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Correlation and path coefficient analysis of yield characters of bambara (*Vigna subterranea L.Verdc*.)

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The study was conducted to determine the inter-relationship between grain yield of Bambara groundnut and its various yield characters at Samaru (11°11'N, 07°38'E, 686 m above sea level) in the Northern Guinea Savanna of Nigeria, using simple correlation and path coefficient analyses. The result reveals strong positive correlation between number of pods/plants (r = 0.74), 100-grain weight (r= 0.35**) and harvest index (r = 0.83**) with seed yield. Harvest index made the highest direct percent contribution to seed yield (39.872%) followed by number of pods/plant which contributed 12.809%. The largest combined percent contribution to seed yield were obtained through number of pods/plant and harvest index (13.677%). Although 100-grain weight had significant positive correlation with grain yield (r = 0.35**), its direct independent contribution to grain yield was found to be very low (0.778%) due to high component compensation and unfavourable weather conditions while the correlation and direct contributions of number of seeds and shelling percentage to grain yield were weak and small, respectively. Therefore, the most important yield determinants of bambara groundnut which should be exploited through a breeding programme for improving its yield potentials, were number of pods/plant, and harvest index.**

Key words: Correlation, path coefficient, yield characters and percent contributions.

INTRODUCTION

Yield characters of crops such as number of flowers per plant, number of seeds/pod, seed size, spikelet number/spike,100-seed weight, fruit weight/plant among others have been found to be associated with the final yield of crops. These relationships tend to give an insight into the importance and possibility of exploiting these characters to improve the yield potentials of crops through the use of certain agronomic practices and breeding programmes. In this regards, several researchers have, therefore identified important yield characters which influence the final yields of many crops. For instance, in legumes, such as green gram, John (1982), reported that number of pods/plant, number of pods/peduncle, and 1000-seed weight significantly influenced yield. In soybean, the main contributing components to yield were number of pods/plant and 100-seed weight (James et al., 1999; Amodu, 2004). In Irish potato, tuber yield/hill, tuber fresh weight and number of tubers/plant influenced the final yield of the crop (Babaji, 2004).

In bambara groundnut, the relationship between characters has not been extensively studied. However Tanimu (1996), reported significant and positive correlation

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Table 1. Correlation coefficients between yield characters and grain yield in bambara groundnut.

Parameter	Grain yield	Number of pods/plant	100-grain weight	Shelling %	Number of seeds/pod	harvest index
Grain yield	-					
No. of pods/plant	0.74**	-				
100-grain weight	0.35**	0.21	-			
Shelling %	0.09	0.02	0.05	-		
No. of seeds/pod	-0.12	-0.08	0.02	0.10	-	
Harvest index	0.83**	0.55**	0.28*.	-0.05	0.11	-

Data is average of two years.* and ** Significant and highly significant, respectively.

of shelling percentage and 100-seed weight with grain yield of the crop. Similarly, a study by Oyiga and Uguru (2011) revealed a strong positive correlation and contributions of number of pods and number of flowers to seed weight per plant of early and late planted bambara groundnut. Misangu et al. (2007), and Itai et al. (2009) have also reported significant positive correlation and large contributions of number of pods/plant to seed yield of bambara groundnut. Although correlation between 100-grain weight and seed yield was not significant, it had large direct contribution to seed yield (Misangu et al., 2007). As a result, information on the relationships between the various yield characters as well as their percentage contribution to grain yield are still needed to determine the extent of contribution of each yield component to the yield. The present study is, therefore, aimed at determining the inter-relationships between grain yield of Bambara groundnut and some of its yield characters in the Northern Guinea savanna of Nigeria using simple correlation and path coefficient analysis.

MATERIALS AND METHODS

Field experiments were conducted during the 2007 and 2008 wet seasons at the Experimental Farm of the Institute for Agricultural Research, Samaru (11011'N; 70 38'E, 686 m above sea level) in the Northern Guinea savanna zone of Nigeria to determine the inter-relationships and contributions of various yield characters to Bambara groundnut seed yield. The experiment was laid out in a randomized complete block design with three replications. The cultivar used for the study was 'Mubi white; a cream white seeded cultivar, bunched, early maturing, high yielding, with medium sized pods and seeds grown widely in Northern Nigeria.

To ensure optimum crop performance, weeds were controlled by pre-emergence application of Galex (metabromuron + metalochlor) at rate of 4.5 L/ha. Sherpa plus (Cypermethrin + Dimethoate) at the rate of 1 L/ha was applied fortnightly along with Benlate (Benomyl) to control insect pests and fungal diseases, respectively. At physiological maturity, the net plot ($9m^2$) of each plot was harvested. The number of pods/plant, 100-grain weight, number of seeds/pod, shelling percentage and harvest index were determined from a sample obtained from the net plot yield.

Simple correlation analysis (Little and Hills, 1978) was done to determine the magnitude and type of association between the characters concerned. Path coefficient analysis which measures the direct and indirect effect of one variable upon another and permits the partitioning of the correlation coefficient into components of direct and indirect effects was employed in line with procedure described by Wright (1921) and modified by Dewey and Lu (1959), Li (1948) and SAS Inst. (1997).

Path coefficients were calculated using the following simultaneous equations which express the basic relationships between correlation and path coefficients:

$$P_1 + r_{12} P_2 + r_{13} P_3 + r_{14}P_4 + r_{15}P_5 = r_{1y}$$
$$r_{12}P_1 + P_2 + r_{23} P_3 + r_{24} P_4 + r_{25}P_5 = r_{2y}$$
$$r_{13} P_1 + r_{23} P_2 + P_3 + r_{34}P_4 + r_{35}P_5 = r_{3y}$$
$$r_{14}P_1 + r_{24} P_2 + r_{34} P_3 + P_4 + r_{45}P_5 = r_{4y}$$
$$r_{15}P_1 + r_{25} P_2 + r_{35} P_3 + r_{45}P_4 + P_5 = r_{5y}$$
$$1 - (r_{1y} P_1 + r_{2y} P_2 + r_{3y} P_3 + r_{4y}P_4 + r_{5y}P_5 = R$$

Where, 1 =number of pods/plant; r = correlation; 2 =100-grain weight; y = grain yield; 3 = shelling percentage; R = residual factors; 4 = number of seeds/plot; P = direct contribution; 5 = harvest index.

RESULTS AND DISCUSSION

The strong and positive correlation between number of pods/plant (r = 0.74**), 100-grain weight (r = 0.35**), and harvest index (r = 0.83**), and grain yield (Table 1) shows that these yield characters are important and have direct bearing on the final yield of Bambara groundnut. The significant positive correlation amongst the yield characters, such as: number of pods per plant and harvest index (r = 0.55**), and between 100-grain weight and harvest index (r = 0.28*) suggest that these characters also make positive indirect contribution to the final grain yield since there is no negative component compensation between them. The relationship between yield and yield characters such as shelling percentage and number of seeds/pod were however not significant (Table 1) which could be attributed to the sacrificial and unfavourable influence through number of pods. These relationships, particularly, the indirect associations could not sufficiently be compared using simple correlation analysis but by using path coefficient analysis (Table 2). This provides effective means of separating the direct and indirect causes of associations; and permits for an in-

Table 2. Path coefficient analysis of yield characters influencing grain yield in bambara groundnut.

Parameter	Value
Number of pods (x_1) vs yield (Y)	r =0 .7400
Direct (P1)	0.3579
Indirect via 100-grain weight (x_2)	0.0185
Indirect shelling % (x_3)	0.0026
Indirect via number of seeds/pod (x_4)	0.8137
Indirect via Harvest index (x_5)	0.3473
Total	**0.7400**
100-grain weight (x_2) vs. yield (Y)	r = 0.3500
Direct (P_2)	0.0883
Indirect via number of pods/plant (x_1)	0.0752
Indirect via Shelling % (x_3)	0.0065
Indirect via number of seeds/pod (x_4)	0.0034
Indirect via Harvest index (x_5)	0.1768
Total	**0.3500**
Shelling % (x_3) vs yield (Y)	r = 0.0900
Direct (P_3)	0.1269
Indirect via number of pods/plant (x_1)	0.0072
Indirect via 100-grain weight (x_2)	0.0044
Indirect via number of seeds/pod (x_4)	-0.0172
Indirect via Harvest index (x_5)	-0.0316
Total	**0.0900**
Number of seeds/pod (x_4) vs yield (Y)	r = -0.1200
Direct (P_4)	-0.1716
Indirect via number of pods/plant (x_1)	-0.0286
Indirect via 100-grain weight (x_2)	-0.0018
Indirect shelling % (x_3)	0.0127
Indirect via harvest index (x_5)	0.0695
Total	**0.1200**
Harvest index (x_5) vs yield (Y)	r = 0.8300
Direct (P_5)	0.6314
Indirect via number of pods/plant (x_1)	0.1969
Indirect via 100-grain weight (x_2)	0.0247
Indirect via shelling % (x_3)	-0.0064
Indirect via number of seeds/pod (x_4)	-0.0184
Total	**0.8300**

depth examination of the factors producing a given correlation and measures the relative importance of each factor. The use of path analysis shows that there was a positive direct association between grain yield and the various yield characters except with number of seeds/pod which was negative (Table 2).

The path coefficient analysis (Table 2) revealed that harvest index made the highest direct positive contribution of 0.6314 to grain yield followed by number of pods/plant (0.3579) while direct contribution by number of seds/pod was negative (-0.1716). Most of the yield characters assessed made their highest indirect contribution to grain yield through number of pods per plant and harvest index (Table 2). The least indirect contribution to the grain yield was via number of seeds per pod which was negative. Number of seeds/pod had negative yield component compensation with number of pods per plant and 100-grain weight. The positive association of shelling percentage with grain yield (Table 2) was compromised by its negative indirect associations with number of seeds/pod and harvest index. The 100-grain weight though significant and positively correlated to grain yield (Table 1), had little direct contribution to grain yield (Table 2).

The significant positive correlation and contributions of number of pods/plant and 100-grain weight to the grain yield are consistent with the findings of Misangu et al. (2007), and Oyiga and Oguru (2011). Although 100-grain weight had significant positive correlation with grain yield, its direct contribution to grain yield was low (0.0883) which contradicts results of previous studies (Karikari and Tabore, 2003; Misangu et al., 2007) due to high component compensation and unfavourable weather conditions. According to Wigglesworth (1996), the negative relationships among plant components could result from competition for ambient resources, such as; nutrients, moisture, light, genetic factors, such as linkage and pleitropy. Investigation by Jonah (2011) also showed that both phenotypic and genotypic associations of number of pods/plant with seed yield per plant were positive and significant. The significant positive correlation and direct positive contributions of number of pods and 100-seed weight conformed with similar results by John (1992) on green gram, Manggoel et al. (2012) on cowpea, James et al., (1999) and Amodu (2004) on soybean.

Result of direct and combined percent contributions of the various yield characters to grain yield is presented in Table 3. The highest direct percent contribution to grain yield was by harvest index (39.872%), followed by number of pods/plant (12.809%). Direct percent contributions of 100-grain weight, shelling percentage and number of seeds per pod were very small. They contributed only 0.778, 1.610 and 2.945%, respectively. Large combined per cent contribution to grain yield were made through number of pods per plant and harvest index (13.677%), combined contributions of number of pods per plant and 100-grain weight to grain yield via number of seeds/pod were -0.079 and -0.001, respectively. Contributions by other factors not accounted for by the various characters considered, as represented by residual factors was 27.236%.

Conclusion

The result revealed strong and positive correlation between number of pods/plant (r = 0.74**), 100-grain weight (r = 0.35**) and harvest index (r = 0.83**) with

Table 3. Direct and combined percent contributions of yield characters to bambara groundnut yield.

Parameter	% contribution
Direct contributions to yield	
Number of pods/plant, $x_1(P_1^2 \times 100)$	12.809
100-grain weight, (x_2) $(P_2^2 \times 100)$	0.778
Shelling %, x_3 $(P_3^2 \times 100)$	1.610
Number of seeds/pod, x_4 $(P_4^2 \times 100)$	2.945
Harvest index, x_5 $(P_5^2 \times 100)$	39.872
Total	58.014
Combined % contributions to the yield	
Number of pods/plant (x_1) and 100-grain weight (x_2)	0.279
Number of pods/plant (x_1) and shelling % (x_3)	0.004
Number of pods/plant (x_1) and Number of seeds/pod	0.079
Number of pods/plant (x1) and Harvest index (x_5)	13.677
100-grain weight (x_2) and shelling % (x_3)	0.006
100-grain weight (x_2) and Number of seeds/pod (x_4)	-0.001
100-grain weight (x_2) and Harvest index (x_5)	0.156
Shelling % (x3) and Number of seeds/pod (x_4)	0.044
Shelling % (x_3) and Harvest index (x_5)	0.401
Number of seeds/pod (x_4) and Harvest index (x_5)	0.263
Total	14.750
Residual ®	
$R = 1- rx_1YP_1 + rx_2YP_2 + rx_3YP_3 = rx_4YP_4 + rx_5YP_5$	27.236
Total	100.00

seed yield of bambara groundnut. Harvest index made the largest percent contribution of 39.872% to seed yield followed by number of pods/plant which contributed 12.809%. The highest indirect percent contribution to seed yield was obtained through number of pods/plant and harvest index (13.677%). We therefore conclude that harvest index and number of pods/plant were the most important yield components of bambara groundnut which should be exploited through a breeding programme for improving its yield potentials.

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