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Reaction of backcross maize populations to *Turcicum* leaf blight

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Abstract

Five maize cultivars, Longe 1, EV8349-SR, EV Jos (moderately resistant), Gusau TZB-SR and EV8429-SR (susceptible) were crossed to Population 42, a cultivar with high level of resistance to *Exserohilum turcicum*, causal agent of turcicum leaf blight. Parental, BC_1 and BC_2 populations were inoculated at knee-high stage and evaluated for their reaction to turcicum leaf blight and yield performance at two locations of Uganda, Namulonge and Kabanyolo. EV8428-SR and KWCA were included as susceptible and local checks, respectively. Except for yield and apparent infection rates (r), differences among populations were significant ($P < 0.05$). The BC_1 and BC_2 generally had less disease than the parental cultivars, but the results were not consistent. Longel BC_1, EV8349-SR BC_2 and EV8429-SR BC_2 yielded >7,000 kg ha^{-1}, while KWCA, the recommended commercial cultivar, yielded 6618 kg ha^{-1}.

Key words: *Exserohilum turcicum*, resistant, susceptible

Introduction

Polygenic resistance to turcicum leaf blight of maize, incited by the fungus *Exserohilum turcicum* (Pass) Leonard and Suggs, is conditioned by 3-6 genes some of which produce major effects (Jenkins and Robert, 1952; Jenkins et al., 1954; Hughes and Hooker, 1971). The evidence of additive gene action is reflected in the success of recurrent selection in concentrating resistance genes for turcicum leaf blight (Jenkins et al., 1954; Ceballos et al., 1991). This is probably enhanced by the relatively high heritability of the polygenic resistance of this pathosystem (Lipps, 1982; Ceballos et al., 1991).

Jenkins and Robert (1952) transferred turcicum resistance to some maize lines through a procedure of crossing and backcrossing with suitable progeny testing. However, the same procedure diluted the resistance of other lines (Jenkins and Robert, 1952; Jenkins et al., 1954).

The Uganda National Maize Research Programme based at the Namulonge Agricultural and Animal Production Research Institute(NAARI) has also used a crossing and backcrossing procedure to develop a number of open pollinated maize populations. Because of the diverse genetic backgrounds of the parent populations, and their varied level of resistance to *E. turcicum*, these populations were thought to be useful material for studying development of northern leaf blight under Ugandan conditions. This study was therefore conducted to assess the variability in the reactions of the backcross derived populations, and to determine the level of resistance and yield performance of the backcross 1 (BC_1) and backcross 2 (BC_2) populations relative to the parents.

Materials and methods

Five open-pollinated maize cultivars, Longe 1, EV8349-SR, EV Jos (moderately resistant), Gusau TZB-SR and EV8429-SR (susceptible) were crossed to Population 42, an open pollinated cultivar with relatively high level of resistance to *E. turcicum* (Adipala et al., 1993) in 1990. From the F1S, BC_1 and BC_2 populations were subsequently developed by crossing back to the parents. For comparison a susceptible (EV8428-SR) and a local (KWCA) were included in the study.

The parents, BC_1 and BC_2 were evaluated at two locations, NAARI, and Makerere University Agricultural Research Institute, Kabanyolo(MUARIK). Both locations have high turcicum leaf blight pressure. In Namulonge, the maize were planted during the long rains only, i.e., March 18, 1991 and April 1, 1992. In Kabanyolo, the planting was on April 2 (long rains) and on September 22 (short rains) of 1992. At both locations, the maize was planted on land under a maize-soybean rotation with soybean as the previous crop, except during the second rains of 1992 at Kabanyolo where the trial was conducted on land previously under maize. The experiment followed a randomized complete block design with four replications, but because of limited seed, only three replications were used at Namulonge in 1991. In each replicate, each population consisted of three 4-m rows, planted at a spacing of 0.75 m between rows and 0.30 m within rows. Two seeds were planted per hill and thinned to one plant/hill, 2 weeks after germination.

Exserohilum turcicum inocula from single spore isolates were raised on Potato Dextrose Agar (PDA) (Difco

Laboratories, Detroit, MI, USA) and used to infest autoclaved sorghum seeds as described by Adipala et al. (1993). At growth stage (GS) 4 (approximately knee height) (Richie and Hanway, 1982) all maize plants in the middle rows were inoculated by placing approximately 30-50 infested sorghum seeds into the whorl of each plant.

Ten plants in the middle row of each plot were tagged and used for successive disease assessments. For each tagged plant, data were collected on number of lesions and percentage leaf area blighted and later averaged for a plot. The number of northern leaf blight lesions were recorded on three leaves, the ear leaf, and that above and below the ear leaf. Percentage leaf area blighted was rated on whole plant basis using a scale of 0-75% (Adipala et al., 1993). Disease ratings were made at 7-10 day intervals for a total of 5 or 6 times, from GS 7.0- 9.4.

At maturity (drying) 10 plants were harvested from each plot and grain yield ha^{-1} at 15.5% moisture determined. The plant stand at Namulonge was poor in 1992 due to damage by termites at maturity and yield data were not recorded.

Lesion number and percent leaf area blighted at various times were used to compute area under disease progress curve (AUDPC) and rates of disease increase (r) for each treatment (Campbell and Madden, 1990). As the intervals and durations of disease assessment varied, the AUDPC values were standardized by dividing the AUDPC by the number of days from the first to the last date of disease assessment.

Analysis of Variance (ANOVA) was performed to determine if differences existed between parents and their backcrosses for turcicum disease reaction and grain yield for each season and location.

Results and discussion

Reactions of BC_2, BC_1 and parent cultivars to turcicum leaf blight are presented in Tables 1 and 2. At Namulonge, final disease severity (assessed at GS 9.3) ranged from 0.5% on Population 42 to 17.1% on EV8428-SR (Table 1). At Kabanyolo mean final disease scores (at GS 9.3) ranged from 2.1% on KWCA to 26% on EV8428-SR (Table 2) and were generally higher than those at Namulonge. Adipala et al. (1993) also reported higher severities of northern leaf blight at Kabanyolo than at Namulonge. The comparatively higher turcicum disease level at Kabanyolo is attributed to the extensive cultivation of EV8429-SR, a cultivar very susceptible to turcicum leaf blight, and the generally higher rainfall and relative humidities (data not presented), conditions which favour

Table 1. Disease and yield response of maize genotypes following inoculation with *Exserohilum turcicum* at Namulonge, Uganda

	First rains 1991[a]					First rains 1992[a]				
Cultivar	Y_s[b]	Y_n[b]	AUDPC1[c]	AUDPC2[d]	Yield (kg ha^{-1})	Y_s[b]	Y_n[b]	AUDPC1[c]	AUDPC2[d]	Yield[h] (kg ha^{-1})
Longe $1BC_1$	3.7	1.7	2.7	3120	1.7	0.9	1.1	1.7	-	
Longe $1BC_1$	4.6	1.9	2.2	2.9	3960	1.0	0.4	0.7	0.9	-
Longe $1BC_2$	-[g]	-	-	-	-	0.5	0.2	0.7	0.9	-
EV8349-$SRBC_1$	5.5	2.2	2.6	3.3	3690	3.9	1.5	2.4	3.2	-
EV8349-$SRBC_2$	-	-	-	-	-	1.6	1.0	2.3	2.5	-
Gusau	10.4	3.8	4.5	5.8	2920	8.6	3.3	5.9	7.2	-
$GusauBC_1$	10.4	3.3	5.0	6.6	4020	3.6	1.8	2.7	4.7	-
$GuasuBC_2$	-	-	-	-	-	6.3	2.4	4.7	6.2	-
Ev Jos	4.2	2.1	2.2	3.9	4050	4.2	2.2	3.2	4.8	-
EV $JosBC_1$	4.9	2.3	2.8	4.4	3710	2.4	1.3	2.4	2.4	-
EV Jos BC_2	-	-	-	-	-	3.0	2.1	1.9	4.2	-
EV8429-SR	11.9	4.4	6.1	7.7	3640	5.6	2.5	3.7	6.4	-
EV8429-SRBC	13.9	4.4	7.3	7.3	4200	4.2	1.9	2.7	3.6	-
EV8429-SRBC	-	-	-	-	-	5.2	2.5	3.2	4.5	-
EV8428-Sr[e]	17.1	4.7	8.3	8.8	3990	7.7	2.8	4.5	4.9	-
Pop. 42[f]	-	-	-	-	-	0.5	0.2	0.4	0.5	-
Mean	8.3	2.9	4.9	4.0	3790	7.9	2.6	2.9	4.1	
$LSD^{0.05}$	5.8	1.3	2.7	2.9	NS	4.8	1.6	2.0	2.6	-

[a]Data for 1991 and 1992 are means of three or four replicates, respectively
[b]Percentage leaf area blighted(Y_s), and number of lesions/leaf(Y_n) at growth stage 9.3
[c]Area under disease progress curve based on percentage leaf area blighted
[d]Areaunder disease progress curve based on lesion counts
[e]Susceptible check
[f]Donor of resistance genes
[g]BC materials were being produced-see Materials and Methods
[h]Data not taken due to termite damage at maturity.

TABLE 2. Disease and yield response of 17 maize genotypes following inoculation with *Exserohilum turcicum* at Kabanyolo, Uganda in 1992[a]

	First rains					Second rains				
Cultivar	Y_s[b]	Y_n[b]	AUDPC1[c]	AUDPC2[d]	Yield (Kg ha^{-1})	Y_s[b]	Y_n[b]	AUDPC1[c]	AUDPC2[d]	Yield (Kg ha^{-1})
Longe1	8.3	2.7	2.8	4.0	4087	8.8	4.0	8.1	5.6	6742
Longe1BC$_1$	4.3	1.4	1.3	1.9	4080	4.8	2.4	5.3	3.2	7222
Longe1BC$_2$	4.8	1.6	1.5	2.2	3478	5.6	3.2	6.7	3.9	5862
EV8349-SR	4.4	1.5	1.5	2.2	4039	5.2	4.0	7.6	3.3	5507
EV8349-SRBC$_1$	5.5	1.8	1.7	2.6	4658	-[g]	-	-	3.3	6882
EV8349-SRBC$_2$	4.4	1.5	1.4	2.0	4083	5.2	2.7	-	-	-
GusauTZB-SR	12.7	4.3	4.4	6.3	4041	18.5	7.2	14.6	10.0	7276
GusauTZB-SRBC$_2$	15.5	5.2	5.4	7.7	3810	10.9	5.0	11.5	7.9	6528
EV Jos	5.3	1.8	1.7	2.5	3684	10.0	5.0	8.8	5.6	4679
EV JosBC$_1$	4.7	1.6	1.6	2.3	4287	8.2	3.9	6.6	4.7	3619
EV JosBC2	4.3	1.4	1.5	2.2	3760	5.2	2.3	5.3	3.4	4991
EV8429-SR	10.1	3.4	4.1	5.6	3518	9.3	3.6	9.1	6.7	6919
EV8429-SRBC$_1$	8.5	2.8	3.4	4.7	4010	19.7	7.5	15.1	12.4	5786
EV8429-SRBC$_2$	13.0	4.2	5.2	7.5	3619	16.9	5.9	13.4	10.3	7052
EV8428-Sr[e]	15.5	5.8	6.4	9.0	4610	26.0	9.4	16.7	13.4	5205
Pop. 42[f]	3.3	1.1	0.9	1.4	3598	3.0	1.9	3.8	1.5	5627
KWCA	-	-	-	-	-	2.1	1.1	2.9	1.6	6618
Mean	7.9	2.6	2.9	4.1	3960	10.3	4.5	9.2	6.4	6186
LSD$^{0.05}$	4.8	1.6	2.0	2.6	NS	8.7	3.1	5.9	5.3	NS

[a]Data are means of four replicates
[b]Percentage leaf area affected (Y_s) and lesions/leaf (Y_n) at growth stage 9.3
[c]Area under disease progress curve based on percentage leaf area affected
[d]Area under disease progress curve based on lesion counts
[e]Susceptible check
[f]Donor of resistance genes
[g]Not included due to lack of seed

development of northern leaf blight (Shurtleff, 1980; Hennessy et al., 1990).

At Kabanyolo, there was significantly ($P < 0.001$) more disease during the short rains (2.1-26%) than during the long rains (3.1-15.5%), but there was more rainfall during the long rains. *Exserohilum turcicum* survives in soil and maize residue (Boosalis et al., 1967; Fullerton and Fletcher, 1974). Higher disease severity during the short rains at Kabanyolo was most likely due to the inocula provided by the previous season's maize crop.

In all the seasons, differences in disease severities between populations were significant ($P < 0.05$). In addition, all populations had less disease than the susceptible check (EV8428-SR). The donor parent, Population 42, had low disease throughout the trials.

The BC$_1$ and BC$_2$ populations did not significantly perform better than the parent populations with respect to disease resistance and yield, although the magnitute of the differences between parents, BC$_1$, and BC$_2$ varied depending on the populations. Different genetic backgrounds probably accounted for the varied response among parents and their respective BC$_1$ and BC$_2$ populations. Except for EV8349-SR, all BC$_1$'s had less disease than the parents in the trials conducted during the first rains of 1992. In 1991, however, the BC$_1$'s had more disease compared to the parents. Similarly, the BC$_2$ populations had less disease relative to their respective parents except for Gusau TZB-SR and EV8429-SR at Kabanyolo. Except for EV8349-SR, BC$_1$ populations had less disease than the BC$_2$ populations. Also, though disease severity significantly varied among the maize populations, apparent infection rates (data not presented) and yield differences (Table 2) were not significant.

Jenkins and Robert (1952) and Jenkins et al. (1954) demostrated that backcrossing to susceptible parents diluted the resistance of the crosses. This implies that polygenic resistance to *E. turcicum* is not easily transferred using simple procedures such as backcrossing. Thus, procedures such as recurrent selections should be employed to concentrate resistance genes into high yielding but susceptible Uganda maize populations. Indeed, Jenkins et al. (1954), and Ceballos et al. (1991) have used recurrent selection techniques and were able to achieve considerable genetic gain, especially in the early cycles of selections.

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