

## THE EFFECT OF ORANGE RUST (*Puccinia kuehnii*) ON SUGAR YIELD IN SIX SUGARCANE VARIETIES IN GUATEMALA

By

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**KEYWORDS:** Orange rust, *Puccinia Kuehnii*,  
Sugarcane, Yield Effects.

### Abstract

A REPLICATED field trial was conducted to estimate the effect of orange rust (caused by *Puccinia kuehnii*) on yield in six sugarcane varieties in a plant cane crop in Guatemala. CP72-2086 is the leading variety in Guatemala constituting 57% of the crop in the 2007–08 harvest season. The other varieties (CG96-135, SP79-2233, CP88-1508, CP89-2143 and PR75-2002) showed symptoms of orange rust in September 2007 when the disease first appeared. The experimental design of the field trial was a split plot in a complete randomised block design where the main plot was variety and the sub plot fungicide treatment (treated with the fungicide Alto<sup>®</sup> (Cyproconazole) at a dose of 500 mL per ha) or untreated. The susceptible variety SP79-2233 was planted on each side of the trial and around individual plots as a natural *P. kuehnii* inoculum source. Orange rust severity in fungicide treated and untreated plots was recorded monthly from three to nine months crop age. Cane yield components (plant height, stalk diameter and stalk population) and cane weight per plot were used to estimate cane yield in tonnes of cane per hectare (TCH); sucrose concentration (Pol % cane) was also assessed at harvest. Yield losses were estimated using a regression of orange rust severity on yield (tonnes sugar per ha, TSH) for the variety CP72-2086. Data suggest that orange rust may reduce sugarcane yields in five of the six varieties. Losses in CP72-2086 were 7.67% (TCH), 8.61% (Pol % C) and 15.78% (TSH), with the regression equation  $y = 20.3 - 0.2x$ . The highest orange rust severity occurred at five to six months crop age in all varieties and symptoms were observed through to plant maturity.

### Introduction

Until the year 2000, orange rust, caused by *Puccinia kuehnii* was of little economic importance worldwide but, in that year, an Australian epidemic caused losses estimated to be worth between 150 and 210 million Australian dollars (Braithwaite, 2005). The variety Q124 was the most widely planted in Queensland, occupying 45% of the total area, and it became susceptible to the disease. The orange rust epidemic was, in economic terms, the most important disease epidemic in the history of the Australian sugarcane industry (Braithwaite, 2005).

Pre-2007, orange rust was found only in countries such as Papua New Guinea, Indonesia, Philippines and Australia (south east Asia, Oceania areas) (Magarey *et al.*, 2005). In June 2007, the disease was detected in Palm Beach County, Florida, USA, on the varieties CP80-1743 and CP72-2086 (Comstock *et al.*, 2008) and this constituted the first report of the disease in the western Hemisphere. The variety CP72-2086 is the most important in Guatemala.

Orange rust was detected for the first time in Guatemala on September 7, 2007 (Ovalle *et al.*, 2008) in a commercial field of the variety CP72-2086. This variety occupied 66% of the total area (210 000 ha) during the 2006–2007 harvest season.

As a first step to confirm the diagnosis, infected leaf samples were sent to the USDA-APHIS Systematic Mycology and Microbiology Laboratory in Beltsville, Maryland, for molecular and morphological examination.

The rust pathogen was confirmed as *P. kuehnii* in November 2007. The potential impact of orange rust on Guatemalan sugarcane crops was unknown at this time.

The purpose of this research was to determine the effect of orange rust on sugar yield in six commercial varieties that had shown disease symptoms.

## Materials and methods

### Tested varieties

The varieties evaluated were: CP72-2086, SP79-2233, CP88-1508, PR75-2002, CG96-135 and CP89-2143. The first four are major varieties in Guatemala and the last two are minor commercial varieties.

### Planting and handling in the field

The experimental design of the field trial was a split plot in a complete randomised block design. The main plot was the variety and the sub plot was either treated or untreated with fungicide (Alto<sup>®</sup> 10 SL fungicide (Cyproconazole) used at a dosage of 500 mL per ha (Staier *et al.*, 2003)). Applications began when the crop was two months of age, when pustules were first observed, and continued at 10 day intervals (nine applications) concluding when the crop was five months of age.

Small plots were five rows, 10 metres long and 1.5 m apart. The variety SP79-2233 (the most susceptible at the time) was planted in inoculum spreader rows, adjacent to each main plot and around the whole trial site. Crops was fertilised at recommended commercial rates (40.8, 60.9, 0.0 kg/ha NPK)

### Disease severity with time

Orange rust disease severity was recorded at monthly intervals, from three to nine months crop age. Severity assessments were made on the top third of the seventh fully expanded leaf. One rating for each of the three central rows from each small plot (three leaves per plot), and one rating from each of the inoculum spreader rows were taken.

Each rating was identified by row to be able to match specific yield of each row with disease severity in that row (18 values for each variety). This enabled yield losses to be correlated with disease severity.

### Harvest

The varieties were harvested at eleven months crop age (February, 2009) independent of optimum variety maturity and without ripener application.

Rows from each plot were harvested and weighed individually to estimate cane yield. Eighteen yield measurements were obtained for each variety (3 rows, 3 reps, treated / untreated) and were analysed using regression techniques.

At harvest five stalk samples from each small plot were analysed for sucrose concentration (Pol % cane).

### Measured variables

The measured variables were cane weight per row to estimate cane yield in tonnes per hectare (TCH) and sugar concentration (Pol % cane) to estimate the derived parameter sugar yield in tonnes of sugar per hectare (TSH).

Cane yield components (stalk length, stalk diameter and stalk number/metre) were also recorded.

### Data analysis

Analysis of variance was undertaken for TCH, Pol % cane, TSH, stalk length, stalk diameter and stalk population. For TCH, TSH, Pol % cane and cane yield components, “t” tests were undertaken to compare treatment x variety effects (CP72-2086, CG96-135 and SP79-2233).

### Results and discussion

Figure 1 shows the severity of orange rust in inoculum spreader rows during crop growth. Relatively high disease severity occurred during the whole evaluation period. This suggests there was a high infection pressure on the test varieties within the trial.

The data suggest 25 percent leaf area was the maximum average severity observed from five to eight months age; however, in individual rows, up to 40 percent leaf area affected was recorded.

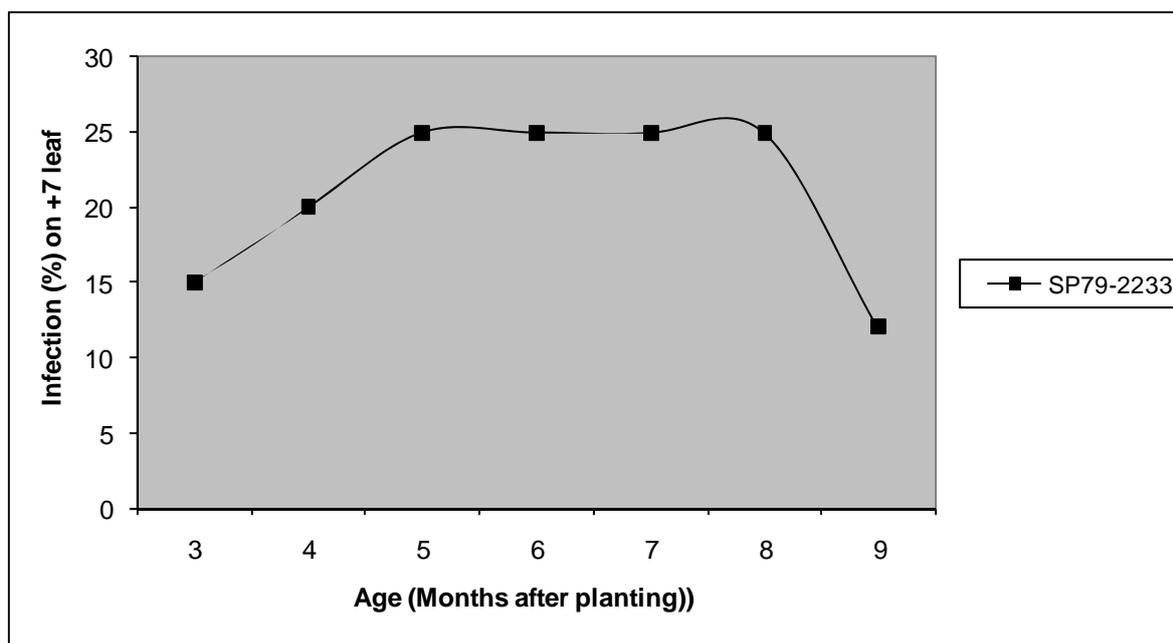


Fig. 1—Severity of orange rust in spreader rows of the variety SP79-2233.

Despite the high infection pressure, fungicide application maintained lower disease severity (near zero) compared with plots without fungicide. When fungicide applications ceased (after five months crop age) disease levels rose in formerly treated plots (Figure 2).

The increase in rust severity in the fungicide treated plot may have reduced the differences between the two treatments.

The percent leaf area infected in these test appears to be less than occurred in the Australian epidemic where up to 70% of the third fully expanded leaf was affected (Magarey *et al.*, 2001). Magarey *et al.* (2003) mentioned losses as high as 40% in central Queensland in the 2000 crop.

The authors suggest that the variation could be related to local weather and agronomic conditions at the sites and the same could be occurring with the Guatemalan test. Besides, differences in variety resistance should be considered.

Orange rust affected biomass (TCH) production in five out of six tested varieties, based on the difference in cane yield in plots with and without fungicide application (Table 1). However, the analysis of variance did not show significant treatment differences (Table 2).

The biggest effect of orange rust was in the variety CG96-135 with average losses of 18.09 TCH (12.25%). CG 96-135 had the largest variance value and, therefore, the biggest experimental data error. This variance caused no significant treatment differences in this variety.

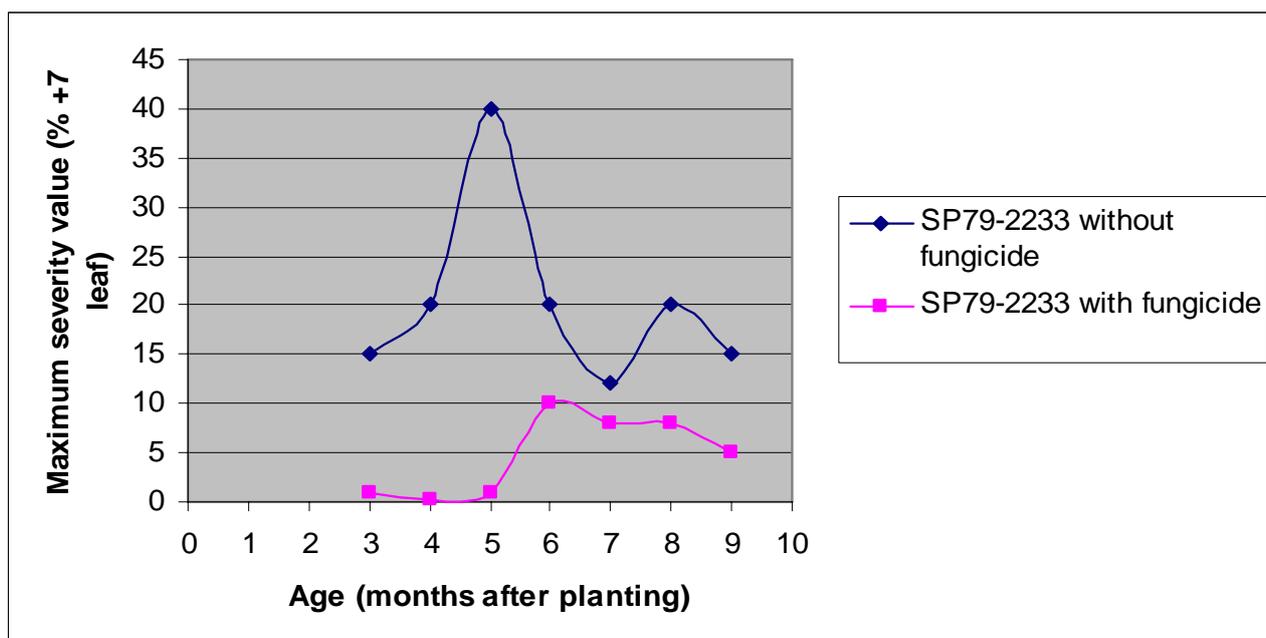
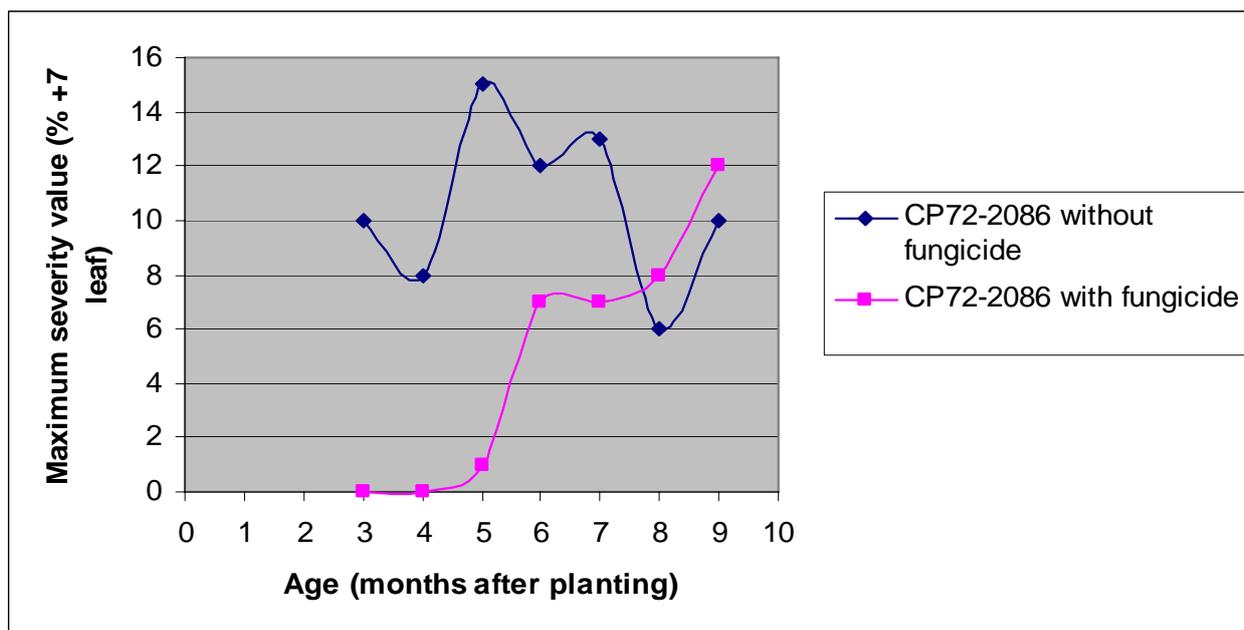


Fig. 2—Severity of orange rust infection without and with fungicide application in the varieties CP72-2086 and SP79-2233.

The variety CP72-2086 showed a 7.67% decrease in cane yield (significant using a “t” test). Biomass differences for the rest of the varieties were not significant.

The smallest effect was seen with CP88-1508 where yield differences were 0.07 tonnes (0.05% of losses). PR75-2002 did not show a decrease in tonnage despite a higher orange rust incidence than CP89-2143 (Figures 3 and 5).

Average TCH in fungicide vs. non-treated plots was 140.78 and 136.52. Average losses associated with orange rust were 3.02%.

**Table 1**—Orange rust effect in tonnes of cane per hectare (TCH) on six commercial varieties in plant cane crop. Harvest season 2008–2009. Amazonas farm, Santa Ana Mill, Guatemala.

	Cane yield (TCH)			Percentage
	With fungicide	Without fungicide	Difference	
CG96-135	147.44	129.38	-18.07	-12.25
CP72-2086	127.77	117.96	-9.80	-7.67
SP79-2233	154.63	150.06	-4.57	-2.95
CP89-2143	126.49	125.68	-0.81	-0.64
CP88-1508	126.02	125.95	-0.07	-0.05
PR75-2002	162.35	170.07	+7.72	4.76
Average	140.78	136.52	-4.26	

**Table 2**—Analysis of variance for tonnes of cane per hectare (TCH), of six varieties with and without fungicide application.

S.V.	D.F	F value	Probability	Significance
Replications	2	3.87	0.02	*
Varieties	5	28.25	0.0001	**
Rep x Var	10	0.52	0.87	N.S.
Treatments	1	1.31	0.25	N.S.

C.V.= 13.94

With five varieties there was a decrease in sugar content (Pol % cane) associated with orange rust (no fungicide application) (Table 3). The variety exhibiting the biggest decrease (8.61 percent) was CP72-2086 (significant “t” test). The exception was the variety CG96-135, which showed 12.97 percent more sugar in non-fungicide plots (also significant with the “t” test). There were no significant differences in Pol % cane for the six tested varieties.

**Table 3**—Orange rust effect on sugar concentration (Pol % cane) in six commercial varieties with and without fungicide application in the plant cane crop, 2008–2009 harvest season, Amazonas farm, Santa Ana Mill, Guatemala.

	Sugar concentration (Pol% cane)			Percentage
	With fungicide	Without fungicide	Difference	
CP72-2086	15.15	13.85	-1.30	-8.61
CP89-2143	15.46	14.45	-1.01	-6.50
CP88-1508	13.91	13.40	-0.52	-3.70
SP79-2233	14.76	14.39	-0.37	-2.51
PR75-2002	15.13	14.88	-0.25	-1.63
CG96-135	12.86	14.53	+1.67	+12.97
Average	14.55	14.25	0.30	-2.03

The effect of fungicide application on the derived tonnes sugar per hectare is shown in Figure 3. Statistical analysis showed there were significant differences (10% level) in TSH for six varieties, with yields averaging 20.5 (fungicide) and 19.5 (no fungicide). However, for individual varieties, the biggest effect of orange rust on yield was with CP72-2086, where losses of 15.78% (TSH) were associated with orange rust; smaller losses were recorded with CP89-2143 and SP79-2233. It is important to take into account that fungicide application was only to five months crop

age, due to application difficulties in older crops. Figure 2 illustrates that, beyond five months, orange rust still occurred reaching more than 10% severity in CP72-2086 in nine-month old crops. The difference in TSH in the variety CP72-2086 was statistically significant (“t” test). The variety CG96-135 showed the smallest fungicide effect as it had a higher sucrose concentration in untreated plots (Table 3); the reason for this is unknown. This particular result should be further investigated in subsequent crop harvests to confirm the effect of orange rust on Pol % cane in this variety.

It is very important to note that the results above are from a field trial planted in an environment conducive to *P. kuehni*. In addition, orange rust spreader rows were planted with the purpose of promoting rust infection. To more realistically estimate sugar losses in commercial fields of CP72-2086, orange rust severity needs to be quantified in these specific fields and related to yield losses using the regression equation of Figure 4.

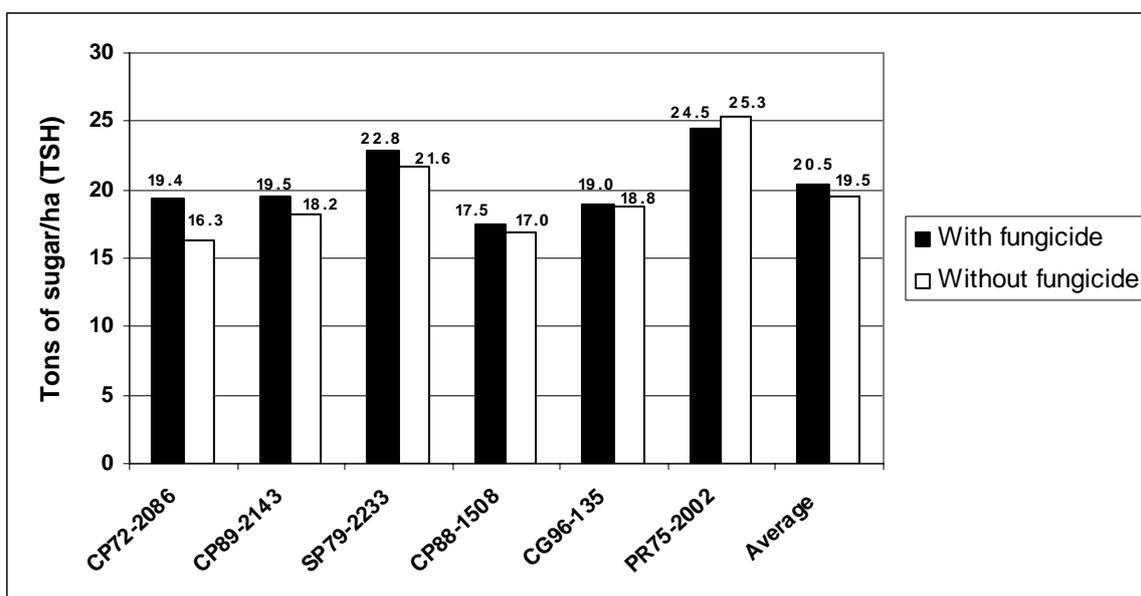


Fig. 3—The effect of orange rust on sugar yield (TSH) of sugar in six commercial varieties in the plant cane crop, 2008–2009 harvest season, Amazonas farm, Santa Ana Mill, Guatemala.

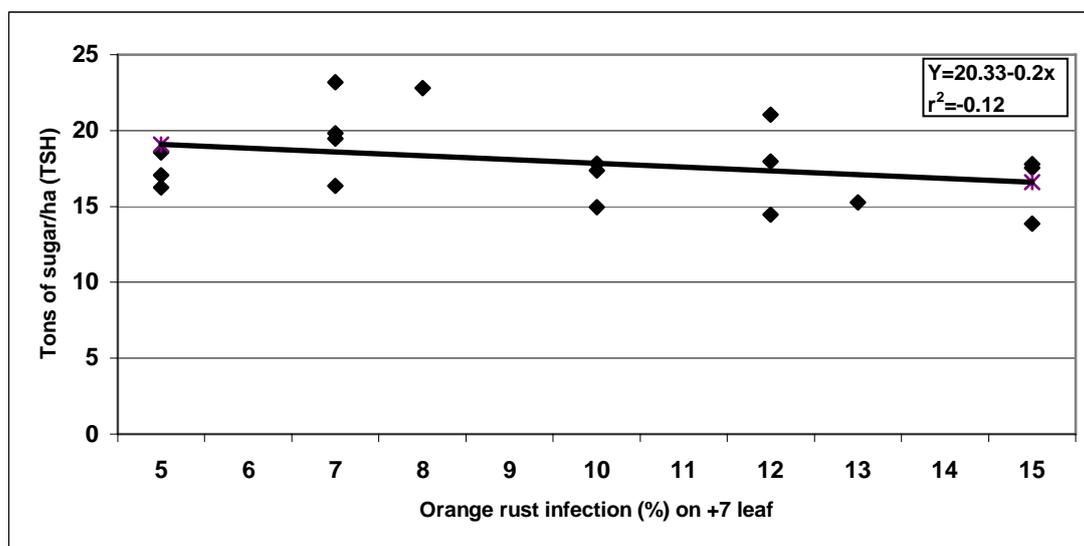


Fig. 4—Linear regression between orange rust severity and yield (TSH) in the variety CP72-2086, 2008–2009 harvest season, Amazonas farm, Santa Ana Mill, Guatemala.

Statistical analysis showed no significant differences in cane yield components (stalk population, stalk length and stalk diameter). However, for stalk population, a difference was seen with the variety SP79-2233 (data not shown).

Disease severity over time in test varieties is shown in the Figure 5. In general, the maximum severity was recorded in crops of five to six months of age; after that severity tended to decrease.

Contrary to brown rust (*P. melanocephala*), orange rust infection continued to occur up to nine months crop age.

The variety with the highest disease severity throughout the season was SP79-2233, with 26.7 percent leaf area affected (on the +7 leaf) being the maximum level recorded. CP72-2086 (12.3 percent leaf area at five months of age) had the second highest level of disease.

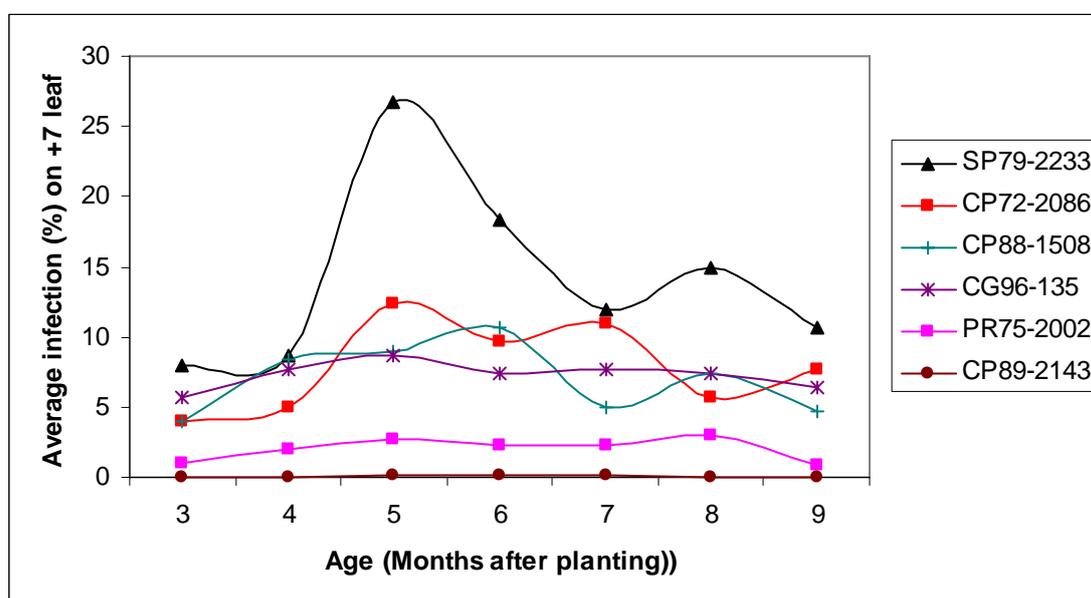


Fig. 5—Orange rust severity with time in six commercial varieties in the plant crop, 2008–2009 harvest season, Amazonas farm, Santa Ana Mill, Guatemala.

## Conclusions

- Orange rust caused significant yield losses in the variety CP72-2086, the major commercial variety in Guatemala.
- Orange rust caused non-significant yield losses in four other varieties.
- Orange rust reached its highest severity at five and six months crop age in all of the tested varieties.
- Orange rust infection occurred in mature (up to nine months) crops.

## Acknowledgements

The authors give thanks to the Field General Manager of Santa Ana Mill, Ing. Javier Fernández, to Sub Field General Manager, Ing. Juan Luis Ponce and to the Field Technicians Mr. Emilio Rosales and Mr. Abner López.

Also thanks to Ing. Ovidio Pérez and Ing. Adlai Meneses for the statistical analysis of data, both of CENGICAÑA senior staff and to Lic. Wendy de Cano and staff for the juice analysis at the CENGICAÑA'S Agronomic Laboratory.

Special thanks go to Dr. Jack Comstock, Research Plant Pathologist, USDA-ARS, Canal Point Experiment Station, for his exhaustive revision of the manuscript.

## REFERENCES

- Braithwaite, K.** (2005). Assessing the impact that pathogen variation has on the sugarcane breeding program. Final report-SRDC Project BSS258. Bureau of Sugar Experiment Stations-BSES. p. 1.
- Comstock, J.C., Sood, S.G., Glynn, N.C., Shine, Jr., J.M., Mckemy, J.M. and Castlebury, L.A.** (2008). First report of *Puccinia kuehnii*, causal agent of orange rust of sugarcane, in the United States and Western Hemisphere. *Plant Dis.*, 92: 175.
- Magarey, R. C., Croft, B. J. and Willcox, T. G.** (2001). An epidemic of orange rust on sugarcane in Australia. *Proc. Int. Soc. Sugar Cane Technol*, 24: 410–416.
- Magarey, R.C., Bull, J.I. and Nielsen, W.A.** (2003). Yield losses caused by several endemic diseases in Queensland. *Proc. Aust. Soc. Sugar Cane Technol.* 25: (CD-ROM).
- Magarey, R., Staier, T., Bull, J., Croft, B. and Willcox, T.** (2005). The Australian sugarcane orange rust epiphytotic. *Proc. Int. Soc. Sugar Cane Technol.*, 25: 648–654.
- Ovalle, W., Comstock, J.C., Glynn, N.C. and Castlebury, L.A.** (2008). First report of *Puccinia kuehnii*, causal agent of orange rust of sugarcane, in Guatemala. *Plant Dis.*, 92: 973.
- Staier, T., Magarey, R. and Willcox, T.** (2003). Control of Orange rust in sugarcane with fungicides. *Proc. Aust. Soc. Sugar Cane Technol.*, 25: (CD-ROM).

## EFFETS DE LA ROUILLE ORANGÉE (*Puccinia kuehnii*) SUR LE RENDEMENT DE SIX VARIÉTÉS DE CANNE À SUCRE AU GUATEMALA

Par

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**MOTS CLÉS:** Rouille Orangée, *Puccinia kuehnii*, Canne à Sucre, Effets sur le Rendement.

### Résumé

UN ESSAI à répétitions a été établi au champ pour estimer l'effet de la rouille orangée (causée par *Puccinia kuehnii*) sur le rendement en canne vierge de six variétés de la canne à sucre au Guatemala. La variété CP72-2086 est la variété principale au Guatemala et constituait 57% de la surface cultivée pendant la campagne 2007-08. Les autres variétés (CG96-135, SP79-2233, CP88-1508, CP89-2143 et PR75-2002) ont présenté des symptômes de la rouille orangée en septembre 2007 lors de l'apparition de la maladie. Le dispositif expérimental était un traitement à parcelles subdivisées en bloc de Fisher, le facteur principal étant la variété alors que le facteur secondaire était le traitement au fongicide (application d'Alto<sup>®</sup>, cyproconazole, à une dose de 500 mLha<sup>-1</sup>) ou la parcelle non-traitée. La variété sensible SP79-2233 était plantée aux deux côtés de l'essai de même qu'autour de chaque parcelle comme source d'infection naturelle de *P. kuehnii*. La sévérité de la rouille orangée dans les parcelles traitées et non-traitées était évaluée tous les mois du troisième au neuvième mois du stade de pousse. La hauteur, le diamètre et la population de la tige de même que le poids de canne par parcelle étaient utilisés pour estimer le rendement à l'hectare (TCH). La concentration de saccharose (Pol % cane) était aussi recueillie à la récolte. Les pertes en rendement étaient estimées en adoptant une régression de sévérité de la rouille orangée en fonction du rendement (tonnes sucre à l'hectare, TSH) pour la variété CP72-2086. Les données indiquent

que la rouille orangée pourrait occasionner une chute de saccharose dans cinq des six variétés. Les pertes dans la CP72-2086 étaient de 7.67% (TCH), 8.61% (Pol % C) et 15.78% (TSH), avec une équation de régression de  $y = 20.3 - 0.2x$ . La sévérité la plus élevée de la rouille orangée se situait entre cinq à six mois du stade de pousse dans toutes les variétés et les symptômes pouvaient être observés jusqu'à la maturité de la plante.

## EFFECTO DE LA ROYA NARANJA (*Puccinia kuehnii*) EN EL RENDIMIENTO DE AZÚCAR EN SEIS VARIEDADES DE CAÑA DE AZÚCAR EN GUATEMALA

Por

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**PALABRAS CLAVE:** Roya Naranja, *Puccinia kuehnii*,  
Caña de Azúcar, Efecto en la Producción.

### Resumen

SE EFECTUÓ un experimento de campo para estimar el efecto de la roya naranja (causada por *Puccinia kuehnii*) sobre el rendimiento de azúcar en seis variedades en caña planta en Guatemala. La variedad CP72-2086 es la más importante en Guatemala y ocupó el 57% del área sembrada en la zafra 2007-08. Las otras variedades evaluadas (CG96-135, SP79-2233, CP88-1508, CP89-2143 y PR75-2002) son variedades comerciales que mostraron síntomas de roya naranja en septiembre de 2007 cuando la enfermedad se presentó en Guatemala. En el experimento de campo se utilizó un diseño experimental en Bloques completos al azar con arreglo en parcelas divididas, en donde la parcela grande fue variedad y la sub parcela fue tratamiento con fungicida (aplicaciones del fungicida Alto<sup>®</sup> (Cyproconazole) en dosis de 500 ml por hectárea) y sin aplicaciones. En cada lado del experimento y alrededor de las parcelas individuales se sembró la variedad susceptible SP79-2233 como fuente de inóculo natural de *P. kuehnii*. Se registró mensualmente la severidad de la roya naranja en las parcelas con y sin tratamiento con fungicida desde los tres hasta los nueve meses de edad del cultivo. Se utilizó los componentes de rendimiento de caña (altura de planta, diámetro de tallos y población) y el peso de caña por parcela para estimar el rendimiento de caña por hectárea (TCH), también se evaluó la concentración de azúcar (Pol % caña) al momento de la cosecha. Las pérdidas en rendimiento de azúcar se estimaron haciendo análisis de regresión entre severidad de roya naranja y rendimiento (toneladas de azúcar por hectárea, TAH) para la variedad CP72-2086. La información sugiere que la roya naranja puede reducir los rendimientos de azúcar en cinco de las seis variedades evaluadas. Las pérdidas en la variedad CP72-2086 fueron 7.67% (TCH), 8.61% (Pol % caña) y 15.78% (TAH), y la ecuación de regresión es  $y = 20.3 - 0.2x$ . La severidad mayor de roya naranja ocurrió entre cinco y seis meses de edad del cultivo en todas las variedades y se observaron síntomas de la enfermedad hasta la madurez de la planta.