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Genotype x environment interaction and selection for yield and related traits in soybean

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Abstract

Fifteen genotypes of soybeans (*Glycine max* L.Merr.) were grown in three locations of Ibadan, Abeokuta and Ogbomoso during the late planting season of 2001, 2002 and 2003. Data on yield and yield traits were subjected to combined analysis of variance. There were variations in the years of production as the relative performance of the genotypes with respect to all the traits were significant under the genotype x year (Gen. x yr) effect. However, days to maturity, number of pods per plant and number of branches per plant were significant under the genotype x location (Gen. x loc.), and the third order interaction effect of Gen. x loc. x yr. Branch number per plant gave negative but significant phenotypic correlation with number of seeds per pod and weight of seeds while its correlation with seed yield was positive in Ogbomoso and Abeokuta locations. Significant genotypic correlation were observed between number of seeds per pod with seed weight and seed yield for Ibadan and Ogbomoso locations though its correlation with seed weight in Ogbomoso location was negative. The significant genotypic correlation of days to maturity with pod number and branch number ensures that these traits would be successfully selected for in yield improvement of soybean for Abeokuta and Ogbomoso locations. Number of seeds per pod and days to maturity with high heritability estimates and significant genotypic correlations can be reliably selected for when soybean improvement is targeted for Ibadan and Ogbomoso specific locations.

Keywords: *Correlation; environment; genotype; heritability; locations; traits*

Introduction

Soybean is an important oil seed and grain legume, which constitutes a major dietary protein in humid and sub- humid tropics. The rapid expansion of the economy has compelled plant breeders to apply breeding methods that would result in large turnover of high yielding varieties of this crop species. Soybean can produce reasonably well under marginal conditions of climate and soil conditions where other crops cannot. As a consequence, any improvement on the efficiency in selection and identifying genotypes suitable to different environments and or locations would have great potential in terms of supplementing the protein and oil needs of humans especially in remote environments where animal protein is expensive.

Character variability and heritability estimates determine to a large extent the rate of genetic advance (Araujo and Coulman, 2002). The knowledge of this variation in plant improvement programme enhances successful character selection and hence effective breeding procedure. Variety selection and subsequent recommendation for release are based on data from yield and agronomic characters (Saleh *et al.* 2002; Singh, 2002). The correlations and heritability estimates of the characters reveals to a great extent the reliability in genotype selection. Genetic and phenotypic correlations arise from both linkages and environment factors that have not reached equilibrium and from pleiotropy (Simmonds, 1979) and are therefore important in crop improvement.

Seed yield of soybean was largely a function of pods per plant, seeds per pod and 100-seeds weight (Oseni, 1994) and that appropriate progress in yield improvement can be made through selection for these characters. Several investigations have shown that soybean performance can be affected by locational and seasonal differences and that days to maturity and seed weight are affected by moisture availability (Tekrony *et al.*, 1987; IITA, 1989; Ojo, 2000; Ojo and Amanze, 2001). Ojo and Amanze (2001) also reported significant genotype x year interaction in tropical soybean and that phenotypic correlation between days to maturity and number of branches per plant and grain yield was also significant. Saleh *et al.* (2002) equally observed positive and significant phenotypic correlation between grain yield and days to maturity in tropical maize hybrid. The performance of soybean varies from one environment to the other. The present study was carried out to determine the effect of G x E interaction in soybean across three locations and to estimate the effect of G x E interaction in selecting for yield and some yield traits.

Materials and Methods

Fifteen Soybean genotypes obtained from Internationl Institute of Tropical Agriculture (IITA) Ibadan, were grown in three locations of Ogbomoso (South Guinea Savanna), Abeokuta (Humid Savanna) and Ibadan (Tropical Rain Forest). The weather data for each location is presented in Table 1. The genotypes were grown in a randomized complete block design with three replications. Compound fertilizer (NPK) at the rate of 7.5 kg N/ha, 81. 5kg $P_2 0_5$/ha single phosphate and 7.5kg k/ha muriate of potash was applied to the soil. Seed sowing was by drilling into four-row plots of $4m^2$ per row to give a total of 480 plants per plot. Shortly after planting, a mixture of Galex (4 liters) and Gramozone (1 liter) in 20 liters of water was sprayed for weed control. Manual weeding was done as at when due. The trials were conducted in 2001, 2002 and 2003 late planting seasons of Ibadan, Abeokuta and Ogbomoso respectively.

Six agronomic traits including number of branch per plant, number of pods per plant, number of seeds per pod, days to 95% maturity, 100-seed weight data from two inner rows were collected in each of the locations. At harvest, (when seeds attained 15-18% moisture content), data on seed yield were collected from the inner rows and expressed in kilogrammme per hectare in each of the locations.

Data analysis

Data from yield and yield traits were subjected to analysis of variance (ANOVA) for each location, year and their interactions and combined ANOVA across locations. Variance component estimates were obtained by equating the mean square for a source of variation to its expectation and solving for the unknown. The variance estimate for each source was substituted into the following formula as by Rasmusson and Lambert (1961).

$\sigma^2_x = (\sigma^2_{gl} / L') + \sigma^2_{gy/y} + (\sigma^2 gly/ Ly) + (\sigma^2_e /rly).$

Where;

σ^2_x = variance of character x and $\sigma^2 g$, $\sigma^2 l$, $\sigma^2 y$, $\sigma^2 e$ are the variances of genotypes, location, year and error terms. Heritability estimates and phenotypic correlations were calculated according to the method of Falconer and Mackey (1996).

Result and Discussion

The mean performance of yield and related traits is presented in Table 2. Ogbomoso recorded the highest mean yield of 1060.5kg/ha, which was significantly higher than yields obtained in other locations. Also yield obtained in Abeokuta (904.7kg/ha) was higher than that of Ibadan (768.15kg/ha). The genotypes in Ogbomoso location matured earliest (93.61) and recorded highest number of branches of 6.3 with highest number of pods per plant (6.3) respectively. Whereas, Abeokuta location recorded highest number of days to maturity (110.31) with least weight of seeds (9.23) as compared to other locations. The mean performance recorded for these genotypes with respect to the traits across the locations in the years of study could be attributed to the diverse genetic background of the genotypes and the differences in the weather co-ordinates. Ibadan location recorded highest rainfall with lowest amount of sunshine (Table 1) which affected the number of flowers forming pods due to abortion associated with heavy rain drops. The resultant effect of these was reduced seed yield as evident in Ibadan location. Whereas, the minimal rainfall characterized with lesser humidity and more sunshine resulted in a more condusive environment for flowering which lead to more pod formation with higher yield as obtained in Ogbomoso location.

The performance of the genotypes was significant and varied widely as shown in the mean square values (Table 3). Genotype by year (Gen. x yr.) effect was highly significant with respect to days to maturity, number of pods per plant and number of branches per plant and significant for seed yield implying that these traits varied among genotypes due to differences in year of production. However, genotype x year interaction is not a repeatable estimate because year effect cannot be reproduced. Ariyo and Ayo-Vaughan (2000), reported year effect not to have repeatable estimate in the study of G x E interaction in Okro. This implied that these traits were affected by the diverse environmental conditions prevalent within the time of crop growth. It could be inferred that high relative humidity inactivates pollinating insects hence lesser pods being formed, which eventually resulted in inconsistent number of pods formed in each location. Even where successful pollination occurred fungal attack as a result of high humidity reduced pod number and quality (Ariyo, 1995). According to FAO (1999), high relative humidity adversely affects cowpea yield and quality. It is worthy of note that number of seeds per pod and days to maturity with 62.04% and 59.06% heritability estimates are less influenced by environment and therefore important in improving the seed yield of soybean. According to Fehr (1987), heritability is a tool in crop improvement programme used in the prediction of genetic gain expected from selection of a character. Saleh *et al.*, (2002); Morakinyo (1996), reported moderate heritability estimates for days to maturity and number of seeds per cob in tropical maize. However, trait selection with moderate heritability from 33.42 to 48.11% could be successfully achieved over many generations of inbreeding in other to accumulate the relevant genes. But the findings in this work revealed that seed yield improvement in soybean could be achieved indirectly by selecting for seed number and maturity date through mass selection.

The phenotypic correlations among six characters across the three locations are presented in Table 4. Days to maturity showed significant phenotypic correlation with all the traits in Ibadan and Ogbomoso locations. This explains that selection for these traits for soybean improvement would be a worthwhile effort only in Ogbomoso location. That number of pods per plant recorded significant phenotypic correlation with branch number in the locations indicated that as branch number increased, more pods were automatically formed. Number of seeds per pod showed significant phenotypic correlation with seed weight in Ogbomoso location only and correlated significantly with seed yield in all the locations. Also, seed weight correlated significantly too with seed yield in all the locations though its correlation with seed yield in Ibadan location was negative.

Days to maturity recorded significant genotypic correlation with number of pods per plant, number of branch per plant and seed weight in Abeokuuta and Ogbomoso locations (Table 5). Pod number per plant correlated with branch number per plant in Ogbomoso location whereas, its correlation with seed weight was significant both in Abeokuta and Ogbomoso locations. Branch number correlated with number of seeds per pod and weight of seeds in Ibadan location while its correlation with seed weight in Ogbomoso location was negative. However, its correlation with seed yield was significant in both locations of Abeokuta and Ogbomoso. Seed weight correlated significantly with seed yield in all the locations but its correlation in Ibadan location was negative. According to Ariyo (1987), traits, which are phenotypically correlated but not genotypically correlated, will not produce repeatable estimates of inter-character association and that any selection based on the relationship is likely to be unreliable. The significant phenotypic and genotypic correlations between days to maturity and all the traits in Ogbomoso location suggest that days to maturity can be used as a criterion for selecting earliness to maturity in breeding for short duration soybean for ogbomoso specific location. Branch number correlated phenotypically and genotypically with seed weight and seed yield in

Table 1: Climatological data of three locations of the study

Location /Year	Vegetation	Mean Rainfall (mm)	Mean Temp. (0^C)	Humidity (%)
Ibadan (2000)	Rain forest	1170.5	26.3	84.2
Abeokuta (2001)	Derived savanna	980.5	29.6	73.0
Ogbomoso (2003)	Guinea savanna	1051.3	30.4	61.8

Table 2: Mean performance of yield and related traits in soybean

Location	Yield (kg/ha)	Days to maturity	No of branch/plt	No of pods/plt	No of seeds /pod	100-seed weight (g).
Ibadan	768.15	101.42	3.6	8.1	4.22	11.11
Abeokuta	904.37	110.31	5.70	9.75	5.41	9.23
Ogbomoso	1060.52	93.61	6.31	10.62	3.42	10.40
Mean	910.97	101.45	5.20	9.46	4.41	10.24
C.V	13.13	6.68	10.77	10.86	22.14	7.57
S.E	69.05	3.46	3.01	5.47	0.43	0.44

Table3. Mean squares and variance components and broad sense heritability estimates for yield and related traits

Trait	Mean Square	σ^2_g	σ^2 g.xl.	Σ^2g.xyr	σ^2gxlxyr	σ^2_e	H_b
Seed Yield	21.76*	1.21*	0.82*	1.32*	1.00*	0.03	43.01
Dys to maturity	37.62*	2.09*	0.35*	2.03**	3.76**	2.48	59.06
No of pod/plant	79.52**	4.44**	0.07	0.91*	2.44**	2.18	33.42
No of branch/plt	57.56**	3.22**	1.17*	3.10**	2.11**	1.11	40.57
No of seed/pod	14.94	0.83*	0.19	0.36	0.16	0.50	62.04
100-seed wt (g)	13.73	1.33*	0.20	0.47	0.42	0.05	48.11

No = number; *, **, sig. at p = 0.05 and 0.01 levels of probability

Table 4. Phenotypic correlation coefficients among six yield related traits in soybean

Character	Location	Number of pods/Plant	Number of Branch/ Plant	Number of Seed/Pod	100-Seed Weight (g)	Seed Yield per/Plant
Days to Maturity	1	0.31*	0.28*	0.37*	0.49**	0.33*
	2	0.21	0.17	0.19	0.61**	-0.13
	3	0.79**	0.40**	0.51**	0.58**	0.64**
Number of Pods/Plant	1		0.43**	0.19	-0.36*	0.30*
	2		-0.25*	0.20	0.41**	0.42**
	3		0.85**	0.23	-0.51**	0.34*
Number of Branch/Plant	1			0.35*	0.24	0.23
	2			-0.37*	-0.31*	0.41**
	3			-0.52**	-0.51**	0.71**
Number of Seed/Pod	1				0.18	0.66**
	2				-0.21	0.41*
	3				0.37*	0.39*
100-Seed Weight	1					-0.38*
	2					0.41*
	3					0.37*

1= Ibadan (2001), 2= Abeokuta (2002), 3= Ogbomoso (2003)
*, ** = sig. at 0.05, 0.01 levels of probability.

Table 5. Genotypic correlation coefficients among six yield related traits in soybean

Characters	Location	Number of pod	Number of branch/ plant	Number of seed/pod	100-seed weight (g)	Seed yield per/plant
Days to maturity	1	0.19	0.22	0.36*	0.12	0.42*
	2	0.44*	0.32*	0.17	0.48**	-0.19
	3	0.91**	0.55**	0.59**	0.72**	0.66**
Number of pods/plant	1		0.21	0.23	-0.21	-0.11
	2		-0.18	0.31*	0.37*	0.51**
	3		0.50**	0.20	-019	0.41*
Number of branch/ plant	1			0.27*	0.36*	0.21
	2			0.13	-0.21	0.39*
	3			0.24	-0.52**	0.82**
Number of seeds per /pod	1				0.29*	0.58**
	2				-0.17	0.22
	3				-0.39*	0.41*
100- seed weight	1					- 0.31*
	2					0.41*
	3					0.48**

1=Ibadan. 2= Abeokuta, 3= Ogbomoso . *,**, = sig at 0.05. 0.01 levels of probability;

Ogbomoso and Abeokuta locations. This implied that increasing seed yield via branch number would automatically result in decreased seed weight in these specific locations. That number of seeds per pod recorded significant phenotypic correlation with seed yield in all the three locations but correlated genotypically in Ibadan and Ogbomoso locations revealed the fact that location environments influence expressions of genetic traits. That days to maturity correlated phenotypically with number of pods per plant, number of branch per plant and weight of seeds in Ibadan location but not genotypically correlated,supports the fact that such significant characters may not be of practical value in selecting for seed yield improvement for Ibadan location if selection is based on the phenotype of the characters (Ariyo and Aken'ova, 1986). Therefore, selection for these traits would not be successful with respect to Ibadan location, as these traits did not give significant genotypic correlation. This places rainforest agroecology (Ibadan) at a disadvantaged location for soybean production. Premium should therefore be placed on days to maturity; number of branch per plant and number of seeds per pod where specific location seed yield improvement is the ultimate.

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