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Correlation and Path Analysis of Yield, Growth and Yield Components of Green Bean (*Phaseolus vulgaris* L.) Varietes

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Abstract

The research was carried out to determine the correlation between pod yield ha $^{-1}$and some growth and yield parameters and the direct and indirect contribution of the characters on pod yield. The research was conducted at Kadawa Irrigation Research Station of the Institute for Agricultural Research, Ahmadu Bello University, Zaria, during the dry seasons of 2009/2010, 2010/2011, and 2011/2012, with four nitrogen, three phosphorus rates and three varieties of green bean (Phaseolus vulgaris L.). Pod yield ha^{-1} , plant height, leaf area index, crop growth rate, total dry weight, number of pods per plant, weight of pods per plant were recorded. The result showed that Correlating the parameters between yield and some growth and yield components showed that pod yield exhibited a positive and highly significant correlation with growth parameters ($p<0.05$) except number of branches. Negative and significant correlation was observed between pod yield ha $^{-1}$ with number of days to 50% flowering. Path analysis revealed that direct contributions of growth parameters were positive except LAI and CGR in 2011/2012. The indirect contribution of characters through plant height and CGR were negative. The highest individual percentage contribution of growth parameter was from LAI (9.52) in 2009/2010, TDW (16.59, 7.07, 9.09) in 2010/2011, 2011/2012 and combined mean, while the highest yield and yield component percentage contribution of 22.0, 29.28, 27.88 and 42.75 was from pod yield and the highest combined percentage contribution of 15.91, 38.61, 42.59 and 25.14 was from number of pods per plant versus pod yield per plant. Plant height, leaf area index and total dry weight be selected for green bean improvement as these parameters if improved upon through breeding could increase pod yields of green bean.

***Keywords**: Phaseolus vulgaris L., Correlation, Path analysis, Yield, Growth*

Introduction

Green bean (*Phaseolus vulgaris* L.) is one of the most widely grown among *Phaseolus* species (Tindall, 1983, Broughton *et al.*, 2003). The crop is a member of the family Fabaceae, it is cultivated in all continents except Antarctica (Gepts, 1998).It creates employment opportunities for rural communities especially women and youth (CIAT, 2006), and constitutes an important part of the human diet in most cultures around the world (Purseglove, 1974).

Yield is an important factor in the production of green bean and is determined by many related parameters. Yield also is affected by the genotype and environmental factors. Direct relationship to pod yield enhances character selection. The improvement of important yield parameters is important; therefore there is the need to understand the magnitude and nature of the association between yield and related parameters. Correlation coefficient measures the association between a pair of variables independently of other variables, Path coefficient analysis is important

because it simultaneously consider several variables. Components of yield may affect yield directly or indirectly and success in crop breeding depends on isolation of genetically superior genotype (Doust*et al*., 1983). Peksen and Gulumser, 2005) reported that yield increase was positively associated with number of pods per plant. The present study was to investigate the inter-relationship of pod yield in green bean with other parameters and the direct and indirect contributions of some parameters to pod yield with a view to identifying the characters that could be useful in yield improvement.

Materials and Methods

The experiment was conducted at Kadawa Irrigation Research Station of the Institute for Agricultural Research, Ahmadu Bello University, Zaria, during the dry seasons of 2009/2010, 2010/2011, and 2011/2012 to assess the correlation and path analysis between yield, growth and yield components 0f green bean. Kadawa is located at 11^{o}39`N; 08^{o}02'E at altitude of 500 m in the Sudan Savannah ecological zone of Nigeria, The treatment consisted of three varieties of green bean (Ex-Brown, Dangora and Yar-Helina), four levels of nitrogen (0, 20, 40, and 60 kg N ha^{-1}) and three levels of phosphorus (0, 22.5, and 45 kg P ha^{-1}). The 36 treatments combinations were laid out in a split plot design. Factorial combinations of varieties and nitrogen were assigned to the main plots, while P was assigned to the sub-plots, and replicated three times. The gross sub-plot area was 12 m^{2} consisting of 4 rows of 4 m length and a width of 3 m (4 mx3 m). Seeds were sown manually at the rate of two seeds per hole, at an intra-row spacing of 30 cm and inter-row spacing of 75 cm. Urea (46% N) and Single Super Phosphate (18% P_2O_5) were used as source of N and P fertilizer and was applied as per treatment to the plots. N was split applied at two and six weeks after sowing (WAS) by band placement while the P doses were applied once at sowing. Data were collected at eight weeks after sowing (WAS) on plant height (cm), leaf area index (LAI), number of branches per plant, crop growth rate (CGR), total dry weight (TDW), days to 50% flowering, pod length (cm), pod diameter (cm), number of pods per plant, weight of pods per plant (g) and weight of pods in kg ha^{-1}.The data collected were subjected to analysis of variance (ANOVA) as described by Snedecor and Cochran (1967) and Little and Hills (1978). Correlation and Path coefficient analysis of yield and some growth and yield components were carried out using the procedure described by Little and Hills (1978). In order to assess the type and magnitude of the relationship among the variables,

Results

Tables 1 - 4 Shows the correlation matrix between some growth, yield, and yield component of green bean varieties at Kadawa during the 2009/2010, 2010/2011 and 2011/2012 dry season and the combined mean of the years. The result showed that pod yield ha^{-1} (kg) exhibited a positive and highly significant correlation with all

characters in all the years except pod diameter in 2009/2010, number of branches in 2010/2011, number of branches, number of days to 50% flowering, pod length and pod diameter in 2011/2012, pod diameter in the combined mean of the years. Negative and significant correlation was observed between pod yield ha^{-1} with number of days to 50% flowering in 2009/2010. A positive and highly significant correlation was observed between number of pods per plant with all the parameters in the three years and the mean of the three years, except number of days to 50% flowering which exhibited negative correlation in 2009/2010, pod diameter in 2009/2010, plant height, number of branches, number of days to 50% flowering, pod length, and pod diameter 2011/2012, pod diameter in combined mean were not significantly correlated with number of pod per plant. The correlation between plant height and number of leaves with most of the parameters were positive and significant.

The direct and indirect contribution of some growth and yield components to pod yield in 2009/2010, 2010/2011, 2011/2012 and the combined mean are shown in Table 5. Direct contribution of the growth parameters were positive with exception of plant height in 2009/2010, plant height and CGR in 2011/2012 and combined mean, LAI and CGR in 2011/2012 that were negative. The indirect contributions of the characters through plant height and CGR with other characters were negative in 2009/2010, 2011/2012 and combined mean. Also negative indirect contributions were observed in 2010/2011 between LAI and CGR per plant with other parameters. Other characters showed a positive direct contribution. Table 6Show the individual percentage contribution of the growth and number of pods per plant to pod yield. It was observed that the highest individual percentage contribution of growth parameters was from LAI (9.52) in 2009/2010; TDW (16.59, 7.07 and 9.09) in 2010/2011, 2011/2012 and combined mean. The highest yield and yield component percent contribution of 22.0, 29.28, 27.88 and 42.75 in all the years and combined mean was from pod yield per plant. From the result, the highest combined percentage contribution of 15.91, 38.61 42.59 and 25.14 was from number of pod per plant versus pod yield per plant in all the years and combined mean

Discussion

The significant and positive correlation recorded between pod yield and some growth parameters like plant height, LAI, CGR, TDW also through indirect contribution indicated interdependency between the characters, it also indicated that, these characters were important yield determinants, these factors determine the vegetative cover and photosynthetic surface area for the interception of adequate sunlight for the manufacture and translocation of assimilates to the pods, hence the positive association between pod yield ha^{-1} (kg) and yield and yield components like pod length, number of pods per plant, pod weight per plant, thus indicating that this parameters are important yield determinant. An improvement of one growth parameters could support the other. Peksen and Gulumser (2005) reported a positive

yield increase in association with number of pods per plant. The negative correlation between some growth and yield component like plant height, days to 50% flowering was due to inter-specific competition between individual organs for light, water, nutrients, assimilates and also inhibition of growth.

The partitioning of the total correlation into direct and indirect contribution showed that, most of the growth components made their greatest contribution to yield through LAI in 2009, and TDW in 2010, 2011 and combined mean. It is an indicator of the assimilatory capacity of the plant and this has a direct bearing on the yield. Lupton (1980) stated that yield improvement must be associated with the crop biomass and probably with some increase in plant height, number of leaves, leaf area and LAI.

The path and correlation coefficient explains the true association between these characters and selection for heavier pod. When the contribution of yield characters to the total pod yield were considered, it was observed that, the greatest contribution was made by pod weight per plant followed by the number of pods per plant. This signifies the importance of these characters as major contributors to yield as a result of assimilates translocation to the reproductive structures thus the increase in number of pods and weight. Doust *et al*. (1983) reported that components of yield may affect yield directly or indirectly and success in crop breeding depends on isolation of genetically superior genotype. The greatest contribution from the combined contribution was from number of pod per plant versus pod weight per plant in most of the observations. Conclusively, plant height, number of leaves, leaf area index and total dry weight could be used as a selection criteria for crop improvement in green for high yield.

Conclusion

Plant height, leaf area index and total dry weight could be selected for green bean improvement as these parameters if improve upon through breeding could increase the crop’s pod yields

Table 1: Correlation matrix between some growth, yield and yield components of green bean varieties in 2009/2010 dry season at Kadawa

	1	2	3	4	5	6	7	8	9	10	11
1	1.000										
2	0.244*	1.000									
3	0.146	0.2981*	1.000								
4	0.417**	0.186*	0.186*	1.000							
5	0.250*	0.298*	0.298*	0.368**	1.000						
6	-0.371*	0.464*	-0.201*	-0.423*	0.601**	1.000					
7	0.594**	0.268*	0.194	0.359**	0.433**	- 0.373*	1.000				
8	0.122	0.553*	0.104	0.160	0.190	-0.279*	- 0.0053	1.000			
9	0.753**	0.350**	0.234*	0.353**	0.577**	-0.418**	0.450**	0.091	1.000		
10	0.714**	0.292*	0.269*	0.446**	0.558**	0.410**	0.576**	0.039	0.737**	1.000	
11	0.783**	0.585**	0.250*	0.533**	0.604**	- 0.499**	0.400**	0.102	0.819**	0.859**	1.000

KEY** = Highly significant at 1% * = Significant at 5%

1	Plant height	8	Pod Diameter
2	Leaf area index LAI	9	Number of Pods per plant
3	Number of Branches per plant	10	Weight of pods per plant(g)
4	crop growth rate	11	Weight of pods in kg ha^{-1}
5	Total dry weight		
6	Days to 50% flowering		
7	Pod length		

Table 2: Correlation matrix between some growth, yield and yield components of green bean varieties in 2010/2011 dry season at Kadawa

	1	2	3	4	5	6	7	8	9	10	11
1	1.000										
2	0.266*	1.000									
3	-0.014	0.210	1.000								
4	0.409**	0.504**	0.258*	1.000							
5	0.423**	0.561**	0.289*	0.681**	1.000						
6	-0.711*	0.344*	-0.261*	-0.541*	-0.603	1.000					
7	0.791**	0.252*	-0.071	0.350**	0.402**	-0.638*	1.000				
8	0.126	0.363**	0.314**	0.353**	0.450**	0.378**	-0.157	1.000			
9	0.424*	0.484**	0.377**	0.779**	0.232*	0.505*	0.291*	0.513**	1.000		
10	0.401**	0.413**	0.306*	0.618**	0.639**	0.525*	0.403**	0.464**	0.829**	1.000	
11	0.444**	0.427**	0.228	0.601**	0.605**	0.477*	0.364**	0.488**	0.699**	0.941**	1.000

KEY** = Highly significant at 1% * = Significant at 5%

1 Plant height
2 LAI
3 Number of Branches per plant
4 CGR
5 TDW
6 Number of Days to 50% flowering
7 Pod length
8 Pod Diameter
9 Number of Pods per plant
10 Weight of pods per plant(g)
11 Weight of pods in kg ha^{-1}

Table 3: Correlation matrix between some growth, yield and yield components of green bean varieties in 2011/2012 dry season at Kadawa

	1	2	3	4	5	6	7	8	9	10	11
1	1.000										
2	0.335**	1.000									
3	0.533**	-0.072	1.000								
4	0.329**	0.398**	0.199	1.000							
5	0.489**	0.365**	0.117	0.418**	1.000						
6	-0.6100*	-0.397*	0.333**	0.351**	0.489**	1.000					
7	0.787**	0.323**	0.500*	0.369**	0.461**	-0.717*	1.000				
8	0.013	0.040	0.020	0.099	0.092	-0.132	0.017	1.000			
9	0.157	0.337**	0.188	0.553*	0.361**	0.103	0.033	0.088	1.000		
10	0.664*	0. .517**	0.105	0.466*	0.459**	0.116	0.086	0.096	0.935**	1.000	
11	0.288*	0.526**	0.096	0.395**	0.428**	0.233	0.154	0.102	0.921**	0.917**	1.000

KEY** = Highly significant at 1% * = Significant at 5%

1	Plant height	8	Pod Diameter
2	LAI	9	Number of Pods per plant
3	Number of Branches per plant	10	Weight of pods per plant(g)
4	CGR	11	Weight of pods in kg ha^{-1}
5	TDW		
6	Number of Days to 50% flowering		
7	Pod length		

Table 4: Correlation matrix coefficients between some growth, yield and yield components of green bean varieties in combined mean at Kadawa

	1	2	3	4	5	6	7	8	9	10	11
1	1.000										
2	0.343**	1.000									
3	-0.223**	0.109	1.000								
4	0.236**	0.492**	0.086	1.000							
5	0.394**	0.608**	0.131	0.837**	1.000						
6	-0.573*	0.508*	0.039	0.540*	0.676**	1.000					
7	0.646**	0.208**	0.103*	0.289**	0.344**	0.496	1.000				
8	0.073	0.204**	0.157*	0.213**	0.257**	-0.0018	0.061	1.000			
9	0.198**	0.243**	0.292**	0.241**	0.272**	0.163*	0.320**	0.126	1.000		
10	0.245**	0.162*	0.249**	0.274*	0.294**	0.144*	0.410**	0.089	0.932**	1.000	
11	0.288**	0.426**	0.238**	0.395**	0.428**	0.338**	0.356**	0.157	0.821**	0.861**	1.000

KEY** = Highly significant at 1% * = Significant at 5%

1 Plant height
2 LAI
3 Number of Branches per plant
4 CGR
5 TDW
6 Number of Days to 50% flowering
7 Pod length
8 Pod Diameter
9 Number of Pods per plant
10 Weight of pods per plant(g)
11 Weight of pods in kg ha^{-1}

Table 5: Direct and indirect contributions of some growth and yield attributes to fresh pod yield of green bean varieties during 2009/2010-2011/2012 dry seasons at Kadawa.

Growth characters	Plant height	LAI	CGR	TDW	Pods plant^{-1}	Pod weight plant^{-1}	Total
			2009/2010				
Plant height	**-0.00421**	0.074974	0.064204	0.005045	0.2281	0.334885	0.703
LAI	-0.00102	**0.308534**	0.028638	0.006013	0.105882	0.136956	0.585
CGR	-0.00175	0.057387	**0.153966**	0.007426	0.106789	0.209186	0.533
TDW	-0.00105	0.091943	0.05666	**0.020179**	0.174554	0.261717	0.604
Pods plant^{-1}	-0.00317	0.107987	0.05435	0.011643	**0.30252**	0.345672	0.819
Pod weight plant^{-1}	-0.003	0.090092	0.068669	0.01126	0.222957	**0.469026**	0.859
			2010/2011				
Plant height	**0.021989**	-0.02151	-0.12853	0.172273	0.180864	0.218918	0.444
LAI	0.005849	**-0.08086**	-0.15839	0.228475	0.206458	0.225469	0.427
CGR	0.008994	-0.04075	**-0.31427**	0.277347	0.332295	0.337384	0.601
TDW	0.009302	-0.04536	-0.21401	**0.407265**	0.098963	0.348849	0.605
Pods plant^{-1}	0.009324	-0.03914	-0.24481	0.094485	**0.426566**	0.452575	0.699
Pod weight plant^{-1}	0.008818	-0.0334	-0.19422	0.260242	0.353623	**0.545929**	0.941
			2011/2012				
Plant height	**-0.24979**	0.057219	-0.04915	0.070321	0.062362	0.380749	0.271714
LAI	-0.08368	**0.170803**	-0.05946	0.052489	0.13386	0.297604	0.511619
CGR	-0.08218	0.06798	**-0.14939**	0.060255	0.219658	0.278681	0.395
TDW	-0.12215	0.062343	-0.0626	**0.143807**	0.143393	0.263199	0.428
Pods plant^{-1}	-0.03922	0.057561	-0.08261	0.051914	**0.397211**	0.536145	0.921
Pod weight plant^{-1}	-0.16586	0.088647	-0.07261	0.066007	0.371392	**0.573417**	0.861
			Combined mean				
Plant height	**-0.01857**	0.031494	-0.05022	0.118802	0.04631	0.160188	0.288
LAI	-0.00637	**0.09182**	-0.1047	0.18333	0.056834	0.10592	0.327
CGR	-0.00438	0.045175	**-0.2128**	0.25238	0.056367	0.258262	0.395
TDW	-0.00732	0.055826	-0.17811	**0.301529**	0.063851	0.192225	0.428
Pods plant^{-1}	-0.00368	0.022312	-0.05128	0.082317	**0.233887**	0.537446	0.821
Pod weight plant^{-1}	-0.00455	0.014875	-0.08406	0.088649	0.192255	**0.653827**	0.861

Table 6: Individual and combined contributions (percent) of growth and yield components to fresh pod yield and their residual effect in 2009/2010, 2010/2011, 2011/2012 and mean

	Percentage contribution			
Growth characters	**2009-10**	**2010-11**	**2011-12**	**Mean**
Individual contribution				
Plant height	0.00177	0.048353	6.239358	0.034495
LAI	9.51931	0.653854	2.917381	0.843083
CGR	2.370555	9.876288	2.231835	4.528391
TDW	0.040718	16.58645	7.068038	9.091967
Pods per plant^{-1}	9.151813	18.19583	15.77765	5.470299
Pod yield plant^{-1}	21.99856	29.80386	27.88073	42.74901
Combined contribution				
Plant height +LAI	-0.06308	-0.09459	-2.85852	-0.11699
Plant height + CGR	-0.05402	-0.56528	2.455426	0.186549
Plant height +TDW	-0.00424	0.757636	-3.51308	-0.4413
Plant height + Pod per plant	-0.19191	0.795417	-3.11545	-0.17202
Plant height+ Pod per yield plant	-0.28176	0.962773	-19.0212	-0.59503
LAI + CGR	1.767139	2.56152	-2.03114	-1.92266
LAI + TDW	0.371057	-3.69496	1.793076	3.366647
LAI + No Pod per plant	6.533627	-3.33889	4.572752	1.043703
LAI + Pod yield per plant	8.45109	-3.64634	10.16634	1.945105
CGR + TDW	0.228662	-17.4321	-1.80034	-10.7413
CGR + Pod per plant	3.28839	-20.8858	-6.56308	-2.39897
CGR+ Pod yield per plant	4.217305	-14.1714	-8.89199	-4.50796
TDW + Pod per plant	0.704452	8.060845	4.124181	3.850588
TDW + Pod yield per plant	6.056217	28.41474	7.569944	11.59229
Pod per plant + Pod yield per plant	15.91453	38.61061	42.59254	25.1403
Residual	9.97981	8.501198	12.40558	11.05378
Total	100	100	100	100

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