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Direct and Indirect Contribution of Yield Attributes to the Grain Yield of Cowpea [*Vigna unguiculata* (L.) Walp], grown in Northern Guinea Savanna, Nigeria.

Yohanna Mamma Kwaga*

Department of Crops Science, Adamawa State University, Mubi, Nigeria.

ABSTRACT

A field trial was conducted in 2011 rainy season to evaluate the performance of some cowpea genotypes at Mubi in the Northern Guinea Savanna ecological zone of Nigeria. The treatments consisted of five erect and semi-erect cowpea genotypes and a local cultivar (Kanannado).These were laid out in a randomized complete block design (RCBD) with three replicates. The path coefficient analysis of grain yield and yield attributes showed that number of pods per plant gave the highest percentage yield contribution of 31.85%. This was followed by plant height at 6 WAS which contributed 5.37%. The highest combined contribution of 8.66% came from pod number and 100 – grain weight. Residual percentage contribution was 49.24%. This showed that yield attributes in this study explained 50.76% of the variability in grain yield in the experimental material Furthermore ,the investigation suggests that number of pods per plant, plant height and 100 seeds weight can be considered as selection criteria in cowpea.

Keywords: Path – coefficient, direct contribution, indirect contribution.

Corresponding author

INTRODUCTION

Cowpea is one of the important leguminous crops cultivated in the Savanna ecological zone of Nigeria as cash crop as well as staple food crop. Different cultivars of the crop are cultivated in the Savanna ecology of Nigeria (Ng, 1995). Although the crop is mostly grown in mixtures with cereals such as maize, millet and Sorghum in the ecology (Blader, 2005), some farmers cultivate it as sole crop especially when sown late during rainy season.

The grain which contains 22.8% protein (Watt and Meril, 1975), provides easily accessible and cheap source of protein to the relatively poor in the society. Imungi and Potter (1983) analyzed mineral content in cowpea leaves and reported high calcium content (1556 mg/100g). The leaves are used locally in preparing soup; however grains remain the most important part of the crop. The performance of the different components of the crop can have significant impact on the grain yield. The analysis of the contribution to yield by the various components can serve as a useful framework for identifying beneficial traits for yield improvement (Ball *et al.,* 2001).

The contribution of the various components of crop to yield could differ in magnitude. Partitioning of assimilates to the various parts of the plant can also determine their contribution to the ultimate yield for which the crop is cultivated, whether it is for fodder, tuber or grains. Path analysis was developed by Wright (1921) as a tool for interpreting correlation between variables to determine hypothetical paths of causation between dependent and independent variables. Lleres (2005) regarded it as statistical technique used primarily to examine the comparative strength of the direct and indirect relationships among variables. Rangaswamy(2010) remarked that ir is a method of decomposing correlation into direct and indirect effects of variables that are hypothesized as casuals'. Analysis carried out by Hague *et al,.* (2012) showed that pod length, number of pods , numbers of clusters and primary branches per plant were the high contributors to pod yield in cowpea.. Also Mangguel *et al.,.* (2012) noted that number of peduncles, number of flowers pods per plant and 100-seeds weight were assessed as useful traits for selection in cowpea. However, Nwofia *et al,* (2013) observed that pod number per m^2 , seeds per plant exhibited negative' direct effect on pod yield in cowpea. In effect, path analysis can serves as a useful statistical tool in studying the influence of the various traits on the performance of crop. Therefore the coefficient analysis of the effects of different yield attributes to the grain yield of cowpea was undertaken with the objective of measuring the direct and indirect contribution of each attribute to the grain yield of cowpea.

Materials and Methods

A Field trail was undertaken in 2011 rainy season at the Teaching and Research Farm of Adamawa Sate University, Mubi, in the Northern Guinea Savanna ecological zone of Nigeria. Six cowpea genotypes were used in the study, consisting of four erect types namely IT97K-499 – 35, IT97 – 131 – 2, IT 98 KD – 391, IAR – 07 – 1050, IAR – 00 – 1074; one semi-erect, IAR-00-1070 and a local variety ("Kanannado") as check.

The experiment was laid out in a randomized complete block design (RCBD) in three replications. Each genotype was assigned randomly to a plot in every replication. All the genotypes were sown on the flat on August 11, 2011. About four seeds were sown per hill at the inter-row spacing of 75cm and intra-row spacing of 20cm and thinned to two seedlings per hill at two weeks after sowing (WAS). Each plot consisted of four rows that were 75cm apart and 5m long ($15m^2$). The two central rows ($7.5m^2$) comprised the net plot. The crop was fertilized using single superphosphate at the rate of 40kg P_20_5 per hectare by side placement at 2 WAS. The trial was hoe weeded twice at 3 and 6 WAS. The different genotypes were harvested by hand picking when the pods matured. Data collected were subjected to statistical analysis using analysis of variance for randomized complete block design and the means separated using Duncan multiple range test (Duncan, 1951).The degree and direction of relationships between yield and yield and yield attributes were done using Pearson's correlation coefficients The correlation coefficients were further partitioned to measure the direct and indirect effects as described by Rangaswamy(2010). Pearson correlation analysis was carried out between grain yield and other plant characters as given below.

$$r = \frac{SPX}{((SSX.SSY)^{1/2}}$$

r= correlation coefficient between X and Y

SPX =Sum of product
SSX= Sum of squares of X
SSY= Sum of squares of Y
X= Variable X
Y= Variable Y

A path diagram was constructed using the correlation coefficient values as given in Fig 1.

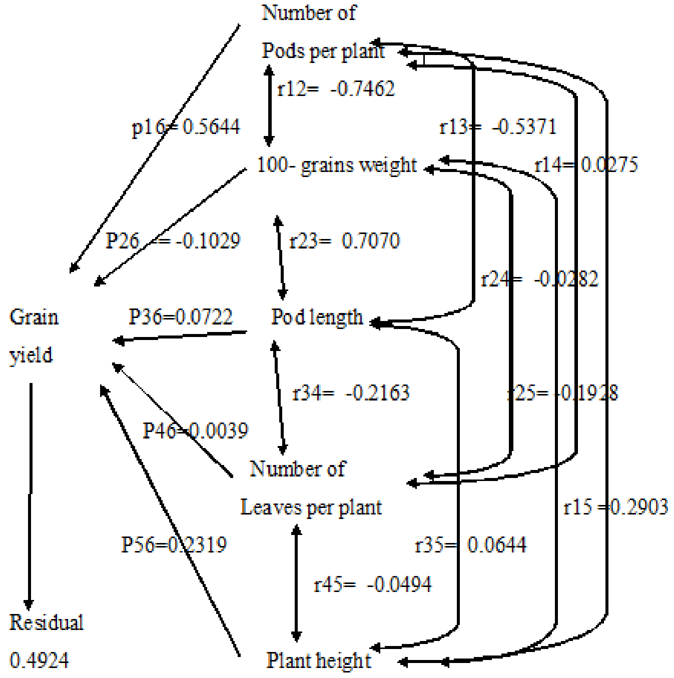

Fig 1: Path diagram showing direct and indirect effects of yield attributes on cowpea grain yield. Single arrows and double arrows indicate direct and indirect effects respectively.

A simultaneous equation was further developed from the path diagram as shown below.

P1 + r12P2 + r13P3 +r1P4 + r15P5 = r16
r12P1 +P2 + r23P3 + r24P4 +r25P5 = r26
r13P1 +r23P2 +P3 + r34P4 +r35P5 = r36
r14P1 +r24P2 + r34P3 +P4 +r45P5 = r46
r15P1 + r25P2 +r35P3 + r45P5 +P5 = r56

The simultaneous equation was entered in a matrix form in the Scientific WorkPlace Studient edition 2,5 soft ware to analyze and obtain the path coefficient values (p).

The direct and indirect percentage yield contribution was calculated as below

(i) Direct percentage contribution = (pi^2)
(ii) Indirect percentage contribution=(2p1pjrij)
(iii)Residual value (R) = 1-(P1r16 + p2r26 + p3r36 + p4r46 +p5r56)

All values obtained were multiplied by 100% to convert to percentage contribution

RESULTS

Effect of genotype on yield attributes

The performance of the genotypes with respect to number of pods per plant, 100 grains weight, pod length, number of leaves per plan (6WAS), plant height (6WAS) are presented in Table 1.The result showed that all the improved genotypes had comparable number of pods per plant and all gave significantly higher number of pods per plant than the local check. The local check exhibited the heaviest 100-seeds weight, followed by IT98KD-391, which was at par with IT97K-131-2 and IAR-00-1074.The latter two genotypes produced seeds of comparable weight with IT97K-499-35, while IAR-07-1050 gave the least seed weight. The local check exhibited the longest pods, which were comparable to those of IAR-00-1074 only. IT98KD-391produced pods that were markedly longer than the pods of the remaining three genotypes which were at par. Genotype had no appreciable effect on 100-seeds and plant height at 6WAS. The highest grain yield was obtained from IAR-07-1050.which out-yielded IT97K-499-35 and local check only. Although the local check gave the least grain yield, it was at par with IT97K-499-35 and IT98KD-391.

Path analysis

The direct and indirect contributions of yield attributes to the grain yield of cowpea are presented in Table 2. Direct contribution of the number of cowpea pods per plant to grain yield was 0.5644; while indirect contribution via 100 grain weight, pod length, number of leaves per plant and plant height were 0.0768, -0.0388, -0.0001 and 0.0673 respectively; giving a total contribution of 0.6696s. Direct contribution of 100 grain weight to grain yield was -0.1029, whereas indirect contribution through number of pods plant per plant, pod length, number of leaves per plant, and plant height were -0.4212, 0.0511, -0.0001 and -0.0447 respectively resulting in total contribution of -0.5178. Direct contribution of pod length to grain yield was 0.0722, while indirect contribution via number of pods per plant, 100 grain weight, number of leaves per plant and plant height were -0.3031, -0.0727, -0.0009 and 0.0149 respectively; giving total contribution of -0.2896. Direct contribution of number of leaves per plant was 0.0039, with indirect contribution through number of pods per plant, 100 grain weight, pod length and plant height as -0.1055, 0.0029, -0.0156 and -0.0114 respectively with total contribution of -0.0357. Direct contribution of plant height to grain yield was 0.2319, whereas indirect contribution via number of pods per plant, 100 grain weight, pod length and number of leaves per plant were 0.1639, 0.0198, 0.0046 and -0.0002 respectively giving a total contribution of 0.4200.

The direct and combined percentage contributions of the yield characters to the grain yield of cowpea are presented in Table 3. The direct contributions from the various yield attributes showed that the highest direct yield contribution of 31.85% came from number of pods per plant. It was followed by plant height (6 WAS), 100 grains weight and pod length recording 5.37%, 1.06%, and 0.52% respectively. Number of leaves per plant appears to have no meaningful direct percentage contribution to grain yield. The combined effects showed that number of pods per plant and 100 grain weight exhibited the highest contribution of 8.66%; followed by pod number per plant and plant height with 7.6%. The third and fourth were 100 grain weight combined with plant height (0.94%) and pod length combined with plant height (0.21%) respectively. Whereas 100 grain weight combined with number of leaves/plant gave zero percentage yield contribution, the remaining combined contributions had negative values. The least combined percentage yield contribution of –4.37% came from combination of number of pods per plant and pod length

Table 1. Influence of genotype on number of pods per plant, 100-grains weight, pod length, number of leaves per plant (6WAS), plant height (6WAS) and grain yield of cowpea.

Genotype	Number of Pods plant^{-1} (no.)	100-Kernels Weight	Pod length (cm)	Number of Leaves plant^{-1} (6WAS) (no)	Plant height (6WAS) (cm)	Grain Yield (kgha^{-1})
T97K-499-35	20.13a	15.42c	15.74c	33.83	39.91	1532bc
IT97K-131-2	18.83a	16.82bc	15.49c	31.33	41.24	2206ab
IT98KD-391	21.47a	17.15b	16.87b	27.42	47.76	2057abc
IAR-17-1050	28.07a	12.76d	15.72c	25.33	45.06	2708a
IAR-07-1074	18.30a	16,62bc	18.80a	28.83	46.08	2237ab
Kanann±ado	7.50b	25.76a	19.13a	28.33	41.34	1217c
SE±	3.241	0.486	0.249	3.011	3.148	267.502
Level of Significance	*	*	*	Ns	ns	*

Means followed by common letters in each column are not significantly different at 5% level of probability using DMRT.
*=Significantly different at 5% level of probability.
ns s=Not significantly at 5% different at 5% level of probability.
WAS= Weeks after sowing

Table 2: Direct and indirect contributions of cowpea yield attributes to the grain yield of cowpea,

Yield	Effect through					
	Pod no .per plant	100 Grains Weight	Pod Length	Number of leaves	Plant height	Total contribution
1	**0.5644**	0.0768	-0.0388	-0.0001	0.0673	0.6696
2	-0.4212	**-0.1029**	0.0511	-0.0001	-0.0447	-0.5178
3	-0.3031	-0.0727	**0.0722**	-0.0009	0.0149	-0.2896
4	-0.0155	0.0029	-0.0156	**0.0039**	-0.0114	-0.0357
5	0.1639	0.0198	0.0046	-0.0002	**0.2319**	0.4200

Direct effects are in bold characters in contrast to indirect effects
WAS = Weeks after sowing

Table 3. Percentage contributions of various yield attributes to the grain of cowpea.

Yield attributes	Percentage contribution (%)
A. Individual direct contribution (pi^2)	
Pod number per plant	31.85
100 grain Weight	1.06
Pod length	0.52
Number of leaves/plant	0.00
Plant height (6 WAS)	5.37
B.. Combined contribution (2 PiPjrij)	
Pod number/plant and 100 grain weight	8.66
Pod number/plant and pod length	- 4.37
Pod number/plant and number of leaves/plant	- 0.01
Pod number/plant and plant height	7.60
100 grain weight and pod length	-1.05
100 grain weight and number of leaves/plant	0.00
100 grain weight and plant height	0.94
Pod length and number of leaves/plant	-0.01
Pod length and plant height	0.21
Number of leaves/plant and plant height	-0.01
Residual	49.24
Total	100.00

WAS = weeks after sowing

DISCUSSION

Three of the improved genotypes , namely: IAR-00-1074,IAR-07-1050 and IT97K131-2 out-yielded the local check ,while all of them exhibited significantly higher number of pods per plant than the local check. I t appears that they could be promising genotypes for cultivation in the ecology.

The path coefficient analysis showed that number of pods/plant exhibited the highest direct contribution and percentage yield contribution to the grain yield of cowpea, which was greater than all the contributions of the other components. This is in consonance with the observations of Udom *et al.,* (2006), Mahmudal *et al.,*(2011) who noted high contribution of number of pods per plant to the yield of cowpea. Nakawuka and Adipala (1999) also reported that number of pods per plant were among the major contributors to yield in cowpea. In yard long bean, Vidya and Oommen (2012) observed that number of pods per plant exhibited high direct effect on the yield of the crop .In experiments conducted on groundnut, Kwaga (2004), Sadeghi and Noorhusseini-Niyaki (2012) reported high contribution of number of pods per plant to grain yield. Similarly Oyiga and Uguru (2011) reported that number of pods per plant gave the maximum positive contribution in bambara groundnut. Shebayan (1998) reported that in soybean, the highest yield contribution came from number of pods per plant. Therefore it in this study it can be inferred that the greatest yield determinant in cowpea is the number of pods per plant. Therefore it appears that number of pods per plant has significant influence on the yield of cowpea. This suggests that the higher the number of cowpea pods per plant the higher would be the grain yield. Therefore cowpea genotypes that exhibit higher number of pods per plant should be considered as useful genetic material for improving cowpea yield. The second to the highest contribution came from plant height at 6WAS. This can be attributed to the fact that almost all the genotypes used in the study were erect or semi-erect which bear their pods above the canopy .This implies greater interception of solar radiation for better production of assimilates than pods that are borne at lower height within the foliage of the plants. Number of leaves per plant showed the least contribution. Oyiga and Uguru (2011) reported high and negative effect of number of leaves per plant on the yield of bambara groundnut This implies that that profuse dense foliage in cowpea crops does not favour grain yield. Although 100-grains weight did not make high positive contribution to grain yield in this study Sadeghi and Norhosseini-Niyaki (2012), reported high contribution 100-grains weight to cowpea yield. In the present work except for the local genotype all the improved genotypes exhibited similar grain weight, therefore variation in grain weight is not expected to have significant effect on grain yield.

The fact that the highest combined contribution came from number of pods per plant and grain weight is an indication of the significant impact of high number of pods per plant and large sized seeds in enhancing grain yield of cowpea in contrast to few number of pods per plant with light shriveled seeds. This is in consonance with the findings of Ruben and Mreme (1990) and that of Ogedegbe and Ogunlela (2012), who noted that two factors can work together to enhance crop yield. This implies the interaction between two factors can have positive influence on their performance so as to enhance ttheir combined effect rather than depressive interaction. The number of pods per plant combined with plant height contributed markedly to the grain yield of cowpea. This shows that the higher number of pods borne above the crop, the greater the contribution to cowpea grain yield. Negative contribution from number of pods per plant combined with pod length indicates that plants with longer pods tend to bear fewer pods per plant with low effect on grain yield. The direct effect of number of leaves per plant, combination of number of leaves per plant with other yield attributes tend to have nearly no contribution to grain yields. This suggests that in cowpea, vigorous vegetation has no appreciable impact on grain yield. The residual value was 49.24%, which implies that there are other contributory factors that have not been included in the present analysis. Ahmed (1997), Muktar *et al.,*(2012) made similar remarks with respect to residual values in path analysis.

CONCLUSION

The path analysis in the present study has shown that in cowpea, number of pods per plant exerts the greatest impact on grain yield. This suggests that breeding work that could enhance number of pods per plant could be beneficial in increasing cowpea grain yield.

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