Original Research Article

Correlation and Path Coefficient Analysis Studies on Grain Yield and Its Contributing Characters in Maize (*Zea mays* L.)

ABSTRACT

In crop breeding, the selection for yield is made complex because of the quantitative and polygenic nature of the character. This study was undertaken to assess character association and show the contribution of various yield contributing characters in some maize varieties through the help of correlation and path coefficient analyses in order to identify appropriate plant characters for selection to improve maize grain yield.Seventeen maize varieties were sown in a randomized complete block design with three replications in a humid environment of Port Harcourt, Nigeria in 2018 under rainfed condition. Data were recorded for days to 50% anthesis, days to 50% silking, anthesis-silking interval, plant height (cm) and ear height (cm), number of plants per plot, number of plants harvested, number of ears harvested, moisture content (%), field weight (kg), and grain yield (t ha^{-1}). Results showed number of plants per plot, number of plants harvested, number of ears harvested and field weight correlated positively and significantly both phenotypically and genotypically with grain yield. Path coefficient analysis at the genotypic level also revealed field weight and days to 50% anthesis as the characters exerting the highest positive direct effect on grain yield. Therefore, maize grain yield could be improved through indirect selection for these characters.

Keywords: *Maize, character association, grain yield, path coefficient analysis, selection*

INTRODUCTION

World over, the importance of maize (*Zea mays* L.) cannot be overemphasized. Its adaptability is quite remarkable and admirable; it thrives well in several diverse environments. The numerous forms of its use has made it a prominent crop, especially among cereals. In Nigeria, maize is grown majorly for its grain. However, production in terms of grain yield is still very low as compared to developed countries (FAOSTAT, 2018). Hence, there is need to improve maize grain yield principally through crop breeding to meet its ever rising demand.

Correlation analysis has been to a great extent used in determining the level of linear association among characters, i.e. it helps show the degree to which characters vary. It is an important tool for effective selection, because response to selection depends on many factors including the interrelationship of characters. Correlation studies according to Hallauer (2007) is helpful if indirect selection gives a greater response to selection for a desirable character than direct selection for the same, particularly when the character exhibits low heritability. Despite being helpful in revealing the direction and degree of linear association between a pair of characters, correlation analysis lacks the ability to uncover the relative importance of each character in terms of cause and effect. Hence, 'path analysis' was proposed to understand the interrelationships of cause and effect of each character (Wright, 1921).

Path coefficient analysis gives more information among variables as it partitions correlation coefficients into direct and indirect effect and causes of association (Dewey and Lu, 1959; Jakhar*et al.,* 2017). This approach is commonly used in crop breeding and has been efficacious in revealing the interrelationships between characters, either yield, grain quality or the effects of interaction of genotype by environment or management of cultivation (Jadhav*et al.,* 2014; Adesoji*et al.,* 2015; Ma *et al.,* 2015; Nardino*et al.,* 2016). The result helps to formulate selection criteria based on the direct and indirect effects. For example, selection aimed at improving a certain desirable character which is difficult to measure (such as yield) with low heritability, can be indirectly carried out by selecting another character (which is easier to measure and has high heritability) which is directly associated with the desirable character (Ojo*et al.,* 2006). Hence, this study was undertaken to access the interrelationship among characters and show the contribution of various yield contributing characters in 17 maize varieties through the help of correlation and path coefficient analyses in order to identify appropriate plant characters for selection to improve maize grain yield.

MATERIALS AND METHODS

Seventeen maize varieties (Table 1) were sown in a randomized complete block design in three replications during the rainy season of 2018 at the Rivers State University's Teaching and Research Farm, Nkpolu, Port Harcourt. For each variety, 2 seeds per hill were sown in row to row and plant to plant spacing of 75 and 25 cm, respectively on 2-rows of 5 m long ridge. Thinning was done at 2 weeks after sowing to maintain a plant population of 53,333 plants per hectare. Othernecessary agronomic practices were followed as per the recommendations of the Institute of Agricultural Research and Training (IAR&T) guide (IAR&T, 2010). In each plot, five random plants were selected and observations were recorded on days to 50% anthesis, days to 50% silking, anthesis-silking interval, plant height (cm) and ear height (cm); while number of plants per plot, number of plants harvested, number of ears harvested, moisture content (%), field weight (kg) and grain yield (t ha^{-1}) were recorded on plot basis. Correlation analysis was done using PBTools version 1.3 statistical package; while path coefficient analysis was achieved by the R software version 3.3.3 with the help of the Agricolae package (R Development Core Team, 2014).

Table 1: List of the Experimental Materials

S/N	Variety
1.	AFLATOXIN SYN 3-W
2.	DT SYN 15-W
3.	IWD C3 SYN
4.	LOCAL CHECK 1
5.	LOCAL CHECK 2
6.	PVASYN-2
7.	PVASYN-5
8.	PVASYN-7
9.	PVASYN-8
10.	PVASYN-9
11.	PVASYN-10
12.	PVASYN-13
13.	PVASYN-21

14.	PVASYN-22
15.	STR SYN 2-Y
16.	TZL COMP.3 C4
17.	TZL COMP.4 C4

RESULTS

Character association

Phenotypic correlation coefficients (r_p) (Table 2) revealed that number of plants per plot (0.451), number of plants harvested (0.539), number of ears harvested (0.581) and field weight (0.999) correlated significantly and positively with grain yield. Number of plants per plot showed significant and positive $r_p$with number of plants harvested (0.976), number of ears harvested (0.937) and field weight (0.440). However, it correlated negatively and significantly with moisture content (-0.285). Days to 50% silking correlated positively and significantly with days to 50% anthesis (0.824) and plant height (0.318). Days to 50% anthesis on the other hand correlated positively and significantly with plant height (0.330) but negatively with anthesis-silking interval (-0.446) and number of ears harvested (-0.294). Plant height had a positive r_p with ear height (0.840) while number of plants harvested correlated positively and significantly with number of ears harvested (0.967) and field weight (0.530). Similarly, number of ears harvested had significant positive r_p with field weight (0.573). Genotypic correlation coefficients (r_g) (Table 2) revealed that number of plants per plot (0.409), number of plants harvested (0.513), number of ears harvested (0.581) and field weight (0.999) correlated positively and significantly with grain yield. Days to 50% anthesis (-0.280) and moisture content (-0.285) correlated significantly but negatively with number of plants per plot while number of plants harvested (0.987), number of ears harvested (0.960) and field weight (0.398) had significant positive $r_g$with number of plants per plot. Days to 50% silking correlated significantly and positively with days to 50% anthesis (0.781), plant height (0.548) and ear height (0.418). Days to 50% anthesis on the other hand had significant positive $r_g$with plant height (0.548) and ear height (0.411) while negatively correlating with anthesis-silking interval (-0.515), number of plants harvested (-0.331) and number of ears harvested (-0.356). Moisture content had significant negative $r_g$with anthesis-silking interval. Plant height and ear height as well as number of plants harvested and number of ears harvested correlated significantly and positively. Also, field weight had a significant and positive $r_g$with both number of plants harvested and number of ears harvested.

Path coefficient analysis between grain yield and yield related characters

The genotypic correlation was used to estimate the direct and indirect effect of yield and yield contributing characters (Table 3). The path analysis depicted the strength of contributions of all independent variables under study on grain yield. Results revealed that number of plants per plot, days to 50% anthesis, anthesis-silking interval, plant height, number of ears harvested and field weight had positive direct effect on grain yield (0.590, 0.807, 0.565, 0.199, 0.287 and 1.085), respectively. Field weight (1.085) had the highest positive direct effect on grain yield, followed by days to 50% anthesis (0.807) and number of plants per plot (0.590). The results also showed that days to 50% silking and ear height exerted indirect effect on yield through days to 50% anthesis, while moisture content exerted indirect effect on yield through number of plants harvested.

Table 2: Phenotypic (r_p) and genotypic (r_g) correlation for yield and yield contributing characters measured in seventeen maize varieties

Characters	Correlation	Days to 50% silking	Days to 50% anthesis	Anthesis -silking interval	Plant height (cm)	Ear height (cm)	Number of plants harvested	Number of ears harvested	Field weight (kg)	Moisture content (%)	Grain yield (t ha^{-1})
Number of plants per plot	r_p	-0.248	-0.248	0.043	-0.179	0.023	0.976**	0.937**	0.440**	-0.285*	0.451**
	r_g	-0.258	-0.280*	0.085	-0.235	-0.023	0.987**	0.960**	0.398**	-0.416**	0.409**
Days to 50% silking	r_p		0.824**	0.140	0.318*	0.226	-0.218	-0.214	0.122	0.038	0.121
	r_g		0.781**	0.131	0.548**	0.418**	-0.261	-0.262	0.231	-0.060	0.238
Days to 50% anthesis	r_p			-0.446**	0.330*	0.244	-0.269	-0.294*	0.116	0.140	0.109
	r_g			-0.515**	0.548**	0.411**	-0.331*	-0.356**	0.213	0.139	0.209
Anthesis-silking interval	r_p				-0.076	-0.069	0.126	0.175	-0.011	-0.184	0.001
	r_g				-0.124	-0.079	0.160	0.203	-0.026	-0.286*	-0.007
Plant height (cm)	r_p					0.840**	-0.141	-0.121	0.123	0.037	0.123
	r_g					0.857**	-0.191	-0.156	0.117	0.067	0.115
Ear height (cm)	r_p						0.041	0.115	0.162	-0.180	0.172
	r_g						-0.001	0.097	0.149	-0.215	0.157
Number of plants harvested	r_p							0.967**	0.530**	-0.224	0.539**
	r_g							0.983**	0.503**	-0.340*	0.513**
Number of ears harvested	r_p								0.573**	-0.188	0.581**
	r_g								0.549**	-0.268	0.557**
Field weight (kg)	r_p									0.044	0.999**
	r_g									-0.008	0.999**
Moisture content (%)	r_p										-0.005
	r_g										-0.048

Table 3: Direct (diagonal bold) and indirect effects (off diagonal – on the row) of 11 characters on grain yield in 17 maize varieties at genotypic level

Characters	Number of plants per plot	Days to 50% silking	Days to 50% anthesis	Anthesis-silking interval	Plant height (cm)	Ear height (cm)	Number of plants harvested	Number of ears harvested	Field weight (kg)	Moisture content (%)	Correlation coefficient of grain yield (t ha^{-1})
Number of plants per plot	**0.590**	0.198	-0.226	0.048	-0.047	0.004	-0.896	0.276	0.432	0.030	0.409**
Days to 50% silking	-0.152	**-0.768**	0.631	0.074	0.109	-0.072	0.237	-0.075	0.251	0.004	0.238
Days to 50% anthesis	-0.165	-0.600	**0.807**	-0.291	0.109	-0.071	0.300	-0.102	0.231	-0.010	0.209
Anthesis-silking interval	0.050	-0.101	-0.416	**0.565**	-0.025	0.014	-0.145	0.058	-0.028	0.021	-0.007
Plant height (cm)	-0.139	-0.421	0.442	-0.070	**0.199**	-0.148	0.173	-0.045	0.127	-0.005	0.115
Ear height (cm)	-0.014	-0.321	0.332	-0.045	0.171	**-0.172**	0.001	0.028	0.162	0.016	0.157
Number of plants harvested	0.582	0.201	-0.267	0.090	-0.038	0.000	**-0.908**	0.282	0.546	0.025	0.513**
Number of ears harvested	0.566	0.201	-0.287	0.115	-0.031	-0.017	-0.892	**0.287**	0.596	0.020	0.557**
Field weight (kg)	0.235	-0.177	0.172	-0.015	0.023	-0.026	-0.457	0.158	**1.085**	0.001	0.999**
Moisture content (%)	-0.245	0.046	0.112	-0.162	0.013	0.037	0.309	-0.077	-0.009	**-0.073**	-0.048

Residual effect: 0.001

DISCUSSION

The knowledge of correlation between characters of economic importance are not only of interest from theoretical consideration of quantitative inheritance of characters, but of practical value since selection is usually concerned with changing two or more characters simultaneously (Prasuna, 2012). Yield being polygenic and quantitative in nature is governed by a large number of genes. The influence of each character on yield could be known through correlation studies with a view to determining the extent and nature of relationships prevailing among yield and yield attributing characters. Correlation coefficient helps in determining the direction of selection and number of characters to be considered in improving grain yield. From this study, grain yield showed positive and significant correlation with number of plants per plot, number of plants harvested, number of ears harvested and field weight at both phenotypic and genotypic levels, indicating that selection for these characters may be important in improving grain yield. This is similar to the findings of Olawamide and Fayeun (2020). Significant positive correlation was observed between days to 50% anthesis and days to 50% silking, as well as between ear height with plant height (Troyer and Larkins, 1985; Selvaraj and Nagarajan, 2011; Dar *et al.,* 2016). Similarly, plant height correlated significantly and positively with days to 50% silking and days to 50% anthesis (Selvaraj and Nagarajan, 2011), number of ears harvested with number of plants per plot, field weight with number of plants per plot, and number of plants harvested with number of ears harvested (Olawamide and Fayeun, 2020). This suggests that improvement of one character will automatically lead to improvement of the other simultaneously. On the other hand, negative significant correlation was observed between anthesis-silking interval and days to 50% anthesis (Ngugi*et al.,* 2013) and between numbers of ears harvested and days to 50% anthesis, suggesting that selection of anthesis-silking interval for a good number of ears harvested will negatively affect days to 50% anthesis.

Path coefficient analysis measures the direct influence of one variable upon the other and permits separation of correlation coefficients into components of direct and indirect effects (Dewey and Lu, 1959). Partitioning of total correlation into direct and indirect effects provides actual information on contribution of characters and thus forms the basis for selection to improve yield. Hence, genotypic correlations were partitioned into direct and indirect effects to know the relative importance of the components. Results revealed that number of plants per plot, days to 50% anthesis, anthesis-silking interval, plant height, numbers of ears harvested and field weight all had positive direct effect on grain yield, showing the importance of these characters (particularly field weight, which had the highest positive direct effect and almost perfect correlation with grain yield) to improve grain yield. Similar result has been reported by Sesay*et al.* (2017) and Olawamide and Fayeun (2020). In this study, it is inferred from correlation and path analysis that field weight is the most important character influencing grain yield. Thus, selection for field weight is a pre-requisite to attaining higher grain yield in maize. Next to it is number of plants per plot and number of ears harvested which both showed high positive direct effect as well as high correlation with grain yield.

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CONCLUSION

Number of plants per plot, number of plants harvested, number of ears harvested and field weight could be used as selection criteria in maize yield improvement because they showed positive phenotypic and genotypic correlation with grain yield. Furthermore, the high positive direct effect exerted by field weight, number of plants per plot and number of ears harvested shows the true relationship of these characters with grain yield. Consequently, selection for these characters could lead to indirect selection for grain yield.

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