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Full Length Research Paper

Suitability of Van der Planks 'r' the rate of Increase of an Epidemic in Estimating the Rate of Whip elongation in Sugarcane Genotypes and Smut Isolates

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Field studies were conducted at the Sugarcane Research Center at Guneid, (latitude 15^0N, longitude 33^0E), for two consecutive seasons 2008/09 and 2009/10. The objectives were to determine the rate of smut whip elongation, thickness, and length in some selected sugarcane genotypes. No significant differences were detected for whip thickness in the different smut isolates and sugarcane genotypes, however, significant differences (P=0.05) were found for whip length in the different sugarcane genotypes. The mean logarithmic rate 'r' of smut whip elongation was 0.07 cm day^{-1} for all the tested varieties. However, in the individual varieties it is between 0.05 and 0.09 cm day^{-1}. The rate of smut whip elongation was found to be unrelated to the resistance/ and or susceptibility ratings of the individual sugarcane genotypes.

Keywords: Smut isolates, epidemic, elongation rate; sori; thickness; *Ustilago scitaminea*;

INTRODUCTION

Sugarcane smut disease is incited by the dimorphic basidiomycete fungus *Ustilago scitaminea* Syd. (Ustilaginomycetes, Ustilaginales). Following its discovery in South Africa in 1897 (McMartin, 1945; Antoine, 1961) it has been spreading steadily throughout the world and, it now occurs in all sugarcane producing countries except for a few islands in Polynesia, Fiji islands and Papua New Guinea (Steiner et al.,1975). The disease has now become endemic in the Sudan since its first record in the 1960s (Abu Gideiri, 1965; Nasr and Ahmed, 1974). Characteristic field symptoms of culmicolous smut include the formation of a long, sometimes curved terminal sorus that is whip-like, in which millions of diploid, airborne teliospores are produced. The disease is known to affect both qualitative (mill loss) and quantitative (field loss) yield components, the severity of which depend on the climatic conditions age and variety of cane grown (Akalach and Touil, 1996; Croft et al., 2000; Solomon et al., 2000).

MATERIALS AND METHODS

A series of experiments were conducted at the Sugarcane Research Center at Guneid (latitude 15^0N, longitude 33^0E), over two seasons from 2008/09 to 2009/10. The climate of the area is semi-arid with mean annual rainfall of about 120 mm. The soils are classified as vertisols with heavy clay content of about 60% and low nitrogen and available P (Blokhuis, 1962; Abu Gideiri, 1965).

Collection and maintenance of *U. scitaminea* Guneid isolates

Single typical sugarcane smut whips were collected from sugarcane varieties NCO 376 (GN1); CO 527 (GN2); and CO 6806 (GN3) from Hegelig Minor, field No.12 at Guneid. The three isolates were maintained separately

each on either cane variety CO 527 or NCO 376. Smut whips were harvested periodically, sun dried for 48 hr and smut teliospores were extracted using a 200 mm diameter 106 gauge mesh laboratory sieves mounted on an Endecotts sieve shaker model EFL 2000. The teliospores were then maintained in sealed polythene bags in the laboratory prior to use in the artificial inoculation trials. Smut isolates from Sennar Sugar Estate with isolate codes (SN), New Halfa Sugar Estate (NH) and Abbasiya (AB) representing Assalaya Sugar Estate were collected, and processed, as above prior to use.

Seedbed preparation, preparation of sugarcane differentials and planting

For all field experiments, the land was prepared according to the standard practice; by a heavy disc plough, then harrowed, leveled and ridged. About 60 single-node cuttings were prepared from 8-10 month old healthy field grown cane from each of 10 sugarcane varieties namely, B 70531, B 79136, BJ 7451, BJ 7938, BJ 83125, BT 74209, COC 671, DB 75159, TUC 75-3, CO 527, CO 997$^{\alpha}$, CO 6806$^{\alpha}$, BJ 83125$^{\alpha}$, BJ 84111$^{\alpha}$, BT 83339$^{\alpha\alpha}$, BBZ 95681$^{\alpha\alpha}$, F 154$^{\alpha}$, B 97263$^{\alpha}$, ROC 10$^{\alpha\alpha}$, FR 9682$^{\alpha\alpha}$, KN 93-14$^{\alpha\alpha}$, N 52/219$^{\lambda}$, NCO 310$^{\lambda\lambda}$, NCO 376$^{\lambda\lambda}$, and R 570$^{\lambda}$. Varieties marked (α) have HR (highly resistant) reaction types; ($\alpha\alpha$) have S or HS (susceptible or highly susceptible) reaction types under Sudan conditions (Marchelo *et al*., 2008); and ($^{\lambda}$) have HR reaction types; ($^{\lambda\lambda}$) have MS (moderately susceptible), S or HS reaction types in China, Taiwan and South Africa (Antoine, 1961; Leu and Tang, 1972; Xu and Chen, 2000). The planting materials were given a long hot water treatment (HWT) at 50^{0}C for 2 hr before being artificially inoculated separately with each of the six smut isolates GN1, GN2, GN3, SN, NH and AB by the standard dip method (DM) and planted in the field. The spacing between ridges was 1.5 m. Plot size was 1 row of 5 meter length. 20 buds were planted in each plot as double setts and, the plots were arranged in a randomized complete block design with three replications.

Determination of the rate of smut whips elongation

Several smutted stools from ten genotypes that were randomly selected from the 25 differentials and 5 shoots with young emerging whips were selected from the smutted stools of each variety. The tips of the emerging whips were then securely cut off by secateurs at the top visible dewlap (TVD) region of the flag leaf, these whips were then tagged.

Evaluation of growth

The emerged lengths of the tagged whips were measured every 2-3 days until a constant length was obtained, the rate of whip elongation per day in centimeters were then deduced from the equation for the assessment of an epidemic Van der Plank (1963).

$X = X_0 e^{rt}$: …..…….…….. (i)

Where: X= proportion of disease at any one time.

X_0= the amount of initial inoculums

r = average infection rate per day

t = time during which infection has occurred.

And by rearrangement**:** $r = 2.30259 / (t_2 - t_1) \log_{10} (X_2 / X_1)$: ……(ii)

Whereby, the average infection rate (r) in this equation was taken as the average rate of whip elongation in cm per day in the tested varieties.

Determination of whip girth and length in some sugarcane genotypes

Three or four 10-15 fully grown whip samples were collected from each sugarcane genotype under evaluation. The girth (cm) and length (cm) of whips were measured individually and data obtained were subjected to analysis of variance and DMRT was used to locate differences between treatment means.

RESULTS AND DISCUSSION

Determination of the rate of whip elongation

Figure 1 A show that the average rate of whip elongation differed between the different varieties. Whip elongation in the different sugarcane genotypes increased steadily at different rates and attained a constant length at 15 days thereafter, no whip increase was noticed. An initial rapid increase in whip elongation was observed in the first 8-9 days thereafter, whip elongation or growth slowed down and a second phase of increase in length occurred between 10 and 15 days where a peak was reached and no further increase was observed after this period. Furthermore, in Fig. 1A we observed that the whip elongation curves in the different sugarcane genotypes were standard sigmoid curves which are typical of disease progress curves in an epidemic. Nevertheless, Figure 1 B further illustrated that, the

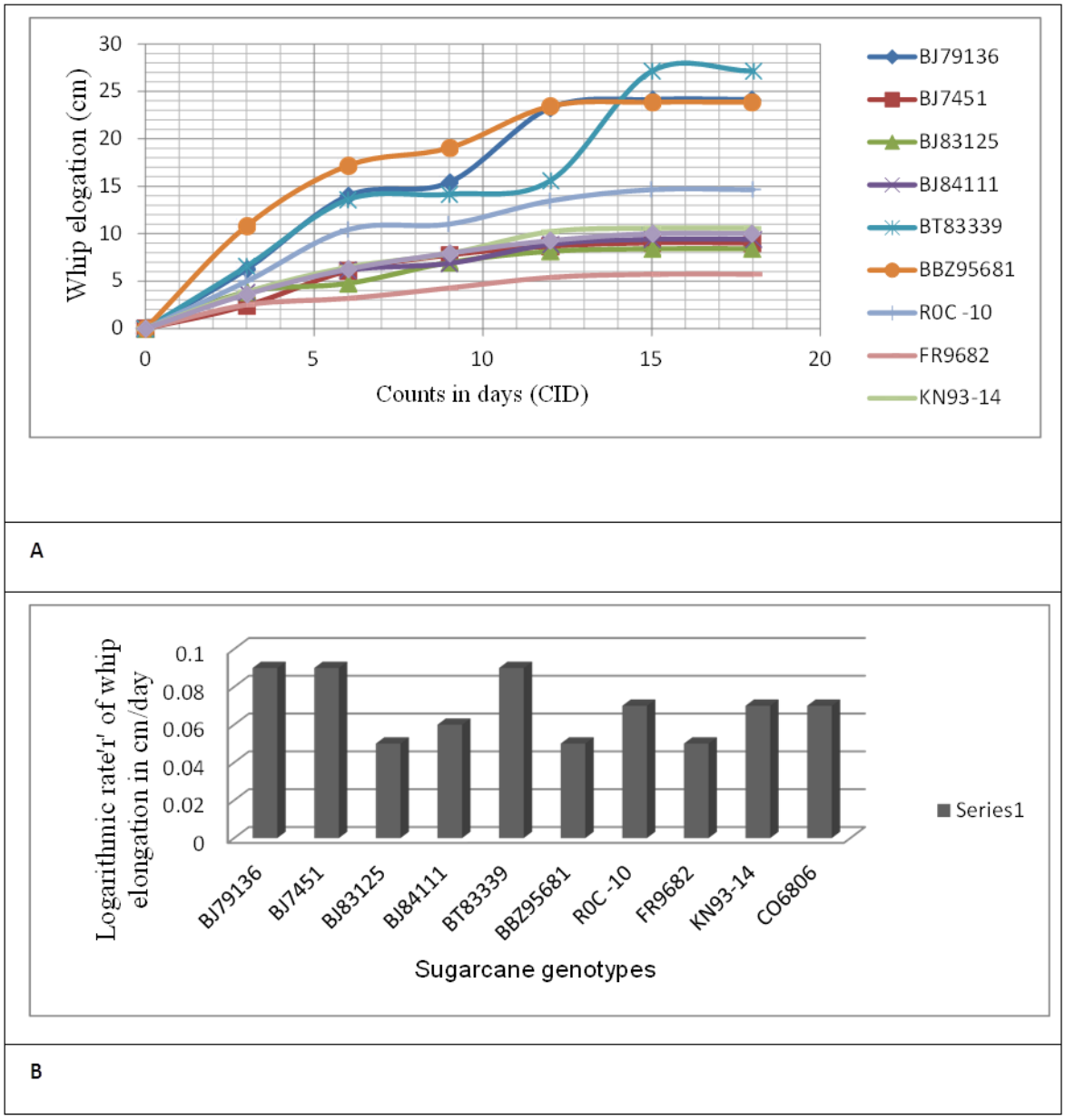

Figure 1: (**A)** The rates of whip elongation for the different sugarcane varieties in days; (**B)** the logarithmic rates (r) of whip elongation in centimeters day^{-1} for the different sugarcane varieties.

various rates of whip elongation in the tested sugarcane varieties ranged between 0.05 cm day^{-1} in varieties BJ 83125, BBZ 95681 and FR 9682 and 0.09 cm day^{-1} which were recorded in varieties B 79136, BJ 7451, and BJ 83339. The average rate of whip elongation for all varieties combined was 0.07 cm day^{-1}. A phylogenetic tree was constructed for the rates of whip elongation according to the methods of Romesburg (1984) and three clusters were obtained (Figure 2). In cluster I (within group similarity coefficient of 0.00) three varieties viz: - BJ 79136, BJ 83339 and BJ 7451 were identified. These varieties were characterized by the highest rate of whip elongation of 0.09 cm day^{-1}. Cluster II (within group similarity coefficient 0.97), four varieties (FR 9682, BBZ 95681, BJ 83125 and BJ 84111) that were characterized by the lowest rates of whip elongation of 0.05 and 0.06 cm day^{-1}were identified. Thereafter, in cluster III (within group similarity coefficient 0.00), were grouped, three

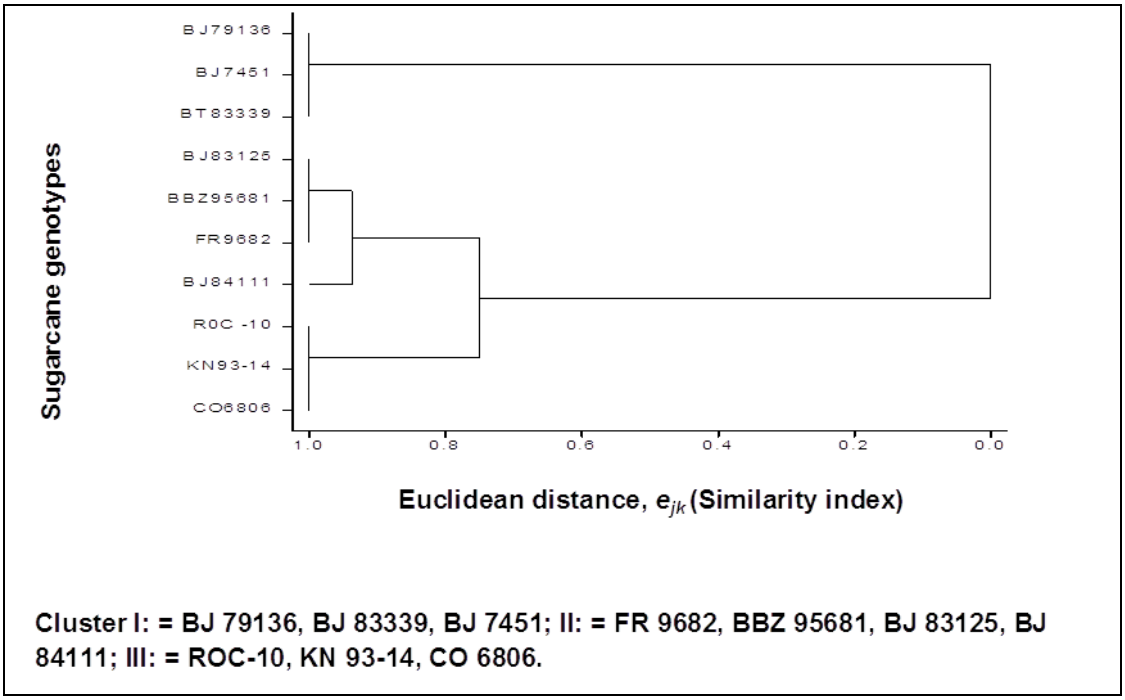

Figure 2: Complete linkage clustergram for standardized count data showing the different varieties grouped according to their rates of whip elongation in cm day^{-1}

Table 1: Combined ANOVA for whip characteristics in some selected sugarcane varieties

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Sources of variation	df	Mean square for characters	
		WL(cm)	WT (cm)
Replicates	2	570.548	0.033
Treatments	9	884.399 *	0.349 NS
Smut isolates	5	2018.551 NS	0.035 NS
Error	45	154.516	0.722

WL = Whip length (cm); **WT** = whip thickness/ girth (cm); **NS** = not significant;
***** = significant at **P** = 0.05 level.

varieties; ROC-10, KN 93-14 and CO 6806 which have intermediate rates of whip elongation of about 0.07 cm day^{-1}.

The rate of whip elongation in the highly resistant variety to smut CO6806 (HR) whip increase was found to be 0.07 cm day^{-1} and in the highly susceptible cane variety BBZ 95681 (HS) the rate of increase was 0.05 cm day^{-1} and 0.09 cm day^{-1} in another highly susceptible variety BT 83339. Thus, indicating that, the rate of whip growth is completely unrelated or weakly related to the resistance rating of the variety to smut. These relationships can be further observed in Fig. 2 where, cluster I (elongation of 0.09 cm day^{-1}) is seen to have a relatedness percentage of 0% to clusters II and III. However, these two clusters which were both characterized by low to moderate (0.05, 0.07 and 0.09 cm day^{-1}) rates of whip elongation have a relatedness percentage of about 80% to each other.

Determination of whip thickness and length in some sugarcane genotypes

Tables 1 and 2 show that whips length as a character was significant (P=0.05) in the different sugarcane genotypes selected, smut whips attained more length in the more susceptible genotypes viz: ROC-10, BBZ95681, and BT83339 compared to the more resistant varieties like CO6806. However, no differences were detected between the different genotypes and six smut isolates in whip girth. These relationships were expected because usually, in the more resistant varieties

Table 2: Whip length and girth or thickness of *Ustilago scitaminea* (Syd.) in some selected sugarcane varieties.

Sugarcane genotypes	Character means	
	WL(cm)	WT(cm)
BJ84111	48.77 ab	0.33
ROC-10	57.23 a	0.35
Kn93-14	46.04 ab	0.33
BJ7451	53.93 ab	0.39
BBZ95681	49.09 ab	0.30
B79136	43.38 ab	0.26
FR9682	47.93 ab	0.28
BJ83125	51.14 ab	0.38
BT83339	49.30 ab	0.33
CO6806	31.16 b	0.24
GM	47.79	0.31
SE (±)	07.18	0.04
CV (%)	26.0	25.1

WL= Whip length (cm); **WT**= Whip thickness (cm); Figures in a column followed by the same letter(s) are not significantly different at (**P**=0.05) according to **DMRT**.

whips are shorter compared to longer and supposedly thicker whips in more susceptible sugarcane varieties.

CONCLUSIONS

Whip length as a character showed significant differences in the different sugarcane genotypes and smut whips were generally longer in more susceptible genotypes than in resistant ones like CO6806. However, no significant differences were found between the different genotypes and the six smut isolates in whip girth. The rate of smut whip elongation differed between the different varieties and measured from the lowest rate of 0.05 cm day^{-1} to 0.09 cm day^{-1}. The mean rate of whip elongation for all varieties was 0.07 cm day^{-1}. However, the rate of whip elongation was found to be independent of the resistance rating of the variety to the smut disease and, it is therefore, a weak variety characteristic compared to resistance.

REFERENCE

Abu Gideiri TA (1965). Sugarcane experiments. Annual Report: Guneid Sugarcane Research substation, ARC, Wad Medani, Sudan.

Antoine R (1961). Smut. In: Martin JP, Abbot EV, Hughes CG, eds. Sugarcane Diseases of the World. Vol. I. Amsterdam, The Netherlands: Elsevier Publishing Co. Ltd., pp. 327-345.

Blokhuis WA (1962). Soil survey of Khasm El-Girba scheme. Annual Report, Agricultural Reseach Division, Ministry of Agriculture, Khartoum, Sudan. pp. 148

Croft B, Irawan J, Berding N (2000). Screening Australian sugarcane clones for smut reaction in Indonesia: initial results. In: Proceedings of Australian Soc. of Sugar Cane Technol. 22: 170-177.

Jones CS, Smith N, Brown RS (1979). Biology of diseases caused by Botrytis spp. In: Smith N, Brown RS, eds. Diseases of Vegetables. Oxford, UK: Blackwell Scientific Publications, pp. 40-49.

Leu LS, Teng WS (1972). Pathogenic strains of *Ustilago scitaminea* Sydow. Sugarcane Pathol. Newsl., 8: 12-13.

Marchelo PW, Obeid A, Bukhari KA (2008). Evaluation of some sugarcane genotypes (*Saccharum* spp.), for resistance to the whip smut disease of sugarcane incited by the fungus *Ustilago scitaminea* Syd. Gezira J. Agric. Sci. 6 (2): 229-242.

McMartin A (1945). Sugarcane smut: Reappearance in Natal, (South Africa). Sugar J. 29: 55-57.

Nasr I A, Ahmed MS (1974). Sugarcane smut in the Sudan. International Sugar J. 76: 67.

Nasr IA (1977). Standardization of inoculation techniques for sugarcane smut disease. Sugarcane Pathol. Newsl. 4: 12-15.

Nzioki HS, Jamoza JE, Olweny CO, Rono JK (2010). Characterization of physiologic races of sugarcane smut (*Ustilago scitaminea*) in Kenya. African J. Microbiol. Research 4 (16): 1694-1697.

Romesburg HC (1984). Cluster Analysis for Researchers. Life Learning Publications, Belmont, U.S.A. pp. 119-140.

Solomon S, Shahi HN, Gupta AP, Srivastava BL (2000). Cane Sugar: Production Management. IBD, Lucknow, India.

Steiner GW, Byther RS, Comstock JC, Heinz DJ, Ladd SL (1975). Present status of smut in Hawaii. Sugarcane Pathol. Newsl. 13: 14-26.

Vanderplank JE (1963). Plant Diseases: Epidemics and Control. Academic Press, New York, USA.

Xu LP, Chen RK (2000). Sugarcane smut breeding, and the status and prospects. Fujian Agric. J. 15 (2): 1-8.