ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Journal of Agronomy 14 (3): 158-163, 2015
ISSN 1812-5379

RESEARCH ARTICLE | OPEN ACCESS

DOI: 10.3923/ja.2015.158.163

Character Association and Path Coefficient Analysis of Maize (*Zea mays* L.) Grown under Incorporated Legumes and Nitrogen

[1]A.G. Adesoji, [2]I.U. Abubakar and [2]D.A. Labe
[1]Department of Crop Production and Protection, Faculty of Agriculture and Agricultural Technology, Federal University Dutsin-Ma, Katsina State, Nigeria
[2]Department of Agronomy, Faculty of Agriculture, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria

ARTICLE INFO
Article History:
Received: May 26, 2015
Accepted: July 11, 2015

Corresponding Author:
A.G. Adesoji
Department of Crop Production and Protection, Faculty of Agriculture and Agricultural Technology,
Federal University Dutsin-Ma,
Katsina State, Nigeria

ABSTRACT
A three year study was conducted in the rainy seasons of 2005, 2006 and 2007 at the Research Farm of the Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria, to evaluate character association and path coefficient analysis of maize (*Zea mays* L.) grown under legume incorporation and nitrogen. The results of this study showed that maize grain yield correlated positively and significantly with all measured characters. Path coefficient analysis indicated that plant height, total dry matter per plant, crop growth rate, cob length, number of grains per cob, 100-seed weight and stover yield showed positive direct effects on grain yield. Plant height and total dry matter per plant and 100-seed weight and stover yield gave the largest combined contributions. In growth characters, the highest individual contributions to grain yield were made by total dry matter per plant and crop growth rate. In yield characters, the highest individual contributions to grain yield were made by 100-seed weight and stover yield. Conclusively, total dry matter per plant, crop growth rate, 100-seed weight and stover yield should be considered for selection criteria in improving these varieties for better yield.

Key words: Correlation, growth characters, maize, path analysis, yield characters

INTRODUCTION

Character association between yield and yield components plays a pivotal role in developing maize varieties with better yield through a well orchestrated breeding programme. Ahmad and Saleem (2003) reported that the efficacy of a breeding programme rests centrally on the direction and magnitude of the association between yield and yield components and also the relative importance of each factor involved in contributing to grain yield. The desire of every farmer is high grain yield which is a product of association among various growth and yield parameters. The available information about this association assists in putting in place a breeding plan to improve the yield. Aliyu *et al.* (2000) reported that where there is a characterization of association between characters, correlation analysis helps to determine the type and magnitude of the association between a pair of characters. It has even been reported that where there are more than two variables, using correlation coefficient alone does not give good picture of the interrelationship (Fakorede and Opeke, 1985). Therefore, path coefficient analysis is used where more than two characters are to be considered. 'Path coefficient analysis is a standardized partial regression coefficient that allows partitioning of correlation coefficient into direct and indirect effects of various traits towards dependent variable and also helps in assessing the cause and effect relationship as well as effective selection' (Bello *et al.*, 2010).

Path coefficient analysis determines the direct influence of one variable on another and also discomposes the correlation coefficient into direct and indirect effects

(De Rodriguez *et al*., 2001). It is a known fact that a yield is an aggregate of total performance of various growth/yield components of a given crop. Therefore, it is important to evaluate the contribution of each of the its different components in a bid to know which one gives greatest influence in grain yield (Ozer *et al.*, 1999). It is also important to determine the role of incorporation of legumes as green manure and nitrogen fertilization on some yield attributes and how they affect the contribution of each character to grain yield. The objective of this study therefore was to determine which association is the best between maize grain yield and yield components and between yield components themselves as well as to identify which of the parameters has highest contribution to grain yield. This is necessary in order to identify which characters that could be used in yield improvement programme of the varieties under study.

MATERIALS AND METHODS

Experimental site and soil characteristics: The study was conducted during the wet seasons of 2005, 2006 and 2007 at the Research Farm of the Institute for Agricultural Research, Samaru (11°11[1] N, 07°38[1] E, 686 m above sea level) in the Northern Guinea Savanna ecological zone of Nigeria. The annual rainfall for the duration of the study in 2005, 2006 and 2007 was 790.4, 1086.7 and 900.4 mm, respectively. The physico-chemical analysis of the top soil (0-30 cm depth) of the experiment site before planting in 2005 as determined by standard procedures showed that the soil was loam with the following properties: pH (0.01M $CaCl_2$), 5.0; organic carbon, 5.3 g kg^{-1}; total nitrogen, 0.53 g kg^{-1}; available phosphorus, 12.25 mg kg^{-1} and exchangeable cations (cmol kg^{-1}) of Ca^{2+}, 1.80; Mg^{2+}, 0.36; K^+, 0.14 and Na^+, 0.11 and CEC, 4.8 cmol kg^{-1}.

Treatments and experimental design: The treatments consisted of two maize varieties (SAMMAZ 12 and SAMMAZ 27), five levels of N (0, 30, 60, 90 and 120 kg N ha^{-1}) and three green manure crops [lablab (*Lablab purpureus*), mucuna (*Mucuna pruriens*) and soybean (*Glycine max* (L.) Merrill)] and a weedy fallow. The experiment was laid out in a split-plot design with nitrogen and variety as main plot treatment and green manure as the sub plot treatment. The experiment was replicated three times.

Crop management practices: Leguminous green manure crops were planted on the flat with narrower inter-row spacing of 37.5 cm. The lablab was sown at 2 stands per hole at 20 cm within row and mucuna was sown at a stand per hole at 20 cm within row. The soybean was planted drilled. The leguminous green crops were incorporated at 49 days (7 weeks) after planting. After 3 days of incorporation, maize seeds were planted with two or three seeds per hole at a spacing of 25 cm on the ridges of 75 cm apart. The maize seedlings were thinned to one seedling per stand at two weeks after sowing. The experimental plot consisted of six ridges of 4.5 m apart and 4 m long (gross plot) and net plot was 3×3 m (9 m^2). The green manure crops were fertilized using 20 kg P_2O_5 ha^{-1} and 10 kg N ha^{-1} to boost their growth. Nitrogen fertilizer as urea (46% N) was applied to the maize at 2 and 6 weeks after sowing (WAS) according to treatment. Basal applications of 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} were carried out at sowing. Weeds were controlled using Paraquat (Gramaxone) at 3 L ha^{-1} to kill weeds that were not properly incorporated and hoe weeding was done at 6WAS.

Data collection: The observations recorded during the course of study were plant height, leaf area index, total dry matter per plant, crop growth rate, cob length, number of rows per cob, number of grains per cob, 100-seed weight, stover yield and grain yield. Data on plant height, leaf area index and crop growth rate were collected from five randomly tagged plants at 9WAS while data on total dry matter were collected on three randomly tagged plants at 9 WAS. Length of cobs from the five tagged plants in each plot was measured and the average was recorded. Total number of rows from five randomly selected cobs from the net plot was counted and the means was recorded. Number of rows per cob was determined and the means was recorded. Number of grains per cob of five randomly sampled cobs from each plot was counted and the mean number of grains per cob recorded. Stover yield was determined at harvest and recorded. One hundred grains were counted from each net plot and weighed and recorded. The grain yield was determined at harvest and recorded.

Data analysis: Correlation and path coefficients were calculated from the means of treatments across replications. The magnitude and type of relationship between characters were assessed through simple correlation analysis (Little and Hill, 1978). The direct and indirect contributions to grain yield by the selected characters of maize were determined using the path-coefficient analysis as described by Dewey and Lu (1959).

RESULTS

Results showed that grain yield was significantly and positively correlated with plant height, leaf area index, total dry matter per plant, crop growth rate, cob length, number of rows per cob, number of grains per cob, 100-seed weight and stover yield ($p = 0.001$) (Table 1). The correlation between plant height and other growth and yield characters was also positive and highly significant ($p = 0.001$). The leaf area index was also positively and significantly correlated with growth and yield components with exception of crop growth rate and 100-seed weight that were not significant. The path diagram

Table 1: Matrix of co-efficient of correlation between grain yield, growth and yield components of maize in combined mean (combined years)

Correlation parameters	1	2	3	4	5	6	7	8	9	10
1	1.000									
2	0.816**	1.000								
3	0.628**	0.677**	1.000							
4	0.241**	0.007^{NS}	-0.102^{NS}	1.000						
5	0.602**	0.487**	0.597**	0.378**	1.000					
6	0.272**	0.362**	0.398**	0.007^{NS}	0.295**	1.000				
7	0.592**	0.548**	0.634**	0.287**	0.870**	0.607**	1.000			
8	0.293**	0.012^{NS}	0.153*	0.684**	0.498**	0.019^{NS}	0.395**	1.000		
9	0.746**	0.626**	0.652**	0.400**	0.794**	0.306**	0.746**	0.548**	1.000	
10	0.507**	0.301**	0.457**	0.602**	0.763**	0.205**	0.680**	0.806**	0.844**	1.000

*Significant at 5% level of probability. **Significant at 1% level of probability. NS: Not significance, 1: Plant height, 2: Leaf area index, 3: Total dry matter/plant, 4: Crop growth rate, 5: Cob length, 6: No. of rows/cob, 7: No. of grains/cob, 8: 100-seed weight, 9: Stover yield (kg ha^{-1}), 10. Grain yield (kg ha^{-1})

showing the interrelationship of some maize growth characters with grain yield is shown in Fig. 1. Plant height, total dry matter per plant and crop growth rate showed positive direct effect. However, leaf area index showed negative direct effect. Crop growth rate produced the highest direct effect (0.6042) which was quickly followed by total dry matter per plant with direct effect of 0.5544 (Fig. 1). The path diagram showing the relationship between grain yield and yield components is shown in Fig. 2. Cob length, number of grains per cob, 100-seed weight and stover yield showed positive direct effects to grain yield. However, number of rows per cob indicated negative effects. The highest direct effect of 0.4778 was produced by 100-seed weight which was quickly followed by stover yield with direct effect of 0.4401 (Fig. 2).

Table 2 shows the individual and combined contributions of various growth characters to maize grain yield. Table 2 shows that the highest individual contribution of 36.51% to grain yield was made by crop growth rate which was immediately followed by total dry matter per plant with individual contribution of 30.73% while plant height and leaf area index made individual contributions of 5.33 and 7.11% to grain yield, respectively. Highest combined contribution of 16.07% to grain yield was made by plant height and total dry matter per plant while lowest combined contribution of -20.02% to grain yield was made by leaf area index and total dry matter per plant. A residual effect of 34.59% was unaccounted for in the analyses (Table 2). Table 3 shows the individual and combined contributions of different yield components to maize grain yield. Table 3 shows that the highest individual contribution of 22.83% to grain yield was made by 100-seed weight followed by stover yield (19.37%), cob length (1.56%), number of grains per cob (0.40%) and number of rows per cob (0.02%). The combined contribution of 100-seed weight and stover yield (23.06%) produced the highest combined contribution to grain yield while the combined contribution of number of rows per cob and stover yield (-0.37%) was the lowest. A residual effect of 10.79% was unaccounted for in the analyses (Table 3).

Table 2: Percentage contribution of different growth parameters to maize grain yield in combined mean (combined years)

Growth parameters	Contribution (%)
Direct contribution $(P_i)^2 100$	
Plant height	5.33
LAI	7.11
TDM/plant	30.73
CGR	36.51
Combined contribution $(2P_iP_jr_{ij})100$	
Plant height and LAI	-10.04
Plant height and TDM/plant	16.07
Plant height and CGR	6.73
LAI and TDM/Plant	-20.02
LAI and CGR	-0.21
TDM/plant and CGR	-6.80
Residual effect$[1-(P_1r_{15}+P_2r_{25}+P_3r_{35}+P_4r_{45})]100$	
Rx	34.59
Total	100.00

Table 3: Percentage contribution of different yield attributes to maize grain yield in combined mean (combined years)

Yield attributes	Contribution (%)
Direct contribution $(P_i)^2 100$	
Cob length	1.56
No. of rows/cob	0.02
No. of grains/cob	0.40
100-seed weight	22.83
Stover yield	19.37
Combined contribution $(2P_iP_jr_{ij})100$	
Cob length and no. of rows/cob	-0.10
Cob length and no. of grains/cob	1.37
Cob length and 100-seed weight	5.95
Cob length and stover yield	8.74
No. of rows/cob and no. of grains/cob	-0.11
No. of rows/cob and 100-seed weight	-0.03
No. of rows/cob and stover yield	-0.37
No. of grains/cob and 100-seed weight	2.38
No. of grains/cob and stover yield	4.14
100-seed weight and stover yield	23.06
Residual effect $[1-(P_1r_{16}+P_2r_{26}+P_3r_{36}+P_4r_{46}+P_5r_{56})]100$	
Rx	10.79
Total	100.00

DISCUSSION

The significant and positive correlation observed between grain yield and growth and yield characters could be attributed

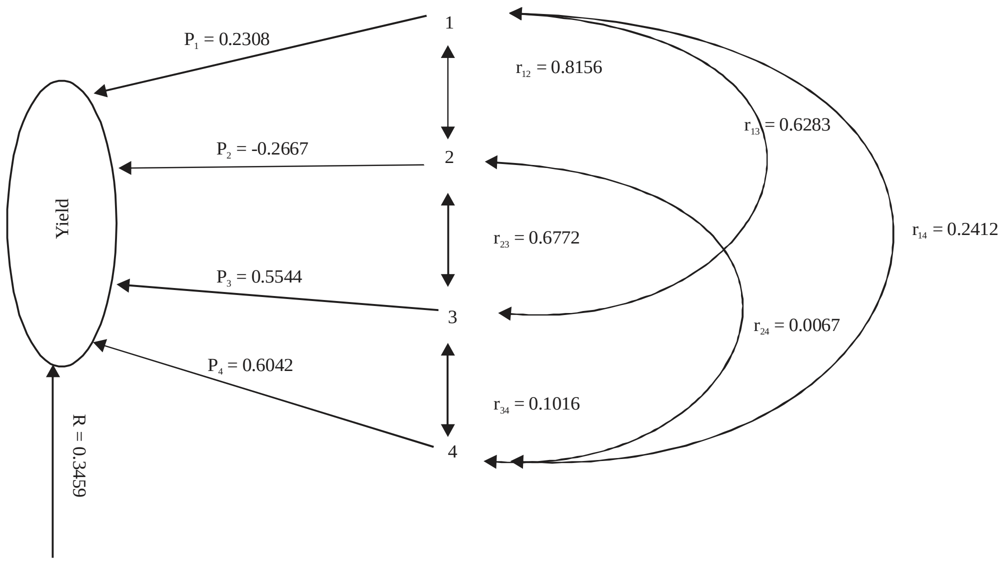

Fig. 1: Path diagram showing interrelationship between maize grain yield (kg ha^{-1}) and some growth parameters in 2005-2007(combined mean), 1: Plant height, 2: Leaf area index, 3: TDM/plant, 4: CGR and R: Residual

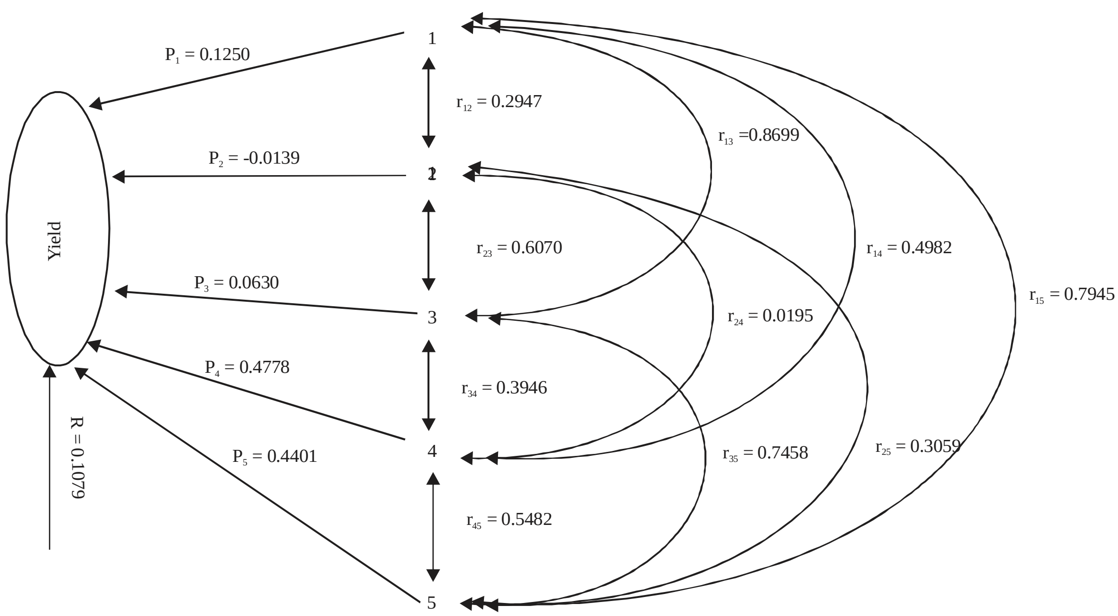

Fig. 2: Path diagram showing interrelationship between maize grain yield (kg ha^{-1}) and some yield attributes in 2005-2007 (Combined mean), 1: Cob length, 2: No. of rows/cob, 3: No. of grains/cob, 4: 100-seed weight, 5: Stover yield and R: Residual

to the fact that these parameters are important determinants of grain yield. This indicated that improvement on these characters would result in better performance and subsequent grain yield improvement. Researchers like Annapurna *et al*. (1998), You *et al.* (1998) reported similar results. Sharifai *et al.* (2006) found that grain yield was positively and significantly correlated with plant height, number of leaves, total dry matter, leaf area index, kernel rows per cob, cob length, cob diameter, cob weight and 100-grain weight. It was further reported that the increase in growth parameters especially plant height and number of leaves would help photosynthetic apparatus to synthesize more assimilates and hence production of higher yield. Leaf area index which correlated positively and significantly with other characters could be linked to the light interception capacity of leaf area index which facilitated better dry matter accumulation.

Mildford *et al*. (1985) reported that light interception is mainly influenced by leaf area index and Scott and Jaggard (1978) had earlier reported that dry matter yield was proportional to the total amount of radiation intercepted by the crop for growth. Total biomass production of a crop, without water limitations, is the product of solar radiation intercepted by the crop canopy over the duration of the cropping period and the efficiency at which the crop converts light energy into plant dry matter (Richards, 2000).

Growth characters like plant height, total dry matter per plant and crop growth rate had positive direct effect on grain yield of maize which indicated that these characters had great influences on yield performance. Path coefficient analysis revealed that the most important contributors from growth parameters to maize grain yield were total dry matter per plant and Crop Growth Rate (CGR). This means that the higher the dry matter per plant, the more assimilate it could translocate to fill the grains for consequent higher grain yield. Higher biomass is a product of higher number of leaves, leaf area index and plant height which could directly and indirectly contribute into higher grain yield. It is a well known fact that crop growth rate is a measure of the rate of dry matter production per unit of time or dry matter increment per unit area of land per unit time. De juan Valero *et al*. (2005) reported that a high crop growth rate emanating from high LAI, high net assimilation or a combination of both seems to cause high yield. The relatively low value obtained in residual effects could be that major contributing growth characters to the maize grain yield were the ones considered in this study.

All the yield characters studied with exception of number of rows per cob showed positive direct effect on the grain yield which suggested that they had great impacts on yield performance. 100-seed weight and stover yield gave the most impressive positive direct effect and individual contribution to grain yield which could be attributed to the fact that the bulk of plant dry matter is stored in stover from there assimilates are remobilized and partitioned to grain yield. The more the dry matter the more assimilates is mobilized to the grains for heavier seeds hence the more the grain yields. Bruening and Egli (1999) reported that grain yield is a function of the number of seeds produced per unit area and the average weight of the individual seeds. The contribution of stover yield to grain yield of maize should not be a surprise because stover yield is a cumulative effect of all other components of a crop with an exception of economic yield parameters. The combined contributions of either cob length and 100 seed weight, cob length and stover yield or 100 seed weight and stover yield showed that improving these characters will definitely improve grain yield. The negative effects of number of rows per cob on grain yield could be that the more the rows the less the grain filling. The low value obtained in residual effects indicated that other factors and variables not considered in this study were of less effect to grain yield.

CONCLUSION

From the results of this study, it can be concluded that correlation studies showed that grain yield of maize had positive and significant associations with all the characters studied. Characters like total dry matter per plant, crop growth rate, 100-seed weight and stover yield made the greatest direct contribution to grain yield of maize. These yield contributing components were also involved in the contribution of other characters to grain yield. Therefore, these characters should be considered as important selection criteria for the improvement of these varieties for higher grain yield. Effort should be made to reduce the number of rows per cob of these varieties because of its negative effects on grain yield.

REFERENCES

Ahmad, A. and M. Saleem, 2003. Path coefficient analysis in *Zea mays* L. Int. J. Agric. Biol., 5: 245-248.

Aliyu, L., M.K. Ahmed and M.D. Magaji, 2000. Correlation and multiple regression analysis between morphological characters and components of yield in pepper (*Capsicum annuum* L.). Crop Res., 12: 318-323.

Annapurna, D., H.A. Khan and S. Mohammad, 1998. Genotypic-phenotypic correlations and path coefficient analysis between seed yield and other associated characters in tall genotypes of maize. Crop Res. Hisar, 16: 205-209.

Bello, O.B., S.Y. Abdulmaliq, M.S. Afolabi and S.A. Ige, 2010. Correlation and path coefficient analysis of yield and agronomic characters among open pollinated maize varieties and their F_1 hybrids in a diallel cross. Afr. J. Biotechnol., 9: 2633-2639.

Bruening, W.P. and D.B. Egli, 1999. Relationship between photosynthesis and seed number at phloem isolated nodes in soybean. Crop Sci., 39: 1769-1775.

De Juan Valero, J.A., M. Maturano, A.A. Ramirez, J.M.T. Martin-Benito and J.F.O. Alvarez, 2005. Growth and nitrogen use efficiency of irrigated maize in a semiarid region as affected by nitrogen fertilization. Spanish J. Agric. Res., 3: 134-144.

De Rodriguez, D.J., J.L. Angulo-Sanchez and R. Rodriguez-Garcia, 2001. Correlation and path coefficient analyses of the agronomic trait of a native population of guayule plants. Indust. Crops Prod., 14: 93-103.

Dewey, D.R. and K.H. Lu, 1959. A correlation and path-coefficient analysis of components of crested wheatgrass seed production. Agron. J., 51: 515-518.

Fakorede, M.A.B. and B.O. Opeke, 1985. Weather factors affecting the response of maize to planting dates in a tropical rainforest location. Exp. Agric., 21: 31-40.

Little, T.M. and F.J. Hills, 1978. Agricultural Experimentation: Design and Analysis. John Wiley and Sons, New York, USA., ISBN-13: 9780471023524, Pages: 350.

Mildford, G.E.J., T.O. Pocock and J. Riely, 1985. An analysis of leaf growth in sugar beet II. Leaf appearance in field crops. Ann. Applied Biol., 106: 173-185.

Ozer, H., E. Oral and U. Dogru, 1999. Relationships between yield and yield components on currently improved spring rapeseed cultivars. Turk. J. Agric. For., 23: 603-607.

Richards, R.A., 2000. Selectable traits to increase crop photosynthesis and yield of grain crops. J. Exp. Bot., 51: 447-458.

Scott, R.K. and K.W. Jaggard, 1978. Theoretical criteria for maximum yield. Proceedings of the 41st Winter Congress of the International Institute for Sugar Beet Research, February, 1978, Brussels, Belgium, pp: 179-198.

Sharifai, A.I., M. Mahmud, A.B. Lawal, I.U. Abubakar and S.G. Mohammed, 2006. Correlation and path coefficient analysis for growth, yield and yield components of early maturing maize (*Zea mays* L.) varieties. Savannah J. Agric., 1: 103-109.

You, L.J., J.P. Dong, Y.Z. Gu, L.L. Ma and S. Zhao, 1998. Target characteristics to develop for improved seed production in maize hybrids. J. Henan Agric. Sci., 10: 3-4.