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Full Length Research Paper

Correlation and heritability estimates of maize agronomic traits for yield improvement and *Striga asiatica* (L.) *Kuntze* tolerance

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A study was carried out to estimate percent heritability and correlation coefficients of desirable maize agronomic characters under artificial infestation with *Striga lutea*. Forty five F_1 hybrid maize of varied striga tolerance and their ten parents inbred were evaluated along with two check entries. This was sited in three locations representing different agro ecologies of south western Nigeria in 1999 cropping season. The results showed high and moderate heritability estimates of 94.0 and 40.0 for striga emergence count and striga syndrome rating respectively, while low heritability estimates of 13.0, 11.32, 16.0, 5.70 and 16.22% were obtained for tolerance index, days to tasseling, days silking, kernel rows/cob and grain yield respectively. Genotypic correlation coefficients of striga emergence count with maize agronomic traits were positive and significant, while phenotypic correlation between striga count and other maize agronomic traits were also positively and significantly correlated, except striga count which was negatively correlated with striga syndrome rating. On the other hand, maize ear aspect alone contributed 19.4% to grain yield, while inherent yield loss of 23.0% was estimated if striga is left uncontrolled. Parameter estimates revealed that all striga and maize agronomic traits were positively associated with grain yield except plant and ear heights under striga infestation. Although, implications of these estimates have been discussed, this study affirmed that genotypic and phenotypic correlation coefficients as well as heritability estimates were found suitable as models for yield improvement and selection for S. *lutea* tolerant genotypes.

Key words: Heritability estimates, correlation coefficient, striga tolerance rating, grain yield.

INTRODUCTION

Variance component and heritability estimates have been extensively used by plant breeders in selection of promising genotypes, and, in prediction of percentage heritability of desirable traits Fanous et al. (1977), Morakinyo (1996) and Anderson et al. (1991). These models have been used in crop yield improvement, adaptation, better nutritional quality, disease/pest resistance, as well as nitrogen use efficiency in crops. For example, Ruming et al. (1998) reported the existence of significant genetic variability for resistance to maize weevil under artificial infestation with *Sitophilus zeamaize*. When they evaluated crosses between exotic and adapted maize varieties in 1995 and 1996 for remained kernel weight (RKW), the broad-sense heritability estimate obtained for RKW was 0.27 and 0.30 in 1995 and 1996 respectively.

Similarly, Lane et al. (1995) identified three sources of resistant gene in wild relatives of pear millet to *Striga asiatica.* In all *Pennisetum setosum* and *Sorghum vericolor* were resistant to striga. From this resistance pattern, 15% of *diploperemis* population were resistant to *Striga hermonthica,* while 70% were resistant to *S. asiatica*. Verkleij et al. (1996) on the other hand carried out comparative studies on resistance of cereals and wild grasses to *S. hermonthica* and *S. asiatica*. Their result

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indicated that wild grasses had higher resistance level to *Striga* than the crop hosts. This probably suggests that their resistance gene could be transferred to the domesticated crop species.

Kaman (1996), in Kenya reported resistance of some maize varieties to infestation with *S. asiatica.* He observed that maize ear height and grain yield differed significantly among cultivars, while striga emergence count was generally low in resistant varieties but did not differ significantly. The least striga emergence count was recorded in hybrid Txi × AP4 with a mean yield of 1.8 t/ha. The use of heritability estimate was also stressed by Morakinyo (1996), especially in enhancing early generation selection of progeny when the estimate is considerably high. Obilana et al. (1981), earlier summarized procedures in heritability estimates into three, namely, regression of offspring on parent, variance component estimate, and, recurrent selection experiment. Whichever, method a breeder decides to use does not really matter, rather, the predictive ability of the estimate in selecting genotypes for advancement makes it highly relevant in selection procedure.

In the same vein, Chiang and Smith (1967) reported 62% heritability estimate on plot means basis for sorghum head length, while Lothrop et al. (1985) reported heritability estimates of 41 and 43% for 1000-seed weight in sorghum. Lukhele (1981) also used heritability estimate to predict yield component in sorghum. From these reports, they all affirmed the suitability of these estimates in prediction and selection of promising crop genotypes during crop improvement programmes.

Strictly speaking, when a breeder decides to use regression, recurrent or variance component methods in estimating heritability, mention can not, but be made of correlation and regression responses of the estimated parameters especially yield and disease/pest resistance. Perhaps the reason why many workers including Mossad and Joppa (1987) and Moli et al. (1974) reported the importance of correlation and regression analyses in selecting resistant crop species of various production stresses.

The objectives of this study, therefore, were to:

(1) Estimate percentage heritability of striga and maize agronomic parameters with a view to determining desirable genotypes.
(2) To determine percentage contribution of some maize agronomic traits to grain yield under *S. lutea* infestation.

MATERIALS AND METHODS

Twenty-four *S. hermonthica* resistant maize inbred lines were evaluated in 1995 and 1996, out of which ten *S .lutea* tolerant inbreds were selected for half-diallel crosses to generate 45 F_1 hybrids. The ten parent inbreds, 45 F_1 hybrids and two check entries were later evaluated in Temidire, Eruwa and Ilora representing three distinct agro ecologies of south western Nigeria namely: derived savanna, southern guinea savanna and forest-savanna transition ecology in 1999 cropping season. The three chosen locations were *S. asiatica* endemic areas where farmers have abandoned the plots due to high striga infestation

Land in Temidire and Eruwa locations were mechanically prepared by two regimes of ploughing, one harrowing and ridging, while Ilora location was manually prepared with hoes due to undulating soil topography. Planting hills were inoculated with 44000 germinable seeds of *S.lut*ea of previous year 14 days before planting so that striga inoculum can re condition itself to the new environment as early as possible using the methods described by Barner et al. (1997).The F_1 hybrids, their parent inbreds, and, two checks were planted on the hills to avoid possible erosion of the striga inoculums. Three maize seeds were planted on a hill and were later thinned to two, ten days after panting. Spacing of 75 × 50 cm was used so as to obtain 55,333 population densities per hectare. Low fertilizer dosage (50 kg/ha) N.P.K. 20-10-10 was applied by broadcast before ridging during land preparation to minimize the likelihood of nitrogen (N) suppressing striga emergence. Constant removal of other weeds except striga seedlings were carried out to enhance full striga emergence.

The trial was replicated thrice using a randomized complete bock design (RCBD) with infested and corresponding uninfested plots.

Data were collected on striga parameters such as plant stand, striga emergence count 10 weeks after planting, striga syndrome rating using scale 1 to 9 as described by Kim (1994) where 1 = normal plant growth with no visible symptom 9 = complete scourching of leaf causing premature death or collapse of host plant with no ear formation and striga tolerance index (yield of infested/yield of uninfested maize). Other parameters included maize plant and ear aspects using a rating of 1 to 5 (where 1 = excellent and 5 = poor), plant and ear heights (cm), days to 50% tasseling and silking, kernels/row and kernel rows/cob as well as grain yield (t/ha) under artificial and natural striga infestations.

Data were statistically analysed using SAS (SAS Institute,1992) soft ware package to compute genetic variances, phenotypic and genotypic correlations, stepwise multiple regression and heritability estimates on plot mean basis for both striga and maize agronomic parameters.

RESULTS, DISCUSSION AND CONCLUSION

The results from the heritability estimates are presented in Table1. Striga emergence count, striga rating and striga tolerant index recorded lower error variances. The magnitudes of genotypic variances were for most characters lower than those of error and genotype × location variances. Although heritability estimates of 94.0% was obtained for striga emergence count, moderate heritability estimate of 40.0% was obtained for striga ratings as against low heritability estimates of 13.0, 11.32, 16.0, 5.70 and 16.22% respectively for striga tolerance index, day to tasseling and silking, kernel rows/ear as well as grain yield (Table1). This suggests that while striga emergence count and rating were highly heritable and can be selected at early generation stage, others might not be as easy as one expects. For example, Striga syndrome rating in the present study has heritability estimate of 40%, hence can be easily selected.

Phenotypic and genotypic correlation coefficients of striga and maize agronomic characters are presented in Table 2. At the phenotypic level, striga count was negative

Table 1. Variance component and heritability estimate (on plot mean basis) of striga tolerance parameters and maize agronomic traits in *S. lutea* infested condition.

Parameter	e δ^2	δ^2gl	δ^2g	h^2b
Striga emergence count	11.21	-10.74	7.58	94.00
Striga rating	0.75	0.13	0.57	40.00
Striga tolerance index	10.3	0.15	0.15	13.00
Days to 50% tasseling	6.09	1.99	1.03	11.32
Days to 50% silking	9.18	3.10	2.37	16.00
No of kernel row/ cob	2.93	0.05	0.18	5.70
Maize grain yield	0.54	0.08	0.12	16.22

e δ^2 variance due to error, δ^2gl variance genotype × location, δ^2g variance due to genotype.

Table 2. Phenotypic and genotypic (rp and rg) correlation coefficients between striga related and maize agronomic characters, under *S.lutea* infestation.

Parameter	Striga count	Striga rating	Plant height	Ear height	Days to silking	Days to tasseling	Kernel rows/ cob	Grain yield
Striga count	-	0.91	0.30*	0.17	0.30*	0.40**	0.85**	++
Striga rating	-0.30*	-	0.36*	-0.72**	0.09	0.50**	++	++
Plant height	0.048	0.025	-	0.05	0.13	0.112	0.076	0.16
Ear height	-0.74**	0.30*	0.001	-	0.23	-0.22	-0.57**	0.23
Days to silking	0.06	0.09	0.015	0.14	-	0.74**	-0.53**	++
Days to tasseling	0.07	0.60**	0.001	0.06	-0.05	-	0.77**	++
Kernel rows/cob	-0.20	-0.34*	0.051	0.20	-0.41**	0.06	-	++
Grain yield.	-0.57**	0.33*	0.114	-0.35**	0.075	0.133	0.18	-

Upper diagonal= genotypic (rg) correlation coefficients. Lower diagonal= phenotypic (rp) correlation coefficients. *, ** Sig. at 0.005 and 0.01.++, genotypic value > 1.0.

and significantly correlated with striga rating (rp=-0.30)*, ear height (rp=-0.74*) and maize grain yield (rp=-0.57)* indicating that the two traits are probably controlled by different genes. This was similar to evidence of Kim (1994) where he affirmed that striga count and rating in *S. hermonthica* were been controlled by independent Striga syndrome rating was however positively count was positively correlated with striga genes and significantly correlated with ear height (rp = 0.31)*, days to silking (rp =0.60)* and grain yield (rp = 0.33)*. Phenotypic correlation of ear height and grain yield was however negatively significantly correlated suggesting that the two traits were not closely associated, and, therefore may not be jointly selected. Similarly, days to silking and kernel rows/cob was negative and significantly correlated (rp = -0.47)*.

Genotypic correlation coefficients shows that striga rating, plant height, days to silking, days to tasseling and kernel rows/cob with coefficients of 0.91*, 0.30*, 0.30*, 0.44** and 0.85** respectively. Striga rating on the other hand was positively correlated with plant height(rg = 0.36)* and day to tasseling (rg=0.50) ** as compared to ear height which was negative, and significantly correlated with striga rating (rg= -0.72) **. Aurelio et al. (1965)

Table 3. Stepwise multiple regression analysis of striga related parameters on maize grain yield under both infestation conditions.

Parameter	Partial R^2	Cumulative R^2	F	{Prob.>F}
Striga Infested condition				
Ear aspect	0.1914	0.1914	99.63**	0.0001
Striga count	0.0063	0.2239	3.4180*	0.005
Tolerance index	0.0031	0.2271	1.6842	0.198
Striga rating	0.0015	0.2285	0.7859	0.37
Striga Uninfested condition				
Ear aspect	0.167	0.167	84.80**	0.0001
Tolerance index	0.130	0.300	77.94**	0.0001
Striga count	0.002	0.320	1.01	0.317

Table 4. Stepwise multiple regression of maize agronomic traits on yield under *S. lutea infestation.*

Character	Partial R^2	Cumulative R^2	F	{Prob.>F}
Plant height	0.083	0.083	38.24**	0.001
Days to silking	0.017	0.100	790	6.0052
Days to tasseling	0.021	0.121	10.00**	0.0017
Striga rating	0.009	0.130	4.16*	0.042
Ear height	0.12	14.2	5.90*	0.015

similarly reported high heritability estimate for agronomic characters in sunflower. He further affirmed the possibility of its early generation selection for desirable agronomic traits. Kim (1994) therefore recommended the use of striga rating and tolerance index as the most suitable parameters for assessing the tolerance level of maize plants. Days to tasseling was positively correlated with days to silking (rg=0.74**). Days to silking on the contrary was negatively and significantly correlated with kernel rows/cob (rg = -0.53**) (Table 2). Days to tasseling was however positive and significantly correlated with kernel rows/cob (rg = 0.77**), suggesting that kernel row/cob is probably a function of maturity date. Some correlation coefficients were greater than unity as found in some traits when correlated with yield related characters.

The results of stepwise multiple regression analyses for striga related parameters are presented in Table 3. Total yield reduction caused by striga related parameters was 23.0%. Reda and Kebebe (1994) had earlier reported a negative correlation between striga count and fresh maize weight indicating an adverse effect of striga count on maize yield. Maize ear height had the highest yield contribution of 19.14%. Other parameters jointly contributed less than 4% to grain yield. This shows that while striga must be controlled on maize plots to prevent inherent yield loss of about 23%, selection in favour of good ear aspect may bring about 19.14% yield advantage. Similarly, ear aspect and tolerance index recorded yield contributions of 16.7 and 13.0% respectively, striga count and rating on the other hand slightly reduced yield by 0.2 and 0.1% under natural striga infestation. This further suggests that breeding for higher maize yield in striga endemic ecologies should focus more on selection for ear aspect.

Table 4 presents the results of stepwise multiple regression analysis of maize agronomic characters under *S. lutea* infestation. These characters jointly contributed 14.2% to maize grain yield, out of which plant height alone contributed 8.3% as compared to ear height, day to silking and tasseling and striga tolerant rating that contributed 1.2, 1.7, 2.1 and 0.9% respectively to grain yield. These contributions though very small, were statistically significant except days to silking.

Parameters estimates under both infestation conditions are presented in Table 5. These estimates determine the significant levels of association of each trait to grain yield. All striga and maize agronomic parameters were positively associated with grain yield under artificial infestation. Similarly, all maize agronomic traits were positively associated with grain yields under natural infestation. Striga related parameters on the other hand, were negatively associated with grain yield except striga rating (Table 5). This probably suggests the need to concentrate on selection for yield related characters such as higher numbers of maize rows/ear, numbers of kernel per row, ear aspect and yield in t/ha rather than selecting

Table 5. Partial R^2 and parameter estimates of striga and maize agronomic characters under both Striga infestation conditions.

Variable	Striga infested condition		Striga uninfested condition	
	Partial R^2	Parameter estimate	Partial R^2	Parameter estimate
Ear aspect	0.191**	0.414	0.16**	0.42
Striga count	0.22*	0.034	0.31**	-0.72
Tolerance index	0.22*	0.056	0.11**	NS
Striga rating	0.23**	0.0362	0.08**	0.012
Plant height	0.08*	-0.0042	0.008	-0.67
Days to silking	0.01*	0.067	0.020**	0.108
Days to tasseling	0.12*	0.060	0.032**	0.033
Kernels/row	0.13**	0.019	0.012**	0.0066
Ear height	0.14**	-0.006	0.003*	0.021
Kernel rows /cob	N.S	N.S	N.S	N.S

$p < 0.15$.

only for *S .lutea* tolerant genotypes *per se* for striga endemic areas. This study affirmed that genotypic and phenotypic correlation coefficients as well as heritability estimates were found suitable as models for yield improvement and selection for S. *lutea* tolerant genotypes.

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