Correlation, path coefficient and regression studies in some advanced lines of soybean grown in southern guinea savannah of Nigeria

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Abstract: **Twenty elite soybean genotypes were evaluated in three locations in 2010 cropping season at Teaching, Research and Experimental Farm of University of Agriculture Makurdi, the experimental farm of the AkperanOrshi College of Agriculture, Yandev–Gboko, Benue State; and Omala Local Government Department of Agriculture Model Nursery Farm, Abejukolo-Kogi State all located in the guinea savannah environment of Nigeria. The laid out was in Randomized Complete Block Design (RCBD) with three replicates. The Analysis of Variance (ANOVA) showed significant differences among the genotypes for the traits such as nodule dry weight; days to 50% flowering; plant height at flowering; days to maturity; plant height at maturity; number of branches; number of seeds /pod; number of seeds/ plant; weight of 100 seeds; and seed yield. Genotype x location interaction was significant for days to 50% flowering; pod weight and number of seeds /pod for the traits studied. High heritability was observed in pod weight and number of seeds per plant. Association with seed yield revealed significance with one seed weight, number of sees per plant, and number of pods. Path coefficient analysis revealed direct effects of weight of one hundred seeds, number of pods per plant and weight of one hundred seeds had positive direct effects with yield.**

Key words: **Soybean, Genetic variability, Genetic advance, Correlation, Path coefficient, Regression and Genotype x Location.**

I. INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is the major world oil seed. It is also a major source of meal for livestock feed (Acquaach 2008). It is an important legume with multifarious uses (Vaughan and Geissler, 2008). According to Javaheri and Baudoin 2010 nearly four hundred different uses of soybean have been reported. Soybean consists of 35 – 40% protein and less than 20% oil (Acquaach 2008). Soybean utilization is gaining popularity in Nigeria because of it numerous potentials that rank it even better than cowpea in the supply of high quality protein (Akande*et. al.*, 2009). According to Harlan 1976 soybean in ranked as number nine out of the twenty five major food crops of the world, ranked according to total tonnage produced annually. Food is the most basic human needs, without them, life on earth for higher organisms would be impossible. As the world population increases, there would be a need for an agricultural production system that is apace with the growth of population. Consequently, more food will have to be produced on less land. This calls for improved and high yielding varieties to be developed by plant breeders. Plant breeding is a deliberate effort by humans to nudge nature with respect to the heredity of plants to an advantage (Acquaach 2008). Yield increase in crops has been accomplished in a variety of ways including targeting yield per se or its component, or breeding for plant that are responsive to production environment (Acquaach 2008). Yield being a complex character, is influenced by a number of yield contributing characters controlled by polygenes and also influenced by environment. So, the variability in the collections for these characters is the sum total of heredity effects of concerned genes plus the influence of the environment. Hence, it becomes necessary to partition the observed variability into heritable and non-heritable components measured as genotypic and phenotypic coefficients of variation (GCV and PCV), heritability and genetic advance expressed as per cent mean. Correlation coefficient (r), measures only the degree (intensity) and nature (direction) of association between characters. Path coefficient analysis measures the direct and indirect effect for one variable upon another and permits the separation of the correlation into components of direct and indirect effects. (Dewey and Lu, 1959). Keeping in view all these aspects, the present study in soybean was conducted with the following objectives; to study the genetic variability for various quantitative traits and to study the correlations, path coefficient and regression among the genotypes.

II. MATERIALS AND METHODS

Seventeen (17) elite soybean genotypes were obtained from the International Institute for Tropical Agriculture (IITA), two (2) from the National Cereals Research Institute Badeggi and one (1) from the University of Agriculture, Makurdi as shown in Table 1. Soil samples were taken from each experimental site for analysis to determine the physical and chemical properties at the NICANSOL soil testing laboratory of the University of Agriculture, Makurdi. The results of soil test and coordinates of the three sites are presented in tables 2 and 3 respectively. In this study, field experiments were conducted during the 2010 cropping season at three locations:

1. The Teaching, Research and Experimental farm of the University of Agriculture, Makurdi;
2. The experimental farm of the AkperanOrshi College of Agriculture, Yandev–Gboko, Benue State; and
3. The Omala Local Government Department of Agriculture model Nursery farm, Abejukolo-Kogi State.

The experimental sites were cleared, ploughed, harrowed, and ridged at Makurdi, Yandev and Abejukolo in that order from mid-June to mid-July of the year 2010. Plots were laid in a Randomized Complete Block Design (RCBD) with three replications at the various locations. Plot size was 5mx1.5m, giving a plot area of 7.5m^2. Inter-row spacing was 0.75m apart. Planting was done by drilling 200 seeds in each plot. All entries were planted at the various locations; on the 26th June, 2010, 12th July, 2010 and 21st July, 2010 in Makurdi, Yandev and Abejukolo respectively. Pendametalin was applied as pre-emergence herbicide within 24hrs after sowing, in all the plots to control the weeds. Hoe weeding was done later as often as weeds were observed in the fields. Side dressing was done using P_2O_5 (26%) at the rate of 30Kgha^{-1}

Data were collected on the following parameters: Nodule dry weight, plant height, lowest pod height, number of branches and number of pods. Days to 50% flowering and days maturity, nodule dry weight; plant height at flowering; days to maturity; plant height at maturity; number of branches; number of seeds /pod; number of seeds/ plant; weight of 100 seeds; and yield in tons per Ha.

100 seed weight and seed yield were recorded on plot basis.

The data from each location was subjected to statistical analysis as described by Steel and Torrie (1980).

III. RESULTS

The combined means, standard error and coefficient of variation for Abejukolo, Makurdi andYandev are presented in Table 4. There were wide ranges (0.16 – 0.66 to 17.20 - 484.00) of means among the traits observed. The standard errors were generally low except for number of seeds per plant (63.22). The coefficients of variation were generally low except for number of seeds per plant (50.0) and nodule dry weight (56.1).

Combine analysis of variance and grand means for traits of soybean evaluated at Abejukolo, Makurdi andYandev is presented in Table 5. There were highly significant (p>0.01) location by genotype interactions for days to 50% flowering, pod weight (g) and number of seeds per pod. The analysis of variance also shows that the genotypes were highly significant differences in the following traits: days to flowering, plant height at flowering, days to maturity, plant height at maturity, number of branches, number of seeds per pod, number of seeds per plant, weight of 100 seeds and seed yield.

The mean performance of seed yield of soybean and its components evaluated at three locations is presented in Table 6. The genotypes with relatively high mean yields were TGX 1984 – 17F (3.463 t/ha), TGX1985 – 12F (2.710 t/ha), TGX 1984 – 22F (2.707 t/ha), and NCRI SOY 5 (2.677 t/ha) while those that may be considered as low yielders include TGX 1835 - 10E (1.377 t/ha) and TGX 1987 – 10F (1.480t/ha). Genotype x environment interaction indicated that there were differential yield ranking of genotype across environments.

Genotypic, phenotypic and environmental variances and broad sense heritability and genotypic coefficient of variation and phenotypic coefficient of variation of seed yield and its components in soybean evaluated at three locations during the 2010 season.The traits studied were highly heritable especially in pod weight. It was observed also, that the traits exhibited low coefficient of genotypic, as well as, phenotypic variations except for pod weight which had high genotypic and phenotypic variances.

The combined genotypic correlation coefficient of seed yield and yield related traits are presented in Table 7. The result indicated that number of pods per plant (0.655**), number of seeds per plant (0.556**) and weight of one hundred seeds (0.519*) had positive and significant correlation with seed yield. Other traits like plant height at flowering (0.42) pod weight (0.396), number of branches (0.38), days to maturity (0.197), days to 50% flowering (0.13) and plant height at flowering (0.122) had positive, but not significant, correlation with seed yield. However, nodule dry weight showed negative correlation with seed yield.Number of pods per plant showed highly positive significant correlation with days to maturity and number of seeds per plant. This seems to indicate that late maturing varieties produce more number of pods.

The combined path analysis of seed yield and yield components for soybean genotypes evaluated in Abejukolo, Makurdi and Yandev during the 2010 season is presented in Table 8.Direct effects (indicated in bold) showed that weight of one hundred seeds and number of pods per plant had positive direct effects with yield.

IV. DISCUSSION

There was a differential yield ranking of genotypes across the locations. Tamene *et al*. (2013) earlier reported differential yield ranking across environments. This agrees with Yan and Hunt (2001) who reported that genotype x environment interaction effect was a crossover type. PCV and GCV estimates were for pod weight(73.08/80.23), followed by number of seeds per plant (41.15/47.25) and number of pods (31.09/40.20). Lowest magnitude of GCV and PCV were recorded for number of branches (7.33/9.67), followed by number of seeds per pod (13.37/14.95) and days to maturity (17.80/23.08) the difference between PCV and GCV were very small for number of seeds per pod, number of branches and days to maturity indicating lesser environmental variation towards expression of these traits.

Highly significant genotypic correlation coefficient of seed yield with number of pods per plant and number of seed per plant were observed. Similarly, a significant positive correlation coefficient was observed between seed yield and weight of one hundred seeds. Many researchers: Nakawuka *et al.* (1999), Iqbal *et al.* (2003), Malik *et al.*, (2006) and Shaahu *et al., (2014)* also found highly significant genotypic correlation coefficient of seed yield with number of pods per plant.

The traits that showed significant correlation with seed yield, in the combined analysis, were further partitioned direct and indirect effects through path coefficient analysis. The path analysis showed that weight of one hundred seeds, number of pods per plant and number of seeds per plant had positive direct effect on seed yield. Although the direct effect of number of seeds per pod was small, its indirect contribution to seed yield was increased through number of pods per plant.

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V. CONCLUSION

The present study revealed that soybean seed yield differs from one location to the other due to genotype x environment interaction effects.

Number of pods per plant, number of seeds per plant, weight of one hundred seeds, number of branches per plant and pod weight are the traits that contributed to seed yield in soybean. Therefore, these are the traits to select in order to improve seed yield in soybean.

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Table 1: Soybean Genotypes, Sources and Characteristics

S/N	Genotype Code	Sources	Variety's Characteristics
1	NCRI SOY 16	National Cereal Research Institute, Badegi.	Medium maturing, resistant to shattering.
2	NCRI SOY 5	National Cereal Research Institute, Badegi.	Medium maturing, resistant to shattering.
3	SAMSOY 2	University of Agriculture, Makurdi.	Medium maturing, susceptible to shattering.
4	TGX 1440 – 1E	IITA, IBADAN.	Medium maturing, resistant to shattering.
5	TGX 1448 – 2E	IITA, IBADAN.	Medium maturing, resistant to shattering.
6	TGX 1485 -1D	IITA, IBADAN.	Early maturing, low shattering
7	TGX 1835 -10E	IITA, IBADAN.	Early maturing, low shattering
8	TGX 1904 -6F	IITA, IBADAN.	Medium maturing, resistant to shattering.
9	TGX 1984 -17F	IITA, IBADAN.	Late maturing..
10	TGX 1984 19F	IITA, IBADAN.	Late maturing.
11	TGX 1984 -1F	IITA, IBADAN.	Late maturing.
12	TGX 1984 -22F	IITA, IBADAN.	Late maturing.
13	TGX 1984 -5F	IITA, IBADAN.	Medium maturing.
14	TGX 1985 -12F	IITA, IBADAN.	Medium maturing.
15	TGX 1986 -1F	IITA, IBADAN.	Medium maturing.
16	TGX 1987 -10F	IITA, IBADAN.	Extra early maturing, resistant to shattering.
17	TGX 1987 -19F	IITA, IBADAN.	Late maturing.
18	TGX 1987 -57F	IITA, IBADAN.	Medium maturing.
19	TGX 1987- 62F	IITA, IBADAN.	Extra early maturing, resistant to rust.
20	TGX 923 -2E	IITA, IBADAN.	Late maturing.

Table 2a: Physical properties of the sites for the research work.

Soil Parameters		Sample Location		
		Makurdi	Yandev	Abejukolo
Particle Size Distribution (%)				
	Sand	70.5	80.0	64.3
	Silt	13.5	15.9	12.2
	Clay	16.0	4.1	23.5
Textural Class		Sandy loam	Loamy sand	Sandy clay loam
P^H	H_2O 1:1	6.35	6.15	6.00

Table 2b: Chemical Properties of the Soils at the various locations

		Makurdi	Yandev	Abejukolo
Organic (%)				
	C	0.77	0.63	0.70
	M	1.33	1.09	1.26
	N	0.107	0.088	0.11
Available	P (ppm)	3.91	2.79	4.18
Exchangeable bases	(Cmol kg^{-1})			
	Ca	3.6	2.41	4.5
	Mg	2.25	1.92	2.84
	K	1.29	0.76	1.48
	Na	0.68	0.48	0.9
	CEC (Meq/100g)	8.04	5.87	9.66

Table 3: Geographical position of the locations

S/N	Location	Elevation (Above Sea Level)	Longittude	Latitude
1	MAKURDI	78m	07^0 51.503"	007^0 30.535"
2	YANDEV	191m	07^0 51.491"	007^0 30.531"
3	ABEJUKOLO	80m	07^0 51.504"	007^0 30.536"

Source: Global Positioning System (GPS).

Table 4: Combine ranges, overall mean, mean squares, degree of freedom an d standard errors of traits of elite genotypes of soybean evaluated at Makurdi, Yandev and Abejukolo during the 2010 season.

Traits	Ranges	Overall means	Standard error	CV
NDW (g)	0.46-1.07	0.77	0.43	56.1
DF	42.00-53.00	46.41	1.42	3.1
PHF (cm)	17.20-63.40	34.16	4.84	14.2
DM	86.00-137.0	110.2	4.14	3.8
PHM (cm)	25.00-85.60	47.61	8.25	17.3
NB	1.80-7.20	4.18	0.84	20.3
NPP	19.80-165.2	63.50	25.81	40.7

PW (g)	0.16-0.66	0.38	0.09	24.3
NSP1	2.00-2.40	2.10	0.08	4.1
NSP2	17.20-484.0	126.4	63.22	50.0
WHS (g)	7.07-18.09	12.07	0.99	8.3
Yld(tonha1)	0.61-6.73	2.55	0.96	40.6

* = significant at 5%, **= significant 1%.

KEY: NDW (g) - Nodule dry weight; DF – Days to 50% flowering; PHF (cm) –Plant height at flowering; DM – Days to maturity;PHM (cm)-Plant height at maturity; NB – Number of branches; NPP – Number of pods per plant; PW (g) – Pod weight;NSP^1 Number of seeds /pod; NSP^2 - Number of seeds/ plant; WHS (g) Weight of 100 seeds; and Yld($tonha^{-1}$) = Yield in tons per Ha.

Table 5: Combined analysis of variance table and grand means for 15 traits evaluated in the 20 elite soybean genotypes at Makurdi, Yandev and Abejukolo during the 2010 season.

Traits	Mean squares				
	Block	Location	Entries	Location x Entries	Error
d.f	2	2	19	38	117
NDW (g)	1.83	3.27**	0.29	0.18	0.18
DF	0.58	124.67**	38.37**	4.04**	2.01
PHF (cm) l	25.14	5279.37**	51.94**	23.47	23.48
DM	136.57	237.01**	409.93**	25.18	17.15
PHM (cm)	84.83	12695.59**	159.06**	50.57	68.07
NB	0.17	7.90*	2.15**	0.54	0.71
NPP	949.1	27682.8**	1106.2	393.0	666.1
PW (g)	0.01	0.05**	0.01	0.01**	0.00
NSP1	0.00	0.39**	0.6**	0.13**	0.00
NSP2	3370.0	157210.0**	7601.0*	4083.0	3997.0
WHS (g)	3.12	195.64**	11.36**	0.85	0.99
Yld ($toha^{-1}$)	0.18	63.28**	2.32**	1.08	1.07

* = significant at 5%, **= significant 1%.

KEY: NDW (g) - Nodule dry weight; PHM (cm)-Plant height at maturity; NB – Number of branches; NPP – Number of pods per plant; PW (g) – Pod weight; NSP^1 Number of seeds /pod; NSP^2 - Number of seeds/plant; WHS (g) Weight of 100 seeds; and Yld ($tonha^{-1}$) - Yield in tons per hectare.

Table 6: Combined mean performance of seed yield of soybean and its components evaluated in Makurdi, Yandev and Abejukolo

Entries	NDW	DF	PHF	DM	PHM	NB	NPP	PW	NSP1	NSP2	WHS	Yld
NCRI SOY 16	0.713	44.89	32.82	113.78	50.56	4.133	69.2	0.3878	2.1111	149.1	12.878	2.891
NCRI SOY 5.	0.508	47.00	35.51	115.33	52.58	4.444	67.4	0.4244	2.2000	136.3	14.344	3.756
SAM SOY 2	0.746	46.44	37.71	115.78	57.26	4.733	74.1	0.4056	2.1111	124.5	13.116	2.477
TGX 1440-1E (check)	0.468	44.00	30.20	113.67	42.38	4.711	57.4	0.3689	2.0667	113.2	12.401	2.326
TGX 1448-2E (check)	0.724	46.33	34.62	115.67	44.27	4.333	63.7	0.3789	2.1111	133.4	12.504	2.684
TGX 1485-1D (check)	0.754	45.22	30.89	110.89	40.31	3.333	58.7	0.4022	2.1778	102.7	11.443	1.984
TGX1835-10E (check)	0.857	45.00	32.71	93.56	42.32	4.511	35.2	0.3700	2.0889	60.8	11.932	2.078
TGX 1904-6F	0.463	43.89	32.60	111.33	50.09	4.044	64.7	0.4067	2.1111	131.7	12.818	2.721
TGX 1984-17F	0.929	50.69	35.98	106.00	44.96	4.556	64.5	0.3633	2.1111	154.9	10.803	2.964
TGX 1984-19F	0.762	43.89	29.74	100.33	52.53	3.533	54.2	0.3678	2.0667	74.1	11.553	2.494
TGX 1984-1F	0.742	46.33	34.89	112.56	44.04	3.622	66.6	0.3967	2.0889	145.8	12.010	2.421
TGX 1984-22F	0.999	46.78	33.73	112.11	46.18	4.844	77.5	0.3544	2.0222	162.4	12.100	3.209
TGX 1984-5F	0.589	45.67	34.71	107.33	50.56	4.333	63.6	0.3878	2.1333	136.8	11.773	2.569
TGX 1985-12F	0.903	46.67	33.62	111.67	47.89	4.444	74.4	0.3989	2.1333	148.2	11.993	2.722
TGX 1986-1F	1.039	45.89	36.71	112.11	50.69	4.289	74.8	0.4500	2.0667	152.1	13.334	3.074
TGX 1987-10F	0.714	47.89	36.82	102.11	46.13	3.156	38.4	0.4167	2.0667	72.2	12.843	1.602
TGX 1987-19F	0.638	46.11	34.53	112.11	45.87	4.244	72.2	0.3978	2.1556	128.0	11.622	2.608
TGX 1987-57F	0.916	45.11	33.67	109.56	48.73	4.644	69.5	0.3600	2.1333	141.6	12.258	2.490
TGX 1987-62F	0.901	50.18	39.05	102.01	49.91	3.868	63.7	0.3503	2.0896	111.3	9.742	2.306
TGX 923-2E (check)	1.078	50.78	33.60	124.33	44.89	4.733	57.7	0.2711	2.0667	146.6	9.622	1.660
Lsd (5%)	0.404	1.32	4.52	3.86	7.70	0.790	24.1	0.0870	0.0803	59.0	0.932	0.375

* = significant at 5%, **= significant 1%.

KEY: NDW (g) - Nodule dry weight; DF – Days to flowering; PHF (cm) –Plant height at flowering; DM – Days to maturity; PHM (cm)-Plant height at maturity; NB – Number of branches; NPP – Number of pods per plant; PW (g) – Pod weight; NSP^1 Number of seeds /pod; NSP^2 - Number of seeds/ plant; NPH – Number of plants harvested; WHS (g) Weight of 100 seeds; and Yld ($tonha^{-1}$) - Yield in tons per hectare.

Table 7: Genotypic, phenotypic and environmental variances and broad sense heritability and genotypic coefficient of variation and phenotypic coefficient of variation of seed yield and its components in soybean evaluated at Abejukolo, Makurdi and Yandev during the 2010 cropping season.

Traits	Genotype variance	Phenotypic variance	environmental variance	Broad sense Heritability (h^2)	Genotypic Coefficient of Variation	Phenotypic coefficient of variation
NDW (g)	367.12	595.42	228.30	0.62	20.84	26.54
DM	736.73	1239.37	502.64	0.59	17.80	23.08
NB	0.45	0.78	0.33	0.57	7.33	9.67
NPP	1.10	1.84	0.74	0.60	31.09	40.20
PW (g)	529.29	638.01	108.72	0.83	73.08	80.23
NSP1	6.67	8.34	1.67	0.80	13.37	14.95
NSP2	75.86	101.15	25.29	0.75	41.15	47.52

KEY: NDW (g) - Nodule dry weight; DM – Days to maturity; NB – Number of branches; NPP – Number of pods per plant; PW (g) – Pod weight; NSP[1] Number of seeds /pod; NSP[2] - Number of seeds/ plant;

Table 8: The combined genotypic correlation coefficient of seed yield and yield related traits of soybean genotypes evaluated in Abejukolo, Makurdi and Yandev during the 2010 season

	NDW	DF	PHF	DM	PHM	NB	NPP	PW	NSP1	NSP2	WHS
NDW											
DF	0.528*										
PHF	0.258	0.631**									
DM	-0.017	0.139	0.006								
PHM	-0.103	-0.076	0.337	0.073							
NB	0.208	0.121	0.05	0.384	0.121						
NPP	0.123	0.020	0.226	0.59**	0.407	0.405					
PW	-0.418	-0.446	0.198	-0.14	0.286	-0.342	0.169				
NSP1	-0.421	-0.105	0.014	0.144	0.092	-0.08	0.183	0.358			
NSP2	0.228	0.225	0.227	0.698	0.148	0.512*	0.844**	-0.058	0.078		
WHS	-0.476*	-0.558	0.01	0.12	0.366	0.039	0.165	0.769**	0.234	0.048	
YLD	-0.14	0.130	0.122	0.197	0.42	0.38	0.655**	0.396	0.258	0.556**	0.519*

** Significant at 0.01 level, * Significant at 0.05 level

KEY: NDW (g) - Nodule dry weight; DF – Days to flowering; PHF (cm) –Plant height at flowering; DM – Days to maturity; PHM (cm)-Plant height at maturity; NB – Number of branches; NPP – Number of pods per plant; PW (g) – Pod weight; NSP[1] Number of seeds /pod; NSP[2] - Number of seeds/ plant; NPH – Number of plants harvested; WHS (g) Weight of 100 seeds; and Yld ($tonha^{-1}$) - Yield in tons per hectare.

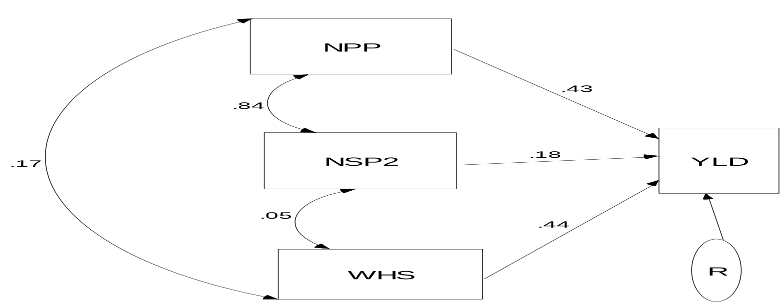

Figure 1: Combined Path diagram for yield and yield components of soybean evaluated at Abejukolo, Makurdi and Yandev during the 2010 season.

Key: Double-arrowed lines indicate the genotypic correlation between traits.Single- arrowed lines indicate the path coefficients (direct effect).NSP2 – Number of seeds per plant; NPP – Number of pods per plant; WHS – Weight of one hundred seeds; YTHA – Yield in tons per hectare; and R – Error.