SHORT, NON-REFEREED PAPER

LOCATION AND SEASONAL EFFECTS ON GENOTYPE SMUT (*SPORISORIUM SCITAMINEUM)* INFECTION LEVELS AMONG IRRIGATED SUGARCANE BREEDING TRIALS IN SOUTH AFRICA

ZHOU MM[1,2,3]

[1]South African Sugarcane Research Institute, P/Bag X02, Mt Edgecombe, 4300, South Africa
[2]School of Agriculture, Earth and Environmental Sciences, UKZN, Pietermaritzburg, South Africa
[3]Department of Plant Sciences, University of the Free State, Bloemfontein, South Africa

Marvellous.Zhou@sugar.org.za

Abstract

Smut (*Sporisorium scitamineum*, formerly *Ustilago scitaminea*) is one of the main diseases of sugarcane in Southern Africa and causes yield losses of 0.25 to 0.75% for every 1% infested stools. Breeding resistant cultivars is part of integrated smut disease management. The objective of this study was to determine the effects of location and season on genotype smut infection among irrigated breeding trials. Data for smut infected stools and smut whips collected from early and late season trials at Pongola and Mpumalanga research stations were analysed using linear mixed models. There were significant (P<0.001) location, season, location by season interaction, genotype, genotype by location, genotype by season and genotype by location by season interaction effects for infected stools and whips. Broad sense heritability in late season averaged 0.89 compared with 0.61 in early season, while that for Mpumalanga (0.79) was higher than for Pongola (0.69) indicating higher selection efficiency in late season Mpumalanga trials. Genotypes had significantly (P<0.001) higher infected stools and whips at Mpumalanga than in Pongola and in late rather than early season trials. Mpumalanga late season trials had significantly (P<0.001) higher infected stools and whips than Pongola late season trials, suggesting a need to establish late season screening trials in Mpumalanga. Genotype 09F2517 with no whips in Pongola had six whips in early trials and 25 whips in late trials in Mpumalanga, while 10F2307 with two whips in Pongola had 77 whips in Mpumalanga. Establishing smut-screening trials in Mpumalanga would increase screening efficiency and validate Pongola smut ratings.

Keywords: Smut resistance breeding, early and late season, infected stools, smut whips

Introduction

Smut fungus (*Sporisorium scitamea)* disease, also known as sugarcane smut, causes yield losses and reduction in cane quality (Ferreira and Comstock, 1989). Sugarcane smut was first reported in commercial crops in South Africa in 1877 (Bailey, 1977) and was later reported in other parts of Africa and Asia. To date, smut has been reported in several sugarcane producing countries (Presley, 1978). Smut is the main disease of sugarcane in Zimbabwe (James, 1973), South Africa (Bailey, 1977), Malawi (Isyagi and Khembo, 2009), Zambia and other sugarcane growing regions in Africa. In South Africa, there are higher levels of smut infection in commercial crops in the irrigated regions.

Smut is controlled by rouging infected tillers, planting smut free seed cane, dipping seed cane sets in a fungicide during planting and planting resistant cultivars. Breeding for smut resistance is a major objective of the South African sugarcane breeding programmes. The objectives of this study were to determine the influence of locations and seasons on genotypes infection levels among irrigated breeding trials and evaluate implications on breeding for resistance.

Materials and Methods

Experiment design and data collection

Data were collected from two series of variety trials planted in 2014 and 2015 at Pongola and Mpumalanga research stations in the early and late seasons. The early season trials were planted from February to March, while late season trials were planted in October to November. A 5x5 lattice block design with five to six replications was used for all trials. During smut inspection the number of infected stools and number of whips per plot was recorded.

Data analysis

Data were analysed using the mixed procedure of the Statistical Analysis System (SAS Institute, 2014) using the linear mixed model,

$$Y_{ijkl} = \mu + L_i + S_j + LS_{ij} + R(LS)_{ijk} + G_l + GL_{il} + GS_{jl} + GLS_{ijl} + E_{ijkl} \quad \text{........Equation 1}$$

where Y_{ijkl} is the number of smut infected or number of smut whips in the lth genotype planted in the kth replication ith location in the jth season, μ is the overall mean, L_i is the fixed effect of the ith locations, S_j is the fixed effect of the jth season, LS_{ij} is the fixed interaction effect of ith location by the jth season, $R(LS)_{ijk}$ is the random effect of the kth replication nested within the interaction effect of the ith location by the jth season and was the experimental error for the location, season and location by season fixed effects, G_l is the fixed effect of the lth genotype effect, GL_{il} is the fixed effect of the interaction of the lth genotype by the ith location, GS_{jl} is the fixed effect of the interaction of the lth genotype by the jth season, GLS_{ijl} is the fixed effect of the interaction of the lth genotype by the ith location by the jth season, E_{ijkl} was the residual error.

Results and Discussion

There were highly significant ($P<0.001$) location effect (L), season effect (S), location by season interaction effects (LS), genotype effect (G), genotype by location interaction effect (GL), genotype by season interaction effect (GS) and genotype by location by season interaction effect (GLS) for number of infected stools and smut whips per plot for the 2014 and 2015 series of plant breeding trials (Table 1). Consistently higher levels of infected stools and smut whips were recorded in Mpumalanga (because its hotter and drier) than Pongola trials (Table 2) highlighting importance of testing genotypes for smut in Mpumalanga (Table 2). Late season trials had consistently higher smut infection than early season, justifying the current smut screening trials panting in the late season (McFarlane and McFarlane, 2002). The LS means showed higher smut infection in Mpumalanga late than Pongola late and Mpumalanga early than Pongola early trials.

The highly significant ($P<0.0001$) G F-values showed strong genetic control for smut infection suggesting high genetic gains can be attained through breeding. The G F-values for infested stools were higher than those for smut whips in both series suggesting that infected stools was a better predictor of genotype differences than smut whips. The significant GL F-values indicated potential differences in reaction to smut infection of genotypes in Mpumalanga and Pongola. Genotype 09F2517 with no whips in Pongola had six whips in early trials and 25 whips in late trials in Mpumalanga while 10F2307 with two whips in Pongola had 77 whips in Mpumalanga indicating strong location effects on smut infection. Establishing smut-screening trials in Mpumalanga would increase screening efficiency for resistance breeding and validate Pongola smut ratings.

The GS F-values were larger than those for GL, suggesting that screening breeding populations in late season was more important than screening at specific locations. There were higher F-values for infected stools than whips, suggesting that infected stools was a better predictor of genotype reaction to smut than smut whips. The R^2 values for infested stools (0.82, 0.76) were higher than for whips (0.79, 0.64). The coefficient of variation (CV) % for infested stools (204.2%, 171.7%) was lower than for whips (247.2%, 250.6%) indicating higher variability with whips data.

Table 1. Location (L) and seasonal (S) effects on genotype (G) smut infection.

	Smut infected stools				Smut whips			
	Series 2014		Series 2015		Series 2014		Series 2015	
Effect	F Value	Pr > F	F Value	Pr > F	F Value	Pr > F	F Value	Pr > F
L	25.16	0.0001	24.77	<.0001	20.26	0.0003	14.00	0.0014
S	20.44	0.0003	124.25	<.0001	29.57	<.0001	62.44	<.0001
L*S	13.78	0.0017	45.77	<.0001	9.77	0.0061	19.57	0.0003
G	28.86	<.0001	25.49	<.0001	26.79	<.0001	14.33	<.0001
L*G	17.50	<.0001	6.25	<.0001	8.43	<.0001	3.62	<.0001
S*G	18.78	<.0001	18.78	<.0001	19.71	<.0001	10.27	<.0001
L*S*G	11.15	<.0001	6.48	<.0001	4.67	<.0001	3.47	<.0001
R^2	0.82		0.76		0.79		0.64	
CV%	204.2		171.7		247.2		250.6	

Table 2: Least Square means for infested stools (Stools) and smut whips (whips) in Mpumalanga (MP) and Pongola (NPG) plant breeding trials. S.E. = standard error.

		Series 2014		Series 2015		Series 2014		Series 2015	
Location	Season	Stools	S.E.	Stools	S.E.	Whips	S.E.	Whips	S.E.
MP		1.05	0.12	1.90	0.14	2.71	0.31	6.35	0.66
NPG		0.16	0.13	0.95	0.13	0.69	0.33	2.95	0.63
	Early	0.20	0.12	0.36	0.13	0.48	0.31	1.06	0.63
	Late	1.01	0.13	2.48	0.14	2.92	0.33	8.24	0.66
MP	Early	0.32	0.17	0.19	0.19	0.79	0.42	0.75	0.89
MP	Late	1.78	0.18	3.60	0.20	4.64	0.46	11.95	0.97
NPG	Early	0.09	0.18	0.53	0.19	0.17	0.46	1.37	0.89
NPG	Late	0.23	0.18	1.37	0.19	1.21	0.46	4.53	0.89

Conclusions

The higher smut infection in Mpumalanga than Pongola as well as late season compared to early season trials suggest screening trials must be planted in late season while an additional screening trial in Mpumalanga, where higher levels of smut infection prevails, can be used to validate Pongola results. Infected stools was a better parameter than smut whips with better prediction of genotype reaction to smut as well as less variable data. Strong genetic control for smut infection exists suggesting higher genetic gains for smut resistance can be attained through breeding.

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