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Full Length Research Paper

Assessment of selection techniques in genotype X environment interaction in cowpea *Vigna unguiculata* (L.) walp

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Ten genotypes of cowpea were grown in four environments comprising the early and late seasons of Ogbomoso and Abeokuta locations in 2005 and 2006. Joint linear regression analysis indicated the presence of Genotype x Environment interaction even though, a proportion was non-linear. The differences in the values of the regression coefficient and the correlation of grain yield revealed that the genotypes responded differently to the environments and that regression coefficient as a technique could not be used to identify genotype performance in specific locations. The use of Deviation mean square and Ecovalence mean square techniques produced similar results on the consistency of genotypes performance hence, Deviation mean square and Ecovalence mean square may not be simultaneously used. However, regression coefficient, Si^3, Pi, and Modified rank sum techniques can be jointly used to select genotypes based on their yielding ability and response to environmental changes.

Key words: Genotype X environment interaction, selection techniques, cowpea, *Vigna unguiculata.*

INTRODUCTION

Cowpea is world's most important protein source. The grain has the largest usable protein content of all culti-vated legumes. In Nigeria, production and release of improved cowpea varieties have been slow especially in the humid and semi humid regions of Nigeria. Highest yields have been obtained in the drier region of the coun-try (FAO, 2000). Stability performance of cowpea varie-ties across contrasting environments is essential for the successful selection of stable and high yielding varieties (Dashiell et al., 1994; Ariyo and Ayo-Vaughan, 2000). Integration of cultivar stability with yield is important for the purpose of selecting high yielding and stable genoty-pes. Therefore, a number of techniques that simultan-eously combine high yield and stability of performance have been proposed. The regression technique (Eberhart and Russell, 1966) has been used. In this technique, genotype response to a given environment is considered.

The Deviation mean square, (Si^2d) considered the mean squares for the deviations from regression as a stability parameter. Ecovalence mean square (Wricke, 1962) (WMS), also determines the response of genotypes to a given environment. These stability parameters fail to sel-ect genotypes on the basis of high yield and stable per-formance. The limitations resulting from these parame-ters therefore led to the development of techniques combining high yield with stable performance (Kroonen-berg, 1995). Lin and Binns (1988) cultivar superiority measure (Pi) based genotype yield in each environment on ranks with the lowest rank assigned to most desirable genotype. By this technique, only genotypes with wide adaptation are selected. A non -parametric statistic (Si^3) of Huhn (1979) was also developed. This technique also based desirable genotype selection on lowest rank value. With these techniques, selection becomes more precise in wide and specific environments. This study therefore, determined the effect of environment on the stable performance of ten elite cowpea genotypes and eva-luated the relationship between the stability and selection techniques.

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Table 1. The mean yield, environment index and ecology of the cowpea genotypes.

Environment	Environment index	Mean seed Yield (kg/ha)	Ecology
Ogbomoso 1	697.4	1697.2	Guinea savanna
Ogbomoso 2	420.3	1401.7	Guinea savanna
Abeokuta 1	208.7	1083.9	Rainforest
Abeokuta 2	-416.7	905.4	Rainforest

1=Ogbomoso and Abeokuta early season; 2= Ogbomoso and Abeokuta late seasons.

MATERIALS AND METHODS

Ten elite cowpea varieties were grown in the early and late seasons of 2005 and 2006 to give a total of four environments. Using a randomized complete block design with three replications, each of the genotype was grown into a five-row plot of 2.7 x 2.4 m and spaced 60 and 45 cm between and within rows to give a total of 24 plants per plot. Insect pests were controlled using karate at 50 ml to 20 liters of water. Weeding was done manually as at when due. The three inner competitive rows were harvested to determine the yield. Data were subjected to combined analysis of variance and joint linear regression analysis following the procedure of Eberhart and Russell (1966) . In this study, a mixed model was assumed where the genotypes were fixed and environment random as the effects of environments on genotypes were tested.

The regression coefficient (b) measures the response of genotypes to environments. When b= 1 there is average stability and adaptable to both poor and good environments, when b > 1 genotypes give above average stability only in good environment. Whereas, when b < 1, it indicates genotypes adaptation to poor environment. Deviation mean square parameter (Si^3d) measures genotype stability. A genotype is stable when the Si^3d is not different from zero. Wrickes (1965) Ecovalence mean square (WMS) stability implies low adaptation. In addition to these stability parameters, three selection parameters were used. Lin and Binns (1988), proposed a statistic which measures genotype superiority as follows:

$$P_i = \sum_{j=1}^{n} \frac{(X_{ij} - M_j)^2}{n}$$

Where:

Pi = Mean square between the cultivar's yield and the overall yield for each location
Xij = yield of i^{th} genotype grown in j^{th} location.
Mj = Maximum yield response among all cultivars in j^{th} location.
n = number of locations.

Another selection statistic as proposed by Huhn (1979) was calculated as follows:

$$S_i^3 = \frac{\sum_j (r_{ij} - \bar{r}_i)^2}{\bar{r}_i}$$

Where:

rij = rank of i^{th} genotype in j^{th} environment
$\bar{r}_i$ = mean of ranks over all environment for i^{th} genotype

In this statistic the lower the Si^3, the more desirable the genotype. Kang and Pham (1991) rank-sum technique was used as the third selection statistics. Ranks and stability ratings were assigned genotype mean yield, such that highest yielding genotype had a rank of 1 and least yielding, had the highest rank. Stability rating of 0 was equally assigned genotype with non significant Si^2d and a rating 4, if significant at 5% probability level and 8 if significant at 1% probability level. This ranting was added to the yield rank, such that genotypes with the lowest rank sums were adjourged high yielding and stable.

Table 2. Joint regression analysis of cowpea yield

Source	DF	MS
Total	199	
Treatment	39	11831.44
Genotype	9	16304.23**
Environment	3	28117.75**
G x E	27	37666.21**
HR	9	5029.41
CR	1	2926.20
DC	8	9347.12*
DR	18	6112.65
Error	80	3646.41

RESULTS AND DISCUSSION

The mean yield of the cowpea genotypes averaged over environments is presented in Table 1. The grain mean grain yield ranged from 905.4 kg/ha for Abeokuta late season to 1692.2 kg/ha for Ogbomoso early season. Early season of Ogbomoso had the largest environment index of 697.4 and therefore the best environment for this study. The late season of Abeokuta recorded least environment index of –416.7 and hence the poorest environment.

The joint linear regression analysis of the 10 cowpea yield across the four environments is presented in Table 2. Genotype and environment effects were significant. Mean square of the deviation from concurrence and regression were significant as tested against the pooled error. This indicated the presence of GXE interaction and that a large proportion of the genotype x environment interaction was non-linear as revealed in the significant interaction of Genotype and Environment. Even the regression concurrence was not significant. The joint linear regression alone could not predict the individual genotype performance with respect to environmental influence Aremu (2005). This therefore places Joint regression analysis as unreliable parameter in selecting for high yield and

Table 3. Genotype mean yield, Regression coefficients (b), Deviation mean square (Si^2d), Ecovalence mean square (WMS), Non-parametric (Si^3)modified rank sum (MRS) techniques.

Genotype	Mean yield kg/ha	Regression coefficient (b) Ebrhert and Russell (1966)	Deviation mean square (Eberhert and Russell (1966)	Ecovalence mean square Wricke (1962)	Si^3 (Huhn, 1979)	Pi Lin and Binns (1988)	Modified rank sum Kang and Pham (1995)
IT90K-59	957.5	1.63±0.43[b]	25734.7**	2.01[d]	13.24	4.93	16
1T97K-499-39	1101.0	1.2±0.05[a]	19851.6	2.14	3.01	1.33	6
1T90K-76	940.2	0.40±0.93[c]	275869.5*	1.68[d]	14.46	12.74	13
1T95K-1091-3	1216.4	2.35±0.19[b]	35761.5	0.63	16.29	7.80	5
TVX-3236	1350	1.07±0.24[a]	13541.4	2.26	6.22	9.48	3
IAR 48B	857.3	1.92±0.37[b]	257637.2**	9.51[d]	20.71	16.17	18
IAR48 W	1032.6	0.09±0.01[c]	11381	9.82[d]	26.75	4.82	7
AGRIBVI	1320.0	0.57±0.21[a]	45397.8	3.01	5.09	3.01	4
Owode	1743.1	1.19±0.44[a]	57347.2	2.52	3.2	2.05	1
Ife-brown	1442.01	1.44±0.16[a]	17031.2	0.75	3.70	2.01	2

a=regression coefficient (b) equal to 1
b=regression coefficient (b) significantly greater than 1
c= regression coefficient significantly less than 1
d= Si^3 d stability parameter significantly greater than 1

stability of performance. According to Acciaresi et al. (1997), the success in identifying high yielding genotype is dependent on effectiveness of stability and selection parameters used. However, high precision has been achieved in selecting for high yield with stable performance (Acciaresi et. al., 1997), on Oats; Singh (2000) on cow-pea; (Yan and Hunt, 2001) on rye. The mean yield, reg-ression coefficient, Deviation mean square, Ecovalence mean square, Si3, Pi, and modified rank sum, for each genotype are presented in Table 3. The mean yield ranged from 857.3 kglha for 1AR48B to 1743.1 kglha for Owode. The regression coefficient for each genotype differed significantly from each other suggesting that the genotypes responded differently to the seasons and the locations. The regression coefficient revealed that IT97K-499-39, TVX -3236, AGRIBVI, Owode and Ife-brown were environment insensitive and could be cultivated in the early and late seasons and still produce high yield, envi-ronment not withstanding. This is evident with Owode which produced the highest mean yield in the four envi-ronments including the good and the poor environments. However, IAR48B was less consistent and therefore require highly nourished soil environment to produce averagely. Deviation mean square were significant in respect of 1T90K-59, 1T90K– 76 and 1AR 48B and therefore less consistent than the others. In addition to these three genotypes, Ecovalence mean square also identified IAR48W to show inconsistent performance in the four environments. Using Si^3 statistic, 1T97K-499-39 recorded least Si^3 value hence most desirable followed by Owode and Ife-brown. The smallest Pi values were recorded for 1T97K- 499-39, Owode and Ife-brown even as IAR48B and 1T90K –76 recorded least values. The Modified Rank Sum method of Kang and Pham (1991), recorded IAR 48B to have highest rank sum value and most undesirable. IT90K-59 and IT90K-76 were equally undesirable. The least value was recorded for Owode and followed by Ife-brown.

Si^3, Pi and Modified rank sum method identified Owode, Ife-brown, TVX -3236 and IT97K-499-39 to be most desirable by combining high yield with consistent performance. IARW, IT90K-59 and IT90K-76 had low yield with less consistent performance making them undesirable. It is revealing to note that these techniques which identified some genotypes to be desirable had non significant deviation mean square. Of the six techniques used, it is worthy of note that regression coefficient could be reliably used especially in multilocational G x E studies as it reveals genotype performance in either good or bad environment. This therefore places premium on the use of regression coefficient to successfully recommend type of planting environment inform of soil nourishment level, temperature, humidity etc. that would be suitable to grow specific genotype for optimal yield performance. Aremu (2005) recommended simultaneous use of regression coefficient alongside deviation mean square and unbiased estimator stability parameters to achieve success in selecting for high yield and stable performance in G xE studies. The correlation coefficient between grain yield, Deviation mean square, Ecovalence mean square, Si^3, Pi and Modified rank sum statistics are shown in Table 4. Grain yield associated positively with regression coefficient (0.46), Ecovalence mean square (0.56), Si^3 (0.77) and modified rank sum (0.62). Although Pi associated significantly with grain yield but the association was negative. Regression coefficient correla- ted significantly with Pi, and modified rank sum (-048; -0.54) but the correlation was negative. Ecovalence mean square techni-

Table 4. Correlation coefficient (r) among seed yield, regression coefficient (b) and selection parameters Si^3, Pi and modified rank sum.

	Regression coefficient	Deviation mean square (Si^3d)	Ecovalence mean square (WMS)	Si^3 (Huhn 1979)	Pi (Lin and Binn (1988)	Modified Rank-sum Kang and Pham (1991)
Mean yield	0.46*	-0.31	0.58**	0.77**	-0.61**	0.83**
Regression coefficient (b)		0.24	0.43*	0.54*	-0.48*	-0.54*
Deviation mean square			0.15	-0.46	0.26	0.57**
Ecovalence mean square				-0.32	0.76**	0.48*
Si^3					0.33	0.73**
Pi						0.63**

que recorded significant correlation with Pi, and modified rank sum even as Si3, and Pi, were equally highly correlated with modified rank sum.

The positive correlation between regression coefficient and grain yield of cowpea indicated that the genotypes were responsive to the different environments. The negative correlation between rank sum and seed yield revealed that modified rank sum is valuable and sensitive in selecting high yielding genotypes. That deviation mean square also recorded negative correlation with seed yield explained the possibility of selecting genotype based on consistent performance. The positive Si^3, Pi and modified rank sum indicated that Si, and Pi selection parameters could be interchangeably used to achieve success in selection of high yielding genotypes. The magnitude of correlation coefficient between seed yield and modified rank sum in this study placed modified rank sum as the most preferred technique when selection for high yield is the premium. This runs contrary to the work of Dashiell et al., (1994) who rated Pi statistics as a better technique in selecting for high yielding genotypes.

However, where adaptation to specific location is the focus, the values from regression coefficient techniques could be used alongside with other selection techniques to avoid duplicating result emanating from combined usage of selection techniques.

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