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YIELD STABILITY OF SOYBEAN GENOTYPES IN MIXTURE OF SORGHUM IN BENUE STATE.

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ABSTRACT

Ten soybean genotypes were evaluated in 3 locations for 2 seasons to determine those suitable for inter-cropping with sorghum and with stable yield under the Benue State environmental conditions. The LER values were all above unity demonstrating that all the genotypes used in this study can maintain their high yield potential under inter-cropping with sorghum. There was highly significant genotype x location interaction emphasising the importance of multilocational trials as a basis for varietal recommendation. The adaptation response of the soybean genotypes used in this study showed that Cameroon Late, TGX 1807-19F, and TGX 1805-31F had general stability and adaptability as they had high mean yields and b-values close to unity. However, based on stability statistics, TGX 1805-31F was considered to be the most stable in the soybean/sorghum inter-crop. From the study, it can 0be concluded that plant breeders need to evaluate their elite soybean lines under inter-crops before release to farmers, because the best yielder under pure stands may not necessarily yield well under inter-cropping. The benefit of such evaluation is to ensure that farmers get the type of varieties which are appropriate to their farming systems.

INTRODUCTION

Generally, soybean is bred world-wide for sole cropping. Consequently, selection and evaluation are carried out under pure stand conditions. However, the majority of farmers in Benue State who produce 75% of Nigeria's soybean (Nyiakura, 1982) insist on inter-cropping it with sorghum or maize (Ogunremi et al, 1990). It is, therefore, necessary for plant breeders to screen elite lines under inter-cropping systems before release. By so doing, varieties that are adaptable to inter-cropping systems are identified and recommended to farmers for optimum yield.

A common index of assessing inter-cropping productivity is the Land Equivalent Ratio (LER), which is defined as the ratio of the area needed under sole cropping to one of inter-cropping at the same management level to produce an equal amount of yield (Andrews & Kassam, 1976). In another definition, Willey & Osiru (1972) defined LER as an index of combined yield for evaluating the effectiveness of all forms of inter-cropping. The LER is also indicative of competitive relationships between species. If the LER is less than unity, there is mutual inhibition; if it is equal to unity, there is mutual co-operation; when it is greater than unity, there is compensation suggesting that the inter-cropping is more productive than the competitive mono-crops. Such a situation indicates the potential for over-yielding (Willey, 1979), a phenomenon which shows that resources are maximised in an inter-cropping system (*Blade et al, 1997*).

The existence of genotype x environment (g x e) interactions and their effects on yield stability are widely recognised (Schutz and Benard, 1967). The plant breeder must consider the g x e interaction in the selection of superior genotypes because it reflects the necessity of evaluating genotypes in more than a single environment. Johnson et al (1995) emphasised the importance of this interaction and its effects upon the selection of soybeans.

Plaisted and Peterson (1959) presented a method to characterise the stability of yield performance when several genotypes were tested at a number of locations within one year. The genotype with the smallest b value would be the one that contributed the least genotype x location interactions and thus would be considered the most "stable" genotype in the test. Finlay and Wilkinson (1963) proposed the use of linear regression of individual genotype yields on mean yield of all genotypes in each environment as a measure of yield stability. Gomez & Gomez (1983) used this method to rank the performance of soybean lines in several cropping systems. They observed that all varieties tended to have higher yields in environments with high environmental indices. Another analysis was presented by Eberhart and Russell (1966) who observed that a desirable genotype would exhibit a high yield and a unit regression as small as possible. In an effort to bring literature on stability together, *Lin et al, (*1986) assembled and discussed nine stability statistics and similarity coefficients. The authors concluded that stability statistics fall into four groups depending on whether they are based on the deviations from the average genotype effect or on the g x e term, and whether or not they incorporate a regression model on an environmental index. These groups of stability statistics were shown to be related to three concepts which represent aspects of stability but unfortunately do not provide a complete picture of the response. Nonetheless, the use of stability statistics is still the most reliable means of estimating yield stability under varying environments. The objective of this study was therefore to identify soybean varieties which can be inter-cropped with sorghum and still maintain high and stable yield under the Benue State environment

MATERIALS AND METHODS

Field experiments were conducted during the rainy seasons of 1997 and 1998 at Makurdi, Otukpo and Yandev locations in the Southern Guinea Savanna of Nigeria. The experiments were laid out in randomised complete block design (RCBD) with 3 replications. Ten soybean genotypes were grown in association with one variety of sorghum (SK 5185).

The experimental plot was ploughed, harrowed and ridged. Each plot consisted of 4 rows which were 6 metres long and spaced 75cm between rows. At land preparation, 150kg/ha of NPK 15.15.15 was applied by broadcast to the experimental plot. An additional 30kg N/ha from Urea was applied to sorghum by side placement at 6 weeks after planting. Soybean was planted at recommended population (266,666 plants/ha) by drilling on top of the ridges for both sole and inter-crop situations while sorghum was planted by the side of the ridges at one-third of recommended plant population (Kalu, 1991).

Harvesting was done from the two (2) centre rows of each plot which were end-trimmed at maturity to allow for a row length of four (4) metres. In each location, agronomic data collected included: Seed yield, days to 50% flowering, days to maturity, height at maturity, lodging, shattering, pods/plant, leaf area, nodulation and disease incidence. Analysis of variance of individual experiments was performed and genotype x environment interactions were assessed by regression analysis. Five stability parameters (coefficient of variation, regression coefficient, interaction variance, ecovalance, and coefficient of Determination) were employed in the evaluation. Stability regression techniques were used to characterise genotypic adaptability and the productivity of the inter-crop was assessed by using Land Equivalent Ratio (LER), calculated on the basis of the sole crop yields of individual soybean genotypes and sorghum (Mead and Willey, 1980).

RESULTS AND DISCUSSION

The productivity of the inter-crop, assessed by LER, indicated that there was a great advantage in inter-cropping sorghum with soybean as evidenced by the fact that all the LER values were above unity (Table 1).

TABLE 1: SOLE CROP YIELD, INTER-CROP YIELD AND LAND EQUIVALENT RATIO VALUES OF 10 SOYBEAN GENOTYPES INTERCROPPED WITH SORGHUM AT THREE LOCATIONS IN 1997 AND 1998

	1997				1998					
rop Mixtures	Sole Crop Yield		Inter Crop Yield		Sole Crop Yield		Inter Crop Yield		Land Equivalent Ratio	
	Soybean	Sorghum	Soybean	Sorghum	Soybean	Sorghum	Soybean	Sorghum	1997	1998
GX1485-1D + Sorghum	2140	-	1700	751	1625	-	1447	1117	1.67	1.38
ameroon CameroonLate +Sorghum	2140	-	1970	782	1737	-	1468	1146	1.86	1.36
GX1660-15F +Sorghum	2000	-	1730	618	996	-	1207	1346	1.60	1.80
GX1807-19F + Sorghum	2080	-	1910	698	1607	-	1387	1096	1.75	1.35
CRI-Soy2 + Sorghum	1950	-	2030	528	1522	-	1156	1159	1.67	1.27
GX1789-7F + Sorghum	1550	-	1550	603	1063	-	887	1154	1.72	1.34
GX1681-3F + Sorghum	1790	-	1560	657	1457	-	1109	1209	1.53	1.30
GX1019-2EB+ Sorghum	1640	-	1610	556	1164	-	1163	1220	1.64	1.53
GX1799-8F + Sorghum	1850	-	1630	611	1389	-	1150	1179	1.61	1.35
GX1805-31F + Sorghum	1600	-	1610	632	1495	-	1403	1175	1.76	1.46
ole Sorghum	-	841	-	-	-	2255	-	-		

Similar results were obtained by *Kamuanga et al.*, (1988) which showed that crop associations consistently gave higher total grain yields (LER > 1) and showed more stability (lower CVs) across sites and seasons than sole cropping where sorghum/maize, sorghum/millet, and sorghum/cowpea crop associations were evaluated.

TABLE 2: SOURCES OF VARIATION, DEGREES OF FREEDOM (df) AND MEAN SQUARES OF YIELD AND SEVEN ATTRIBUTES AND DISEASE SCORES OF TEN GENOTYPES OF SOYBEAN INTERCROPPED WITH SORGHUM AT THREE LOCATIONS IN BENUE STATE IN 1997 AND 1998

rces of Variation s ction	df.	Yield	Days to 50% Flower	Days to maturity	Plant Height (cm)	Plant Lodging	Pod Shattering	pod/ Plant	Nodulation	Bacterial Pustule infection	Cercospora	Mosaic
lication/Loc x Year NS	12	0.066NS	0.38NS	1.78NS	6.68NS	0.24*	0.05NS	14.30NS	0.03NS	0.05NS		0.02NS
cations (L) 7NS	2	5.738NS	1.67NS	1190.91NS	421.08NS	0.37NS	1.49NS	419.04NS	0.54NS	0.01NS		0.12NS
ars (Y)	1	4.73**	3.20**	763.02**	6.02NS	0.44**	2.45**	2760.47**	0.75**	o.10NS		
5NS	0.012NS		Genotypes (G)	9	0.44**	29.67NS	62.28NS	158.66NS	0.17**	0.59NS		
:.14NS	0.28NS	0.03NS	0.07NS	0.079NS								
Y 8N	2	2.145**	11.59**	1790.97**	1218.45**	0.69**	1.89*	2108.71**	1.02**	0.09NS		0.18NS
Y 6NS	9	0.056NS	30.07**	297.13**	170.16**	0.03NS	5.08**	963.88**	0.42**	0.06NS		0.10NS
L	18	0.393**	20.28NS	181.34NS	144.40NS	0.25NS	0.43NS	367.78NS	0.34NS	0.05NS	0.00NS	0.110NS
L x Y NS	18	0.072*	28.04**	254.04**	254.72**	0.39**	0.66**	724.52**	0.58**	0.08NS		0.15**
or (Pooled) 4	108	0.043	0.59	12.63	15.30	0.13	0.21	34.32	0.05	0.11		0.07

NS= Not Significant * = Significant at 5% and ** = Significant at 1% levels

The results of analysis of variance showed highly significant differences for yield among genotypes and their interaction with year and location (Table 2) which suggested that yield of soybean genotypes responded differently to corresponding year and location (*Lee, et al* 1994).

The variance component due to g x l is seven times larger than that due to g x y indicating that yield performance of soybean genotypes was more varied across location than across years. This information could be considered in a selection programme by testing at several locations instead of testing for several years (Baker, 1969).

When the Finlay and Wilkson (1963) model was applied to the analysis of this experiment, Cameroon Late, TGX1807-19F, NCR-Soy2 and TGX1805-31F were shown to have above average stability. TGX 1660-15F, TGX 1019-2EB and TGX 1799-8F which have below average yield and b value equal to unity are poorly adapted to all the six environments. Cameroon Late, TGX 1807-19F and TGX 1805-31F with high mean yields and a regression coefficient close to unity have general stability and adaptability. TGX 1485-1D and TGX 1681-3F which have b values above unity are said to show specific adaptability to favourable environments (Eberhart & Russell, 1966). Stability parameters of the genotypes tested are presented in table 3. On the basis of coefficient of variation (CV), TGX 1485-1D was the most stable in yield performance, but it did not possess any other stability attribute. On the other hand, Cameroon Late exhibited the highest yield, low CV a regression coefficient approximating unity, and a low coefficient of determination. TGX 1807-19F also showed similar stable attributes. However, TGX 1485-1D was the only entry which satisfied the criteria for a stable genotype i.e. high and positive phenotypic index, b = 1, and coefficient of determination (R^2) around unity, and as such could be considered for recommendation to be inter-cropped with sorghum over a wide range of growing environments). (*Aquilar et al.,* 1989). Further more, this genotype contributed the least to the genotype by environment interaction as measured by ecovalence (W^2), and the interaction variance (^{2}).

Therefore, by these means, TGX 1805-31F represents the most stable of the ten soybean genotypes in this study.

	Stability	Estimates			
rop Mixtures	Yield(kg/ha)	CV	b	δ^2	W
GX1485-1D+Sorghum	1579	15.8	1.303	42498	76
ameroon- Late + Sorghum	1719	16.3	0.852	64560	13
GX1660-15F+Sorghum	1469	25.9	1.131	38134	37
GX1807-19F+Sorghum	1649	19.8	1.161	31799	285
CR-Soy2+Sorgum	1593	38.0	0.574	93748	50
GX1789-7F+Sorghum	1219	38.6	0.621	10081	15
GX1681-3F+Sorghum	1335	36.3	1.370	24545	91
GX1019-2EB+Sorghum	1387	31.4	1.045	90261	95
G1799-8F+Sorghum	1390	44.0	1.183	27448	22
GX1805-31F+Sorghum	1507	18.1	0.854	6337	39

coefficient of Variation W^2 = GE interaction across all
regression slope R^2 = Coefficient of determina
eviation mean square (interaction variance)

ilar et al., 1989). Further more, this genotype contributed the leas onment interaction as measured by ecovalence (W^2), and the interactio efore, by these means, TGX 1805-31F represents the most stable of the types in this study.

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