and it is commonly more severe, at the edges of the fields. Some association between low temperatures and more severity, thus, certain varieties show problems with yellow leaf at high altitude and none in the low altitude. Although nine years ago SCYLV had been confirmed by serological methods in Guatemala (Ovalle and Nelson, 2003), recently, using molecular methods, sugarcane yellowing phytoplasma (SCYP) was also detected and this patogen pathogen can cause the same symptoms than SCYLV (Maldonado *et al*., 2009).

Transmission and spread: The transmission of the disease caused by the virus is through seed pieces and by the aphids *Melanaphis sacchari,* and *Rophalosiphum maidis* (Chinea, 2000; Vázquez de Ramallo, and Ramallo, 2004). The phytoplasma is transmitted by West Indian Canefly or "Coludo" (*Saccharosydne saccharivora*) reported as the insect vector (Arocha *et al*., 2005).

Importance: Although nearly one hundred percent of varieties analyzed by laboratory methods in Guatemala have been infected with the virus, none of the major varieties or the promising ones show effects on production.

Control: In countries where the disease is causing production losses, the recommended method of control is the use of resistant varieties.

Figure 14. SCYLV infection symptoms. On the right photograph, a healthy leaf (top) and two different symptom intensity

Chlorotic streak

Causal agent: Despite research conducted over 80 years in various countries, it has not been possible to identify the causal agent of chlorotic streak. The disease has several characteristics that suggest it could be a virus, but nobody has been able to confirm its cause of the disease (CENICAÑA, 1995).

Symptoms: The main symptom of this disease is the presence of light green bands on the leaves, variable in length, with defined edges that later become yellowish bands with irregular edges. Eventually, necrosis can occur sometimes

along the entire length of the band (Figure 15). The bands are wide (from 3 to 10 mm), with irregular edges, sometimes, they are also wavy (CENICAÑA, 1995). Diseased plants show decreased development, which is evident at the lower height and lower tillering. Pieces of seed from infected stools have problems in germination and symptoms are frequently present in adult plants that grow in heavy and wet soils (Tokeshi, nd; CENICAÑA, 1995).

Transmission and spread: The disease is transmitted through the roots, seed pieces (Victoria *et al*., 1984) and runoff from rain or irrigation. An infested field can be kept for long periods of time (several months) even in the absence of sugarcane plants. The chlorotic streak can not be spread by cutting tools or machetes.

Importance: Variety CG96-135 has been susceptible near the sea, when planting seeds without heat treatment, in slow drain fields or waterlogged.

Control: Seed heat treatment by immersion in hot water at 50^{o}C for 30 minutes is effective (Chinea *et al*., 2000) therefore, the treatment for ratoon stunting disease is enough to control also chlorotic streak. (Victoria *et al*., cited by CENICAÑA, 1995).

Figure 15. Chlorotic streak symptoms on leaves

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