Asian Journal of Plant Sciences

ISSN 1682-3974

Asian Journal of Plant Sciences 5 (4): 586-589, 2006
ISSN 1682-3974

Response to Selection in Sorghum for Resistance to Head Bug (*Eurystylus oldi* Poppius)

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Abstract: Early generation selection based on pedigree selection procedures was applied on F_2 populations of *Sorghum* to select and improve the level of resistance to *Sorghum* head bug (*E. oldi*). The base population (F_2), $F_{2:3}$, $F_{2:4}$ and 6 checks (3 resistant and 3 susceptible cultivars) were evaluated for 4 resistance traits in a randomized block design. Reduction of 178 and 407 head bugs/5 panicles for $F_{2:3}$ and $F_{2:4}$ generation was obtained which corresponded to 39.65 and 17.75% of percentage gain/generation of selection. The grain damage rating also reduces considerably. Percentage gain/generation of 57.00 and 59.76 for $F_{2:3}$ and $F_{2:4}$ for their grain yield was obtained. Significant but negative phenotypic and genotypic correlations were obtained except for 1000-grain weight, similar trend was observed for correlated response. High percent genetic gain was recorded for all the traits at both generations of selection.

Key words: *Eurystylus oldi* Poppius, resistance traits, selection, *Sorghum bicolor* L. Moench

INTRODUCTION

Eurystylus oldi Poppius (Hemiptera:Miridae) or *Sorghum* head bug is an important insect pest of *Sorghum* (*Sorghum bicolor* (L.) Moench) in Asia and Africa. In West Africa head bug have gained importance in recent years due to the introduction of elite, early flowering cultivars with compact panicles. *E. oldi* damages *Sorghum* plants by its feeding and oviposition activities on the panicles, leaves and within the plant (Gahukar, 1991; Steck *et al.*, 1989). Head bug damage spoils the grain quality by rendering the grain soft, which leads to high incidence of grain mould, thus resulting in poor seed germination and renders the grain unfit for human consumption (Sharma and Lopez, 1990; 1991) Search for resistant sources has yielded some cultivars with varying levels of resistance (Sharma *et al.*, 1994; Showemimo, 1998). Inheritance studies have revealed resistance to be recessive without maternal effect, preponderantly non-additive gene action in control, while additive gene action is also important in some cases.

A pedigree selection procedure, that utilizes quantitatively inherited traits, which are characterized by off spring (s)-desired parents resemblance (Falconer, 1981; House, 1995) was employed to measure the response of *Sorghum* resistant to *E. oldi*. Therefore, this study reports the progress obtained after two generations of the selection scheme.

MATERIALS AND METHODS

F_2 populations of crosses between 3 *E. oldi* resistant cultivars (HRhb 94001, HRhb 94002 from ICRISAT and Malisor 84-7 from IER, Mali) and 3 *E. oldi* susceptible cultivar (HRhb 94001S from IAR, Samaru, HRhb 94002S from Ghana and ICSV 112 from ICRISAT). The experiment was conducted for four cropping seasons (1995-1998) in the research field of Institute for Agricultural Research (IAR) Samaru, Zaria, Nigeria located in 11°11'N; 07°38'E at 686 m above sea level. Factorial mating system was used to produce 9 F_1 hybrids; these were selfed and advanced to F_2 populations. To achieve early generation selection and improvements, the F_2 population was considered base or source population. Ten percent selection intensity was exerted on the F_2 population due to high variability and segregation at this generation. Selection was biased towards desired resistance traits.

The F_2 seeds from each population were planted 2 to 3 weeks after infector rows were planted. Screening and selection were done by artificially infesting each *Sorghum* head at 50% flowering or half anthesis stage with 10 pairs of *E. oldi* adult using the No choice method of head cages as recommended by Sharma *et al.* (1992). The selection criteria were based on the following desired resistance traits; number of head bugs/5 panicles (counted 20 days after infestation); grain damage rating (evaluated at physiological maturity on a 1-9 scale)

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according to Sharma *et al.* (1992); 1000-grain weight (the weight of 1000-grain from the 5 randomly tagged, caged and infested panicles after threshing); grain yield (the weight of threshed grains in kg ha^{-1}). The procedure of resistant and 3 susceptible cultivars) were evaluated for desired resistance traits. The trial was arranged in randomized complete block design with three replications. screening and selection was repeated in 1996 for the F_3 populations, (thus F_2 derived lines in F_3 ($F_{2:3}$) and in 1997 for the F_2 derived lines in F_4 ($F_{2:4}$).

The base population (F_2), $F_{2:3}$, $F_{2:4}$ and six checks (The plot size was 2 rows each, 5 m long with 0.75 m and 0.25 m inter and intra row spacing, respectively to give approximately 88,888 plants per hectare. Prior to ridging and sowing, 32 kg ha^{-1} of P_2O_5 as single superphosphate fertilizer was applied as basal dressing. Split application of nitrogen fertilizer (Urea) was done: 32 kg ha^{-1} was applied as basal dressing while 30 kg ha^{-1} was applied 3 weeks after thinning as top dressing. A mixture of Gramoxone and Sorghoprim A at the rate of 300 mL/20 L of water was sprayed as pre-emergence herbicide. Weeds were controlled afterwards by hoe weeding at 3 and 6 weeks after sowing. Vetox 85 was sprayed to control stem borer.

Analysis of variance was computed for all data recorded, orthogonal comparison was made among means of entries; selection differential was used to estimate gains/generation. Phenotypic and genotypic correlation coefficient and correlated responses were computed as used by Singh and Chaudhary (1985). Genetic advance was estimated using the method proposed by Obilana and Fakorede (1981).

RESULTS

Means squares and significant levels of F-test for four *E. oldi* resistance traits are presented in Table 1. The mean squares show highly significant effect among F_2, $F_{2:3}$ and $F_{2:4}$ for all the resistance traits except 1000-grain weight among $F_{2:4}$ population. Table 2 presents the means for each of the derived lines, resistant and susceptible checks, estimated gain and percentage gain/generation for 4 desired resistance traits. There were decreases as the generation of selections progresses for number of head bugs/5 panicle and grain damage rating, while there were increases as the generation of selection progresses for 1000-grain weight and grain yield. The $F_{2:4}$ gave better result compared to the resistant check for all the traits. Gain/generation revealed a considerable loss in terms of the number of head bugs and grain damage rating ($F_{2:3}$ = -178, $F_{2:4}$= -407 and $F_{2:3}$= -0.90, $F_{2:4}$= -2.20, respectively). A gain/generation of 3.47 and 7.01 for $F_{2:3}$ and $F_{2:4}$ for 1000- grain weight, similar gain/generation of 272 and 405 for $F_{2:3}$ and $F_{2:4}$ for grain yield, respectively was obtained. The corresponding percentage gain/generation was also presented (Table 2).

Phenotypic (r_p) and genotypic (r_g) correlation coefficients (Table 3) were negative and highly significant between number of head bugs and grain yield (r_p = -0.6102 and r_g = -0.5917). Grain damage rating was also negative and highly significantly correlated with grain yield (r_p= - 0.6492) while significant at p = 0.05 at genotypic correlation. Positive and significant phenotypic correlation was obtained between 1000-grain weight and grain yield. Negative and significant phenotypic correlation was obtained between number of head bugs and grain damage rating and 1000-grain weight. The correlated response revealed negative percentage for number of head bugs and grain damage rating in association with grain yield while positive percentage was recorded for 1000-grain weight (10.71%) in Table 3.

Expected genetic gain and percentage genetic gain for all the traits in two generations of selection are presented in Table 4. Decrease in number of head bugs

Table 1: Mean squares and significance levels of F-test for four *E. oldi* resistance traits in *Sorghum*

		Mean squares			
Source of variation	df	No. of head bugs/5 panicles	Grain damage rating	1000-grain weight (g)	Grain yield (kg ha^{-1})
Replication	2	52264**	0.57	11.76	5121
Resistant parents (RP)	2	13	1.87**	17.31*	16292
Susceptible parents (SP)	2	2796	2.11**	0.41	2030
F_2 population	8	129098**	8.96**	27.14**	113671**
RP Vs F_2	1	611027**	3.12**	6.47	30178
Error	22	3497	0.10	2.61	13617
$F_{2:3}$	24	56997.50**	5.96**	41.09**	80034**
RP Vs $F_{2:3}$	1	164462.90**	6.88**	7.11	21403
Error	54	1319	0.15	5.01	5538
$F_{2:4}$	24	50013**	4.19**	32.05	73006**
RP Vs $F_{2:4}$	1	106488**	2.99**	4.00	27513
Error	54	2359	0.02	3.82	4496

*, * * = Significant at 0.05 and 0.01 probability levels, respectively

Table 2: Mean of F_2, $F_{2\cdot3}$, $F_{2\cdot4}$, resistant and susceptible checks for resistance to *E. oldi*

Type	No. of head bugs/5 panicles	Grain damage rating	1000-grain weight (g)	Grain yield (kg ha^{-1})
F_2	519.00	4.00	17.78	835.00
$F_{2\cdot3}$	341.00	3.10	21.25	1107.00
$F_{2\cdot4}$	112.00	1.80	24.79	1240.00
Res. Check	219.00	2.67	18.95	956.00
Sus. Check	927.00	6.13	13.01	731.00
Gain/generation (at $F_{2\cdot3}$)	-178.00	-0.90	3.47	272 .00
“+(At $F_{2\cdot4}$)	-407.00	-2.20	7.01	405.00
% Gain/ generation	39.65	43.66	54.45	57.00
	17.75	31.75	58.23	59.76

+Expressed as a proportion of F_2 generation

Table 3: Phenotypic and genotypic (in bracket) correlations among for *E. oldi* resistance traits and their correlated responses (CR %)

Traits	No. of head bugs/5 panicles	Grain damage rating	1000-grain weight	Grain yield
No. of head bugs/ 5 panicles	1.00			
Grain damage rating	-0.4349*	1.00		
	(-0.2133)			
1000-grain weight	-0.4431*	0.2553	1.00	
	(-0.1042)	(0.0571)		
Grain yield	-0.6102**	-0.6492**	0.4349*	1.00
	(-0.5917)**	(-0.4681)	(0.3235)	
(CR %) with grain yield	-15.92	-19.13	10.71	

, * denote significant at 0.05, 0.01 level of probability, respectively

Table 4: Expected genetic gain (ΔG) and percentage genetic gain (%ΔG) of F_2, $F_{2\cdot3}$ and $F_{2\cdot4}$ for four resistance traits of *E. oldi*

	No. of head bugs/5 panicle		Grain damage rating		1000-grain weight (g)		Grain yield (kg ha^{-1})	
Type	ΔG	ΔG+ (%)	ΔG	ΔG (%)	ΔG	ΔG (%)	ΔG (%)	ΔG
F_2	639.80	-	5.07	-	8.88	-	567.00	-
$F_{2\cdot3}$	133.90	17.31	1.47	22.48	11.60	56.64	571.00	50.18
$F_{2\cdot4}$	79.51	37.25	0.85	36.64	13.72	54.19	579.9	50.39

+ Expressed as a proportion of proceeding generating. -No percent gain over base population

and grain damage rating was recorded as the generation of selection progresses, an increase in genetic gain was recorded for 1000-grain weight and grain yield. There was an increase percentage genetic gain for all the traits in the two generation of selection except for 1000-grain weight.

DISCUSSION

The reduction in number of head bugs and damage rating, further evidenced by the gain/generation of selection and percentage gain/generation of selection, revealed that selection for head bug resistance is feasible and probably more so after two or more generation of selection. The corresponding increase in 1000-grain weight and grain yield as the generation of selection progresses attest to this fact. The large gain/generation of selection in this study suggests that the gene (s) of resistance is being fixed. According to Barry *et al.* (1983). changes in gene frequencies as the cycle of selection increases leads to gene fixation.

Phenotypic and genotypic correlation between traits in any population is important if progress is to be made in selecting superior genotypes/cultivars/lines. Grain yield was negatively but significantly correlated with all other traits except 1000-grain, this implies that selecting genotypes with higher number of head bugs and grain damage rating will lead to significant decrease in grain yield, meanwhile, grain yield will improve by selecting genotypes with lower number of head bugs and grain damage rating. The positive and significant phenotypic correlation between 1000-grain weight and grain yield shows that selecting genotypes for resistance vis-à-vis grain yield and grain weight are important. The negative and significant phenotypic correlation and negative genotypic correlation between number of head bugs and grain damage rating and 1000-grain weight mean that selection of higher number of head bugs could increase grain damage rating and lower the grain weight. This result agrees with those of Beyo (1996), Showemimo (1998) and Showemimo *et al.* (2000). Correlated response measure changes in a trait due to indirect selection on an associated trait. Therefore, this study revealed a minimum of 16 and 19% reduction in number of head bugs and grain damage thus, a meaningful improvement in resistance along with increase grain yield is achievable through selection via these traits. Approximately 11% correlated response is expected in improving resistance vis-à-vis grain yield by selecting for healthy and heavier grains.

The reduction in genetic gain of number of head bugs and grain damage rating from F_2 to $F_{2:3}$ and $F_{2:4}$ indicate that the fewer the number of head bugs the lower the grain damage rating, however, the higher the grain weight and grain yield as the generation advances, thus, the better the predictability of lines towards head bug resistance. Similar results were reported by Obilana and El-Rouby (1980) and Whan *et al.* (1982).

In conclusion, selection and response to selection for resistance to *Sorghum* head bug (*Eurystylus oldi* (Poppius)) in early generation using pedigree selection method is achievable and advantageous in term of shortening time, money and space in the development of improved resistant genotypes. The improved populations will readily serve as superior or sources of genotypes resistant to *E. oldi.*

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