CARIBBEAN FOOD CROPS SOCIETY

46

Forty Sixth
Annual Meeting 2010

Boca Chica, Dominican Republic
Vol. XLVI – Number 2
T-STAR Invasive Species Symposium

PROCEEDINGS
OF THE
46th ANNUAL MEETING

Caribbean Food Crops Society
46th Annual Meeting
July 11-17, 2010

Hotel Oasis Hamaca
Boca Chica, Dominican Republic

"Protected agriculture: a technological option for competitiveness of the Caribbean"

"Agricultura bajo ambiente protegido: una opción tecnológica para la competitividad en el Caribe"

"Agriculture sous ambiance protégée: une option technologique pour la compétitivité de las Caraïbe"

United States Department of Agriculture,
T-STAR Sponsored Invasive Species Symposium

Toward a Collective Safeguarding System for the Greater Caribbean Region:
Assessing Accomplishments since the first Symposium in Grenada (2003)
and Coping with Current Threats to the Region

Special Symposium Edition
Edited by
Edward A. Evans, Waldemar Klassen and Carlton G. Davis

Published by the Caribbean Food Crops Society

ISSN 95-07-0410

Copies of this publication may be received from:

Secretariat, CFCS
c/o University of the Virgin Islands
USVI Cooperative Extension Service
Route 02, Box 10,000
Kingshill, St. Croix
US Virgin Islands 00850

Or from

CFCS Treasurer
P.O. Box 506
Isabella, Puerto Rico 00663

Proceedings of the Caribbean Food Crops Society. 46(1): 65-73. 2010

ORANGE RUST OF SUGARCANE: ITS IMPORTANCE AND PROSPECTS FOR ITS CONTROL

Dr. Richard N. Raid, Professor of Plant Pathology, University of Florida/IFAS, Everglades Research and Education Center, 3200 East Palm Beach Road, Belle Glade, FL, USA 33430. Phone: 561-993-1564; Email: rnraid@ufl.edu

INTRODUCTION

There are two important rust diseases of sugarcane: brown rust (also known as common rust) and orange rust (Egan 1980). Incited by *Puccinia melanocephala*, brown rust arrived in the Western Hemisphere and Australia in 1978, causing devastating yield losses of up to 33% in the Dominican Republic and 50% in Mexico (Dean et al. 1979; Liu 1979; Presley, et al. 1978; Purdy et al. 1983). At the time of its introduction, the highly-rust susceptible variety B-4362 dominated sugarcane production in the Caribbean region. Following this outbreak, sugarcane producers were forced to replace B-4362, and other popular varieties that proved to be rust susceptible with more resistant genotypes. Frequently, this replacement meant sacrificing the high yield potential of the once popular cultivars. There is evidence to support that brown rust arrived in the Americas from the Cameroons in West Africa via transoceanic transport of urediniospores (Purdy et al. 1985).

In 2007, disease symptoms somewhat dissimilar to brown rust were noted during June in Florida. This disease seemed to increase in severity throughout the summer, a period when brown rust typically subsides, due to temperatures beyond its optimum. Investigations soon revealed the presence of orange rust, incited by the fungus *Puccinia kuehnii*. This constituted a first report of this particular rust in the Western Hemisphere (Comstock et al. 2008). During this initial season, orange rust was noted on two important cultivars: CP80-1743, and CP72-2086. Together, these cultivars accounted for approximately 25% of Florida's hectarage (Glaz 2008). Although comparisons of yields from that harvest with those of historical yields suggested significant losses, the extent of those reductions could not be precisely determined.

A COMPARISON OF SYMPTOMATOLOGY AND MORPHOLOGY

Like most rust diseases, orange rust is characterized by leaf lesions (pustules) that erupt through the leaf epidemis upon maturing (Figure 1). With initial symptoms of infection being small, elongated yellow flecks, under favorable conditions of leaf wetness and temperature, these lesions give rise to thousands of orange spores called urediniospores. It is the orange color of these spores that give rise to the name of the disease: orange rust. While brown rust likewise produces pustules, the spores are darker brown in color. A comparison of pustules of the two rusts reveals that brown rust pustules tend to be long and slender (2--20 mm x 1–2 mm), while those of orange rust tend to be shorter (2–10 mm x 1–3 mm) (Raid and Comstock 2000). Both orange and brown rust pustules occur predominantly on the undersurface of the leaf.

Microscopically, orange rust may be distinguished from brown rust by its urediniospores (Castlebury 2010). Those of *P. kuehnii* are light in color and have an atypical thickening, while those of *P. melanocephala* do not (Figure 2). This means that the cell walls of *P. melanocephala* appear much darker and more uniform with regards to cell wall thickness. Additionally, urediniospores of *P. kuehnii* have small projections called spines that are non-uniformly distributed over the cell wall surface, while the spines of *P. melanocephala* are uniformly distributed and greater in number. With age, orange rust pustules may eventually produce a second spore form, the teliospore, which gives pustules a whitish appearance (Magarey 2000).

EPIDEMIOLOGY

Aside from differences in symptomatology, the two sugarcane rust diseases, orange and brown, also differ noticeably in the time of year during which they prevail. Being favored by relatively cool to moderate temperatures (Comstock and Ferreira 1986), brown rust is favored in the spring, in Florida from March through May. Orange rust, by comparison, is favored by the warmer temperatures (Magarey 2000; Martins et al. 2010) that prevail from June through November. Brown rust attacks new, rapidly expanding leaves, such as those near the top visible dewlap leaf (the topmost fully expanded leaf) most aggressively, while orange rust is usually prevalent on more mature leaves, somewhat lower in the canopy. Regarding crop maturity, brown rust prevails while the crop is four to six months of age, while orange rust is most severe on crops from six months through harvest. Although both rusts may result in significant foliar desiccation and loss of photosynthetic tissue, brown rust is the more aggressive of the two diseases, exerting its damage over a much shorter time span.

SPREAD OF ORANGE RUST TO FLORIDA AND THE AMERICAS

The primary source of inoculum for the arrival of orange rust into the Western Hemisphere remains a controversial topic (Glynn 2010). As a group, rust diseases are noted for their ability to be transported long distances, and there is ample evidence to support the hypothesis of brown rust arriving to the Americas via transoceanic air currents from western Africa (Purdy et al. 1985). However, orange rust was confirmed only in Asia and Australia prior to 2007, and meteorologic and climatic models do not support long distance spread by air directly from those regions to the Americas (Isard 2010). But regardless of how it arrived, orange rust has now staked its presence in the Americas, and its range is expanding. Table 1 lists the countries and the year of its detection. First observed in Florida in June 2007, it spread to 11 Western Hemisphere nations, most significantly, Brazil, the world's largest sugarcane producer, in December 2009 (Canteri 2010; Ruaro 2010). Given its airborne nature and its current widespread presence, it is likely that orange rust will soon spread to all sugarcane-growing countries in the Americas within the very near future.

A COMPARISON OF TWO ORANGE RUST EPIDEMICS

Following its initial discovery in Florida during 2007, orange rust persisted throughout the harvest season and could be found at low but detectable levels on green cane even during the winter of 2007/2008. This was a winter that was free of the frosts that occasionally blanket the region, with South Florida having a subtropical rather than tropical climate. Orange rust during spring 2008 maintained itself but did not develop appreciably until temperatures started to climb in the late spring. By May, severities had reached 5%, and by June 15% on top-visible-dewlap leaves minus four of the highly susceptible variety CL85-1040. Severities climbed to over 30% by July and stayed above that level throughout the fall. By contrast, the following winter (2008/2009) was a cold winter, with a region-wide severe frost in late January turning a large percentage (but not 100%) of the green cane leaves in the area necrotic. This drastically depleted the number of active orange rust pustules, significantly reducing levels of primary inoculum. Orange rust during 2009 stayed at very low levels throughout the entire spring and did not exceed 5% until well into July. By August, levels were similar to those that had existed during

2008, but the epidemic was some two months later. Figure 3 graphically illustrates orange rust severity over time during the respective years. This comparison illustrates the impact of a regional frost or freeze on rust epidemics in Florida.

YIELD LOSS DUE TO ORANGE RUST

Yield losses to sugarcane caused by brown rust can be substantial and have been well documented (Comstock et al. 1992; Raid et al. 1991a, 1991b). However, prior to the year 2000, orange rust was generally regarded as a disease of rare economic importance (Magarey 2000). However, a significant orange rust outbreak in Australia on the widely planted cultivar Q124 changed this view, with losses in excess of 40% being reported (Magarey et al. 2001). Soon after its first discovery in Florida, replicated trials were established to determine the yield loss potential for orange rust using fungicides to establish varying levels of rust for comparisons (Raid et al. 2010). The experiment was conducted on the highly orange rust susceptible variety CL85-1040 over two years. The fungicide pyraclostrobin was applied at 7-, 14-, 21-, and 28-day intervals to experimental units of sugarcane which measured five rows by 15 meters. Non-sprayed plots served as controls and the treatments replicated eight times. A separate trial conducted on an orange rust resistant variety demonstrated that the fungicide utilized had no significant impact on sugarcane yield in the absence of orange rust. In 2008, a year that was very favorable for orange rust development, disease severities ranged from near zero in the 7-day treatment to over 35% in the controls from early July through harvest. Millable stalk populations were reduced by 12% and stalk biomass by 32% when controls were compared with the 7-day treatments. Together, these accounted for reductions of 43% in tons of cane per hectare. Sucrose concentrations were significantly reduced by nearly 18% on this cultivar. Overall, cumulative losses in terms of sugar per unit area of cane measured 53% on CL85-1040 during the orange rust favorable year of 2008.

In 2009, rust build-up was significantly delayed by extreme cold conditions that occurred in late January. This delay influenced the impact of orange rust on the various yield components. In contrast to 2008, when stalk populations were reduced by 12%, millable stalk populations were virtually unaffected (<2%), presumably because rust did not build up to sufficient levels previous to the physiological age when millable stalk numbers are determined. This phenotypic stage typically occurs during June and July, and as Figure 3 illustrates, rust severities were low during these months in 2009. Reductions in stalk biomass in 2009 were similar to those in 2008 (33%) while reductions in sucrose levels were lower (14% in 2008 vs 18% in 2008) but still significant. Overall yield losses in 2009 on this susceptible variety amounted to 43%. These studies demonstrate the destructive nature of this disease. Such losses mandate disease management.

HOST PLANT RESISTANCE TO ORANGE RUST

Significant differences in genetic resistance to orange rust within sugarcane cultivars has been obvious since the onset of the original outbreak in the Americas. In Florida, a number of commercial cultivars have exhibited a high degree of resistance, even immunity, while others have displayed susceptibility (Figure 4). Of the commercially important cultivars in production when orange rust first made its appearance in 2007, widely grown CP80-1743 (nearly 20% of the hectarage), CP72-2086, and CL85-1040 were the most visibly affected, with CL85-1040 being the most susceptible. Together, these three cultivars accounted for approximately 25% of the total Florida hectarage (Rice et al. 2009). In 2008, two additional important varieties displayed moderate susceptibility: CP83-2143 and CP78-1628. This increased the percentage of susceptibility to 52% and, in 2009, another cultivar fell, chiefly CP88-1762, which was being used as a replacement for some of the previously mentioned cultivars that were being phased out due to orange rust. At present, nearly 71% of the total Florida sugarcane hectarage is planted to these cultivars that support orange rust infection and sporulation (Rice et al. 2009). Fortunately, all but CL85-1040 are at most moderately susceptible; however, this illustrates the difficult situation being faced by both sugarcane producers and breeders.

This scenario is reminiscent of the situation with brown rust (Shine et al. 2005; Raid 1989) soon after its arrival into the Americas and indeed mimics that of rust fungi on a myriad of crops. Variants within the rust populations routinely develop that are capable of overcoming the genetic resistance being sought by breeders. This means that breeding for rust resistance on sugarcane has now become that much more difficult, dealing with two rather than one pathogen.

FUNGICIDES AS POTENTIAL MANAGEMENT TOOLS

While host plant resistance must remain the mainstay of any management program developed for orange rust, or any rust for that matter, preliminary results using fungicides to help manage orange rust have displayed promise. Raid (2008a, 2008b) demonstrated that two major classes of fungicides, demethylation-inhibiting fungicides (DMIs) and quinone outside-inhibiting fungicides (QoIs or strobilurins), both provided for significant reductions in rust severity, even when applied at three-week intervals. Based on this and additional data, a crisis exemption was obtained in 2008 for the use of two fungicides, pyraclostrobin and metconazole, and this was subsequently followed by a Special Local Needs (Section 24C) registration. Labeling restricted the number of sequential application of either fungicide to two, mandating alternation with the other for management of fungicide resistance. Results of commercial applications during 2008, applied almost solely to the susceptible variety CP80-1743, were favorable, with yield in fields receiving fungicides ranging from 6–26% higher than the yield from unsprayed fields (control plots) (Shine 2009). In general, yield response was correlated with the number of applications and the economic returns from the reductions in yield loss more than paid for the cost of fungicide application.

Although promising, there is much to be learned regarding fungicides as a management tool. Fungicidal efficacy, fungicide rates, application intervals, program initiation, and fungicide alternations have all proven to be significant factors in reducing rust severities and limiting yield loss due to this important pathogen (Raid et al. 2011a, 2011b). Ultimately, it is hoped that fungicides will be available in a more supportive role, capable of reducing losses on susceptible varieties while new, more resistant varieties are being developed and expanded. However, given the propensity of rusts to develop new races or variants (Braithwaite 2005; Raid 1989; Shine et al. 2005), their value could be immeasureable.

CONCLUSIONS

Orange rust, caused by *P. kuehnii*, was first observed in the Western Hemisphere in 2007, and it appears to be here to stay. Given the propensity of its spores to be disseminated over relatively large distances, it is likely that orange rust will be present in all sugarcane producing countries within the Americas in the very near future. On highly susceptible varieties and under favorable conditions (warm temperatures and moist conditions), it may result in yield losses in excess of 40–50%. Host plant resistance has been noted and is indeed the major means of control at this time. However, the presence of rust variants (or races) has already been suggested, so breeders and producers must be ever vigilant to avoid significant outbreaks and lapses in control. In the interest of negating widespread losses, producers should be urged to diversify their cultivar holdings should new rust variants arise. Regarding chemical control, a number of fungicides have demonstrated efficacy and even economic feasibility. Their use to limit the scope of an epidemic and to perhaps lengthen the longevity of a susceptible variety, providing time for its replacement by more resistant varieties, appears to be an option worthy of consideration.

REFERENCES

Braithwaite, K. 2005. *Assessing the Impact That Pathogen Variation Has on the Sugarcane Breeding Program*. Final Report–SRDC Project BSS258, BSES Limited, Brisbane, Australia.

Canteri, M. 2010. Sugarcane orange rust in Brazil. *Sugarcane Orange Rust Conference*, University of Florida, Everglades Research and Education Center, Belle Glade, FL (August 4).

Castlebury, L. 2010. Morphology of *Puccinia kuehnii*, the causal agent of sugarcane orange rust. *Sugarcane Orange Rust Conference*, University of Florida, Everglades Research and Education Center, Belle Glade, FL (August 4).

Comstock, J. and S. Ferreira. 1986. Sugarcane rust: Factors affecting infection and symptom development. *Proceedings of the International Society of Sugar Cane Technologists* 19: 402-410.

Comstock, J., J. Shine Jr., and R. Raid. 1992. Effect of rust on sugarcane growth and biomass. *Plant Disease* 76: 175-177.

Comstock, J., S. Sood, N. Glynn, J. Shine Jr., J. McKenny, and L. Castlebury. 2008. First report of *Puccinia kuehnii*, causal agent of orange rust of sugarcane, in the United States and Western Hemisphere. *Plant Disease* 92: 175.

Dean, J., P. Tai, and E. Todd. 1979. Sugarcane rust in Florida. *Sugar Journal* 42(2): 10.

Egan, B. 1980. A review of the world distribution of *Puccinia* spp. attacking Sugar cane. *Procedings of the International Society of Sugar Cane Technologists* 17: 1373-1381.

Glaz, B. 2008. Sugarcane variety census: Florida 2007. *Sugar Journal* 71(2): 6-11.

Glynn, N. 2010. Spread and possible origin of sugarcane orange rust. *Sugarcane Orange Rust Conference*, University of Florida, Everglades Research and Education Center, Belle Glade, FL (August 4).

Isard, S. 2010. Aerobiological modeling of sugarcane orange rust transport from West Africa and Cameroon to the Western Hemisphere. *Sugarcane Orange Rust Conference*, University of Florida, Everglades Research and Education Center, Belle Glade, FL (August 4).

Liu, L. 1979. Rust of sugarcane in Puerto Rico. *Plant Disease Reporter* 63(4): 256-258.

Magarey, R. 2000. Orange rust. In *A Guide to Sugarcane Diseases*, edited by P. Rott, R. Bailey, J. Comstock, B. Croft, and A. Saumtally, 121-125. Montpellier, France: Centre de Cooperation Internationale en Recherche Agronomique Pour le Development (CIRAD) and International Society of Sugar Cane Technologists (ISSCT).

Magarey, R., T. Wilcox, B. Croft, and A. Cordingley. 2001. Orange rust, a major pathogen affecting crops of Q124 in Queensland in 2000. *Proceedings of the Australian Society of Sugar Cane Technologists* 23: 274-280.

Martins, T., R. Raid, W. Burnquist, A. Urashima, A. Bergamin Filho, and J. Comstock. 2010. Influence of temperature and leaf wetness duration on orange rust of sugarcane. *Phytopathology* 100: S78.

Presley, J., R. Perdomo, and J. Ayats. 1978. Sugarcane rust found in the Dominican Republic. *Plant Disease Reporter* 62: 843.

Purdy, L., L. Liu, and J. Dean. 1983. Sugarcane rust, a newly important disease. *Plant Disease* 67: 1292-1296.

Purdy, L., S. Krupa, and J. Dean. 1985. Introduction of sugarcane rust into the Americas and its spread into Florida. *Plant Disease* 69: 689-693.

Raid, R.. 1989. Physiological specialization in sugarcane rust (*Puccinia melanocephala*) in Florida. *Plant Disease* 73: 183.

Raid, R. 2009a. Efficacy of fungicides for control of sugarcane orange rust, 2007. *Plant Disease Management Reports* 3: V138.

Raid, R.. 2009b. Efficacy of fungicides for control of sugarcane orange rust, 2008. *Plant Disease Management Reports* 3: V139.

Raid, R., D. Anderson, and F. Coale. 1991a. Yield loss incited by *Puccinia melanocephala* on a highly susceptible sugarcane cultivar in Florida. *Phytopathology* 81: 699.

Raid, R. and J. Comstock. 2000. Common rust. In *A Guide to Sugarcane Diseases*, edited by P. Rott, R. Bailey, J. Comstock, B. Croft, and A. Saumtally, 85-89. Montpellier, France: Centre de Cooperation Internationale en Recherche Agronomique Pour le Development (CIRAD) and International Society of Sugar Cane Technologists (ISSCT).

Raid, R., J. Comstock, and N. Glynn. 2010. Yield loss incited by orange rust (*Puccinia kuehnii*) on a highly susceptible sugarcane cultivar in Florida. *Phytopathology* 100: S106.

Raid, R., J. Comstock, and N. Glynn. 2011a. Influence of two fungicides containing cyproconazole on orange rust severity of sugarcane in Florida, 2009. *Plant Disease Management Reports* 5: (in press).

Raid, R., J. Comstock, J. Shine Jr., and D. Anderson. 1991b. *Effect of Sugarcane Rust on Yield Components of CP72-1210 Plant Cane*. EREC Ressearch Report EV-1991-5. Everglades Research and Education Center, University of Florida, Belle Glade, FL.

Raid, R., N. Glynn, and J. Comstock. 2011b. A comparison of three DMI fungicides for control of orange rust on sugarcane. 2009. *Plant Disease Management Reports* 5: (in press).

Rice, R., L. Baucum, and B. Glaz. 2009. Sugarcane Variety Census: Florida 2008. *Sugar Journal* 72: 6-12.

Ruaro, L. 2010. Status of sugarcane orange rust in Parana, Brazil. *Sugarcane Orange Rust Conference*, University of Florida, Everglades Research and Education Center, Belle Glade, FL (August 4).

Shine, J. 2009. Fungicide applications for management of orange rust: A commercial perspective. Sugarcane Orange Rust Workshop, University of Florida, Everglades Research and Education Center, Belle Glade, FL (May 28).

Shine, J., J.. Comstock, and J. Dean. 2005. Comparison of five isolates of sugarcane rust and differential reaction on six sugarcane clones. *Sugarcane International Journal* 23: 24-29.

Table 1. Countries in the Western Hemisphere where orange rust had been detected as of July 1010 and the year of its detection.

Location	Detected
United States (Florida)	2007 (June)
Costa Rica	2007 (August)
Guatemala	2007 (September)
Nicaragua	2007 (September)
Cuba	2008
Mexico	2008 (July)
Panama	2008 (February)
El Salvador	2008 (February)
Jamaica	2008
Belize	2009
Brazil	2009 (December)

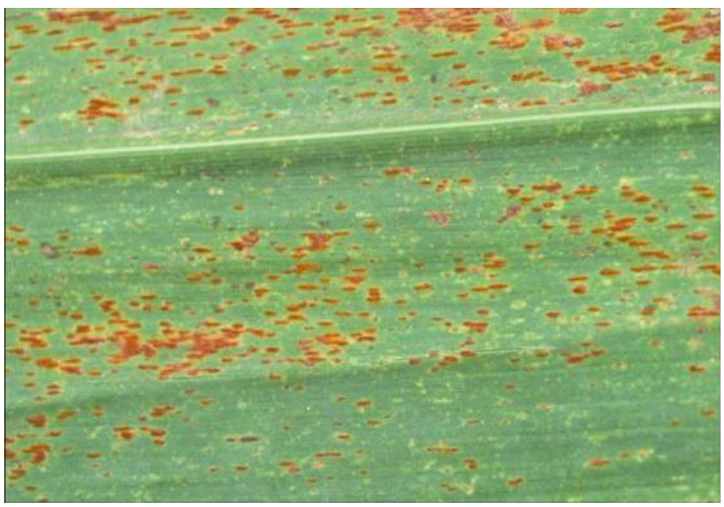

Figure 1. Orange rust symptoms on the lower surface of a sugarcane leaf. Note the bright orange coloration of the pustules containing urediniospores. Brown rust pustules (absent) are typically longer and darker brown in color. Yellow flecks are early infections that may produce open pustules given favorable conditions for sporulation.

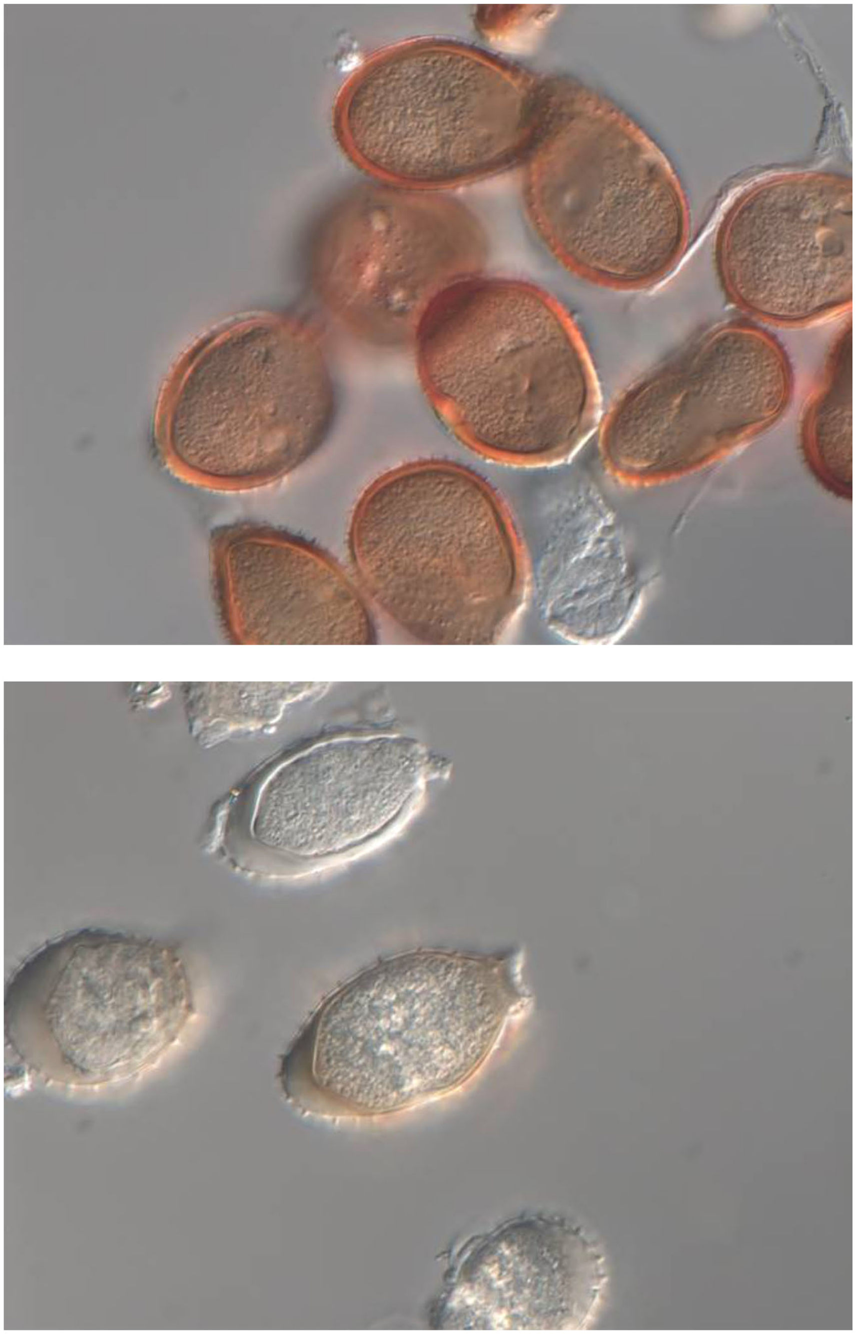

Figure 2. Magnified view of brown rust (top) and orange rust (bottom) urediniospores. Cell walls of orange rust are lighter in color, have an apical swelling and fewer spines than those of brown rust. (Photomicrographs courtesy of Lisa Castlebury, USDA/ARS Systematic Mycology Laboratory, Beltsville, MD).

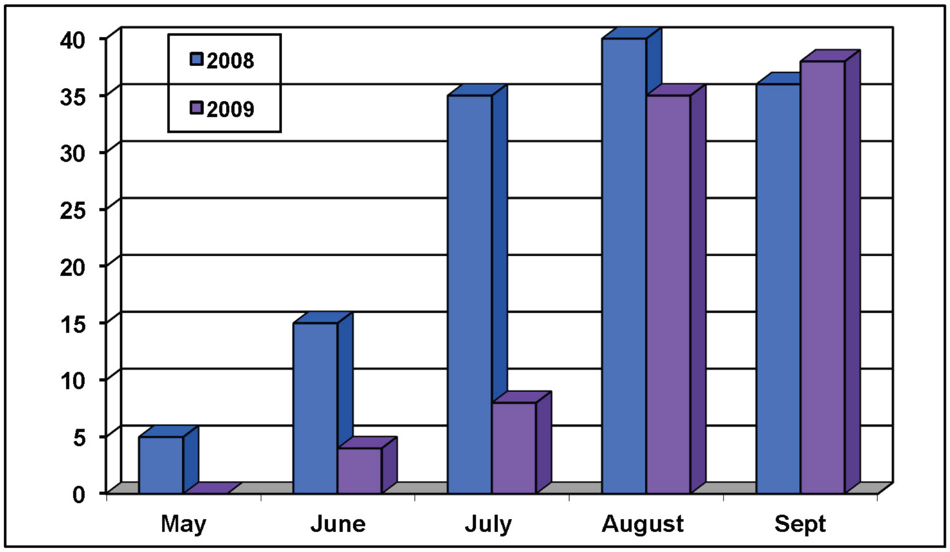

Figure 3. Rust severity (%) over time (month) during the 2008 and 2009 orange rust epidemics. Note the significant delay in orange rust buildup in 2009 as compared to 2008. This was due to an area-wide frost in January, which depleted, but did not eradicate levels of primary inoculum.

Figure 4. Two plantings of sugarcane showing significant differences with regard to varietal susceptibility to orange rust. The variety on the left is the moderately susceptible variety CP80-1743, while on the right is a highly resistant variety.