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Full Length Research Paper

Variation and interrelationships for pod and seed yield characters in bambara groundnut (*Vigna subterrenea*) in Adamawa State, Nigeria

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Entries of ten accessions of bambara groundnut were evaluated for variation and interrelationships for pod and seed yield characters in a randomized complete block design with three replication for two years. Seed and pod yield component characters were measured and evaluated. Significant differences (P<0.05) were recorded for seedling and seed yield characters. High broad sense heritability provides that to large extent additive genetic effects are more important that non additive and environmental influences. The number of nodules and effective nodules could effectively discriminate among the accessions evaluated. The number of trifoliate had the largest direct effect on pod yield, suggesting its influence on pod yield, while the number of effective nodules recorded the largest indirect effect on pod yield and its largest indirect effect through fodder weight/plant. The path analysis revealed the adverse effect of pod/plant on pod yield/ha^{-1} was largely due to indirect effect of plant height at flowering, fodder weight and number of effective nodules. The seed weight had the largest influence on seed yield/ha^{-1}; this was masked by plant height at flowering and petiole length. Pod length could be a selection indicator for seed yield. The incorporation of these characters in existing accessions is practicable because of their relative importance.

Key words: Association analysis, bambara groundnut, heritability, masking action, phenotypic variance, pod and seed yield ha-^{1}.

INTRODUCTION

Bambara groundnut (*Vigna subterranea*) is indigenous to Africa and has been cultivated for centuries from Senegal to Kenya, and from Sahara to South Africa and Madagascar. It originated in several areas in Nigeria, notably between Jos (Plateau) and Yola (Adamawa) (Hepper, 1970). The crop is extensively cultivated throughout Guinea, Sudan and Sahel savannah agro ecological zones of the country, with exceptions in the riverine areas, for household consumption and livestock feed and a reliable source of income. However, accurate consumption and yield figures are limited (Taminu et al, 1990). The estimated seed yield from farmers' fields in the Sudan and Sahel savannah is 1000kg/ha^{-1}, but this has reduced significantly due to inherent abiotic and biotic stress. In most agro ecological zones of the north eastern Nigeria, production is limited by inconsistent yield, within season drought, poor establishment, low soil fertility and susceptibility to pests and diseases. Subsequently, areas under Bambara cultivation had noticed decline in pod and seed yield. The challenges of adapting bambara groundnut to stress require systematic approach to exploit increase yield stability in stress prone environment.

Bambara groundnut has received little attention in terms of crop improvement; traditional landraces are still being cultivated by farmers. Therefore, low yields, susceptibility to biotic stress are most frequent. Determination of the magnitude of genetic divergence among the landraces is a prerequisite for genetic improvement; to predict pod and seed yield and selection criteria for improvement in yield through indirect yield components via selection index. Correlation and regression analyses have been extensively used in the determination of most effective breeding procedure in crop improvement but the

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Table 1. Mean squares, phenotypic and genotypic variance and heritability estimates for agronomic characters.

SV	df	E7d	E11d	EHtfl	RtLFl	NdFl	End	LvFl	LwFl	Pd/pit	Pd/plot	Fwt/plt	Fwt/plot	Pwt/plt	Pdw	Sl	Sw	Spp Swt/plt	Pdl
Rep	2	139.03**	1798.43**	7.23**	10.03	1156.43**	696.10**	0.08	0.25	48.91**	90250.52	4.61	28350.30*	304.15*	0.008	0.0010	0.007	0.03±58.35	0.07
Acc	9	78.46**	57.94	3.61**	43.57**	358.23*	153.39	1.45	0.41	27.18	36917.35	28.74*	18909.67*	44.63	0.006	0.03**	0.20**	0.05±310.90**	0.34**
Error	18	28.11	68.0	0.83	11.63	126.02	74.13	0.72	0.27	13.23	15888.71	6.55	5090.32	28.55	0.003	0.003	0.006	0.03 ± 26.85	0.06
R^2		0.66	0.77	0.76	0.66	0.71	0.67	0.50	0.40	0.59	0.64	0.69	0.71	0.66	0.57	0.86	0.66	0.52± 0.85	0.74
σp		97.20	103.27	4.16	51.32	442.24	202.81	1.93	0.59	36.00	47509.82	33.11	22301.22	63.66	0.008	0.03	0.20	0.07± 328.79	1.94
σg		69.09	35.27	3.33	39.69	316.22	128.68	1.21	0.32	22.77	31621.11	26.56	17210.89	35.11	0.005	0.03	0.20	0.04 ± 301.94	1.89
Hb		71.08	34.13	80.0	77.82	71.50	63.42	62.69	54.23	63.25	66.56	80.22	77.17	55.15	62.50	100.0	100.0	57.14 ± 92.0	97.42

*, **= Significant at 5% and 1% level of probability.
E7d= Emergence count at 7 days, E11d= Emergence at 11 days, E14d =Emergence at 14 days,, HtFl= Height at flowering, RtFl= Root at flowering, NdFl= Nodules after flowering, Effnd=Effective nodules at flowering, Lvl Fl= Leaf length at flowering, LvwFl= Leaf width at flowering, Pdplt= Pods/plant, Pdplt=Pod/plot, Fdwt/plt=Fodder weight /plant, Fdwt/plot= Foddr weight/plot, Pwtha-1=Pod weight/hectare, Pdw=Pod width, Sl=Seed length, Sdw=Seed width, Spp= Seed/plot, Wt100s= Weight of hundred seeds, Notri= Number of Trifoliates, Pdl= Pod length.

path analysis was designed to quantify interrelationships of different components and their direct and indirect effect on dependent variable (Rao et al., 1997). This could provide information desirable for developing selection methodologies for pod and seed yield in this environment. This study therefore seeks to determine the magnitude of variation among agronomic characters of bambara groundnut as a prerequisite for crop improvement and to evaluate interrelationships among characters for pod and seed yield.

MATERIALS AND METHODS

Entries of ten accessions of bambara groundnut seeds sourced from Adamawa, Gombe and Borno states (North eastern Nigeria) and preserved in the germplasm of the University for 6 months. The establishment of the experiment coincides with the planting period for bambara groundnut in the north eastern Nigeria. Field evaluation was laid out in a randomized complete block design was during 2006/07 and 2007/08 cropping season at the Teaching and Research Farm. Location and climatic variables at Mubi, Adamawa state are; 13°E Latitude;10°1N Longitude; altitude 599 m; average annual precipitation condition 760mm; average minimum tempe-rature 12°C; average maximum temperature 36°C. The soil type was a sandy-loam soil. The soil analysis for both years of evaluation indicated a p^H of 5.16, 20.00% sand; 22.40% clay; 0.68% organic carbon; 1.12 organic matter content; 1.36 total nitrogen, 1.35 phosphorus; 9.10ppm potassium; 2.50 ppm sodium; 2.50 ppm carbon; 0.60 ppm magnesium; 18.70 CEC; 20.50 ECEC; 6.10 C:N ratio; and 1.10 base saturation. Both pod and field evaluations were used in this study. For the pot experiment, two seeds of each accession was planted in six pots of 45 m^2 filled with sterilized soil. Field planting was done at 0.30 m within row and interow spacing of 0.75 m. Weeding was carried out manually using hoes at 2 - 3 weeks after planting, at flowering and at mid podding. No fertilizer and insecticidal application was carried out. For both years of evaluation, data was collected on emergence count at 7, 11 and 14 days after planting. By harvesting two stands of bambara groundnut plants in the pot at flowering, the number of nodules were counted and effective nodules was determined by the presence of purple pigmentation in slice root nodules. Other characters measured include number of pods/plant, fodder weight (kg), pod length and width (cm), seed weight (kg) and weight of hundred seeds (g).

Data collected for both years of evaluation were pooled and submitted for statistical analyses. The mean for each trait over three replication and two years was computed for each accession using PROC MEANS. Using PROC GLM, PROC CORR, and PROC REG procedure of SAS (1999). The principal components analysis was carried out using PRINCOMP procedure of SAS statistical software (SAS Institute Cary N. C 1997). Principal components with eigen values greater than 1.0 were selected. Correlation values between the original characters and their respective principal components were obtained. Taking pod and seed yield as response variable, the direct and indirect effects of characters on pod and seed yield were analyzed using path coefficient analysis as specified by Dewy and Lu (1959).

RESULTS AND DISCUSSION

The means squares, variance components and broad sense heritability estimates are shown in Table 1. Significant differences (P<0.05) among the accessions was recorded for emergence at seven days, height at flowering, root length at flowering, number of nodules at flowering, fodder weight/plant, fodder weight/plot, pod yield/ha^{-1}, seed length and width, seed weight/plant, number of trifoliate and pod length. This is an indication of the inherent variation among the accessions, besides this could provide basis for genetic studies. Estimates of phenotypic variance were greater in magnitude than their corresponding genotypic and environmental variance. Exceptions was recorded in seed length and width, they recorded same estimates for genotypic and phenoltypic variance. Heritability estimates were moderate to high for most characters implying that these characters are highly heritable among the

Table 2. Eigen values proportion and eigen vectors for agronomic characters of bambara groundnut**.**

Character	Prin 1	Prin2	Prin 3	Prin4	Prin 5	Prin 6	Prin 7
E7d	0.26	0.04	-0.17	0.17	0.24	-0.10	0.23
E14	0.30	0.01	-0.04	0.37	-0.04	-0.002	-0.09
E11d	0.26	0.18	-0.03	0.31	-0.16	0.13	0.05
Ht at Flowering	-0.18	0.22	0.13	-0.28	0.18	0.02	0.008
Rt Fl	0.16	-0.005	-0.17	-0.36	0.15	0.35	-0.05
Nd Fl	0.33	-0.15	0.11	0.11	0.23	-0.18	-0.09
Eff nd	0.30	-0.19	0.08	0.13	0.19	0.16	-0.03
LvlFl	-0.18	0.18	0.04	0.27	0.30	0.30	0.34
LvwFl	-0.21	-0.08	0.08	0.20	0.27	0.40	0.36
Pdplt	-0.11	0.30	-0.25	0.13	0.02	-0.18	-0.11
Pdplot	0.01	0.32	-0.34	-0.006	-0.04	0.15	-0.21
Fdwtplt	0.28	0.02	-0.04	-0.15	0.34	-0.04	0.16
Fwtplot	0.17	0.32	-0.22	0.031	0.06	-0.03	0.13
Pdwt/plt	0.10	0.39	-0.08	-0.06	0.14	-0.04	0.0008
Pwtha-1	-0.14	0.33	-0.04	-0.05	0.11	-0.36	0.01
Pdw	0.27	0.08	-0.08	-0.06	-0.34	0.16	0.22
Sdl	0.17	0.06	0.36	-0.06	0.04	-0.16	0.10
Sdw	0.23	0.20	0.17	0.16	0.14	0.20	-0.30
Spp	0.005	0.01	0.07	0.33	0.04	0.39	-0.48
Sdwt/plt	0.03	0.18	0.44	0.04	0.08	0.02	-0.16
Sdwt/plot	0.05	0.28	0.37	-0.12	-0.10	0.10	-0.06
Wt100s	0.17	0.10	0.28	-0.12	-0.11	0.05	0.31
Notri	0.25	-0.06	-0.11	-0.23	-0.30	0.23	0.15
PdL	-0.06	0.23	0.21	0.27	-0.39	-0.10	0.17
Eigen value	5.16	3.48	3.44	2.26	1.54	1.36	1.14
Proportion	0.22	0.15	0.14	0.09	0.06	0.05	0.04

E7d = Emergence count at 7 days, E11d = Emergence at 11 days, E14d = Emergence at 14 days,, HtFl = Height at flowering, RtFl = Root at flowering, NdFl= Nodules after flowering, Effnd = Effective nodules at flowering, Lvl Fl = Leaf length at flowering, LvwFl = Leaf width at flowering, Pdplt = Pods/plant, Pdplt = Pod/plot, Fdwt/plt = Fodder weight /plant, Fdwt/plot = Foddr weight/plot, Pwtha^{-}1 = Pod weight/hectare, Pdw = Pod width, Sl = Seed length, Sdw = Seed width, Spp = Seed/plot, Wt100s = Weight of hundred seeds, Notri = Number of Trifoliates, Pdl = Pod length.

accessions evaluated. Perfect heritability was recorded for seed length and width. A high heritability for characters provides that these characters are less influenced by environmental factors; selection based on the phenotype expression could be worthwhile for genetic studies. A high heritability and genotypic variance suggest favoura-blea dvances in selection for these characters. The multivariate analysis of variation indicated that the first seven principal axes recorded eigen values greater than 1.00 and altogether they summarize 77% of the total variation observed (Table 2). The first principal axis recorded 22% of the total variance and had almost all the characters correlated positively with it. Principal axis 1 was described largely by seedling characters. Characters of importance in axes two and three are reproductive and seed yield characters. The number of nodules and effective nodules at flowering could effectively be used to discriminate among the accessions evaluated. As shown in Table 3, significant (P<0.05) and positive correlation coefficient was recorded in the association between pod weight and plant height, nodules at flowering, pods/plant, fodder weight and num-ber of trifoliate, implying pleitropic genetic action among these characters for enhanced pod yield. An independent association between pod yield/ha and number of nodules and effective nodules suggesting an independent action in the selection index for these characters. Our result is in line with the reports of Adeniyi et al (2005) in soybeans.

The direct and indirect effects of some characters on pod yield/ha^{-1} (Table 3) showed that the number of trifoliate had the largest positive direct effect on pod yield and its largest reduction in fodder weight/plant. The masking action of number of trifoliate on pod yield may be associated with partition and distribution of photo-synthate. Although fodder weight recorded a positive correlation coefficient with pod yield. This demonstrates

Table 3. Direct and indirect influence of characters on pod yield in bambara groundnut.

Character	Direct Effect	HtFl	NdFl	Effnd	Pd/plt	Fwt/plt	Notri	Correlation coefficient
HtFl	0.24		-1.34	3.32	-1.72	0.74	-0.94	0.30
NdFl	-0.25	0.10		-0.39	1.28	-0.30	-0.08	0.36
Effnd	-1.63	0.62	-1.10		-0.20	2.96	-1.00	-0.37
Pd/plt	1.67	-0.65	1.73	-1.61		-1.22	-0.53	-0.45
Fwt/plt	0.40	0.44	-0.55	1.71	-0.25		-0.26	0.35
Notri	1.70	0.53	0.10	-0.57	0.20	-1.47		0.49

HtFl = Height at flowering, NdFl = Nodules after flowering, Effnd = Effective nodules at flowering, Pdplt = Pods/plant, Fdwt/plt = Fodder weight /plant, Notri = Number of Trifoliate, Pdl = Pod length.

Table 4. Direct and indirect influence of characters on seed yield on bambara groundnut.

Characters	Direct Effect	Pdwt	Sdl	Sdw	Spp	Swt/plot	Wt100s	Notri	Pdl	Htfl	Correlation coefficient
Pdwt	-0.72		0.85	-1.49	1.90	0.07	0.15	2.00	1.62	-0.92	0.22
SdL	-0.32	0.29		-0.43	0.57	0.02	-0.27	0.41	-0.21	0.50	0.56**
SdW	1.60	-2.05	-0.84		-1.42	0.07	0.48	-0.94	1.87	1.68	0.45**
Spp	0.92	1.10	0.44	0.44		-0.13	0.20	0.72	-2.85	-0.67	0.17
Swt/plot	2.77	1.06	1.40	1.11	0.37		0.22	0.12	-2.89	-3.39	0.76**
Wgt100s	0.21	-0.32	-0.24	0.15	0.10	0.02		0.16	0.11	0.25	0.44**
Notri	1.09	0.86	0.27	0.27	2.12	-0.01	-0.06		-0.81	-3.43	0.30
PdL	1.81	-1.83	-0.71	1.97	-1.17	0.08	-0.41	-0.54		1.26	0.43**
HtFl	-0.34	-0.28	0.46	0.29	0.26	-0.03	-0.01	-0.13	-0.03		0.18

HtFl = Height at flowering, Fdwt/plt = Fodder weight /plant, Sdw = Seed width, Spp = Seed/plot, Notri = Number of Trifoliate, Pdl = Pod length, swt/plot = Seed weight/plot, Pdl = pod length

the defects of selection based on intercharacter correlation alone. A similar result was obtained by Ariyo et al (1987) for pod yield in Okra (*Abelmoschus esculentus*). The number of effective nodules recorded the largest indirect effect on pod yield/ha^{-1} and its largest indirect effect through fodder weight/plant. The path analysis revealed the adverse effect of pods/plant on pod yield/ha^{-1} was largely due to indirect effect of plant height at flowering, fodder weight/plant and effective nodules at flowering.

Considering the direct effects of number of trifoliate and pod/plant on pod yield/ha^{-1} and its association with yield, they appear most reliable index for pod yield. The direct and indirect influence of selected characters on seed yield /ha^{-1} and correlation coefficients are shown in Table 4. Seed weight/plot had the largest positive direct effect on seed yield/ha^{-1}. This influence was masked by the plant height at flowering and petiole length. Although both recorded a positive correlation coefficient with seed yield/ha^{-1}.The pod weight/ha-^{1} recorded large indirect effect on seed weight and its largest indirect effect through pod length. The path analysis indicated that the direct effect of pod length was largely due to the indirect effect of pod length, seed length, seed/pod, weight of 100 seeds and number of trifoliate. For seed yield/ha^{-1}, seed weight/plot could be selected as are reliable indicator for seed yield/ha^{-}1 in bambara groundnut. Similarly pod length could be a selection indicator for seed yield/ha^{-}1, its positive correlation coefficient with seed yield implies that longer pods will produce more seeds. Both characters constitute component traits for seed yield/ha^{-1}.The little residual values obtained in both cases suggest that necessary characters had been included in the model model. The result of the stepwise multiple regression analysis of characters on seed yield/ha^{-1} indicated that seed weight/plot, number of trifoliate and plant height at flowering are important determinants of seed yield/ha^{-1}. They altogether summarized 78% of total variation in seed yield. Therefore emphasis should be placed on these characters during selection process. The introgression of these characters in existing accessions is practicable because of their relative association with seed yield.

REFERENCES

Adeniyi IA, Ariyo OJ, Adebisi MA, Ojo DK, and Aminu SO (2005). Yield components in soybeans using path coefficient analysis and stepwise regression analysis. Proceedings of the Genetic Society of Nigeria Conference, 6-9 Nov., Edited by Olakojo SA, Ogunbodede BA and SR Akande. pp. 61-65

Ariyo OJ, Akenova MC, Fatokun CA (1987). Plant character correlation and path analysis of pod yield in Okra Euphytica 36: 687-695.

Dewy DR, KH Lu (1959). A correlation and path coefficient analysis of components of crested wheatgrass seed production. Agron. J. 51: 515-518.

Hepper FN (1970). Bambara groundnut (*Voandzeia subterranean)* Field Crop Abstracts 23:1-6.
Rao TS, Ramu RM (1997). Breeding investigations in Bhindi (*Abelmoschus esculentus* L.) Moench Mysore J. Agric. Sci 10:146 (Abstr).
SAS institute (1997) SAS Users Guide: Statistics. Version 5 ed. SAS Inst. Gary, NC .
Tanimu B, Ado S, Aliyu G (1990). Genotypic variability in bambara groundnut cultivars at Samaru, Nigeria. In: Proceedings of the 17th Annual conference of Genetic society 0f Nigeria (I.O Obigbeshan, Ed) Institute for Agricultural Research and Training. Obafemi Awolowo University Nigeria. pp. 54-60.