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Path Analysis for Agro-morphological Traits in Maize

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Abstract

The objective of study was to determine relationship between grain yield and agro-morphological traits in winter maize by the application of path coefficient analysis. For this study the eleven open pollinated maize genotypes were planted under randomized complete block design with three replication at National Maize Research Program, Rampur, Chitwan, Nepal during 2013 winter season. The findings of this study showed that the number of kernels rows per ear (0.833), plant height (0.371), days to 50% tasseling (0.250) had high positive direct effects on grain yield. Different yield related traits influenced not only through their direct effect but also through indirect contribution towards grain yields. Number of kernels rows per ear, plant height have positive direct effect with grain yield. Thus selection could be made for high yielding maize genotypes on the basis of these traits.

Key words: Path analysis; maize; agro-morphological traits; grain yield

Introduction

Maize is an important cereal crop, cultivated throughout the world, is of significant importance for countries like Nepal, where rapid increase in population have already out stripped the available food supplies.The suitability of maize to diverse environments is unmatched by any crop as the expansion of maize to new areas and environment still continues, as it has a range of plasticity.

Path coefficient analysis provides means to quantify the interrelationship of different yield components and indicate whether the influence is directly reflected in the yield or take some other path ways to produce an effect. Unlike the correlation coefficient which measures the extent of relationship, path coefficient measures the magnitude of direct and indirect contribution of a component character to a complex character and it has been defined as a standardized regression coefficient which splits the correlation coefficient into direct and indirect effects.

Besides the direct effect of the exogenous (X_1) on the endogenous (Y), there is indirect effect of X on Y via other X's by virtue of its relationship with others. A change in a variable, say X_1, will affect its linear correlation r_{12}, with another variable, X_2, which invariable affects Y.

Let P_i be the direct effect of X ion Y, and change is only partial and proportional tor_{12}. That is,$r_{ij}P_j$ Is an indirect effect of X_i via X_j. Hence, the direct and indirect effect could be partition has done by Dewey and Lu(1959) for an 8-independent variable,

r1 y=P1+ r12P2+r13P3 + r14P4+ r15P5 +r16 P6 +r17P7 + r18P8 +r19P9 (1)

r2y=r12P1+P2+r23P3+r24P4+r25P5+r26P6+r27P7 + r28P8 +r29P9 (2)

r3 y=r13P1+ r23P2+ P3+ r34P4+ r35P5 +r36P6+r37P7 + r38P8 +r39P9 (3)

r4 y= r14P1+r24P2 + r34P3+ P4+r45P5 +r46P6+r47P7 + r48P8 +r49P9 (4)

r5 y=r15P1+r 25P2 + r35P3+ r45P4+P5+r56P6+r57P7 + r58P8 +r59P9 (5)

r6y=r16P1+r26P2 +r36P3+r46P4+ r56P6 +P6+r67P7 + r68P8 +r69P9 (6)

r7 y= r17P1+ r27P2 + r37P3+ r47P4+ r57P5+ r67P6+P7 + r68P8 +r79P9 (7)

r8y=r18P1+r28P2 +r38P3+r48P4+ r58P5+r68P6+r78P7 +P8 + +r89P9 (8)

r9 y= r19P1+ r29P2 + r39P3+ r49P4+ r59 P5+ r69P6+r79P7 + r89P8 +P9 (9)

These are converted to percentages to balance the differences in units. The percentage direct contributions, combined contributions of any two variables and the residual effect are worked out as follows.

a) The direct percentage contribution= $(P_i)^2$ x100
b) The combined contributions of any two variables= $2(P_iP_jr_{ij})$
c) The residual effect (R_x) =1–(r1yP1+ r2 yP2+ r3 yP3+r 4yP4+r5 yP5+ r6yP6+ r7 yP7+r8yP8+r9Yp9)

Path coefficient analysis provides more information among variables than do correlation coefficients since this analysis provides the direct effects of specific yield components on yield, and indirect effects via other yield components (Garcia del Moral *et al.*, 2003).

Path analysis, a statistical technique that partitions correlations into direct and indirect effects, differentiates between correlation and causation Afifi and Clark (1984), Wright (1934). This technique is independent of units of measurement therefore the relative importance between causal relationships may be determined Li (1975); Pantone *et al.* (1989).

Kumar *et al.* (2006) observed that days to 50 percent tasseling, Anthesis-Silking Interval (ASI), ear height and100-seed weight had highest direct effect on grain yield. The days to 50 per cent silking exhibited negative direct effect on grain yield.

Jayakumar *et al.* (2007) noticed that grains per row recorded maximum positive direct effect on grain yield followed by ear length, ear girth, days to tasseling total sugars and plant height. The maximum negative direct effect on grain yield was recorded by ear girth followed by days to silking and grain weight,

Alok Kumar *et al.* (1999) revealed that the number of grains per row, number of rows per ear, ear circumference, ear length and days to 50 percent flowering had direct effect on grain yield.

Grain yield, being a quantitative trait is a complex character of any crop. Various morphological and physiological plant characters contribute to yield. Plant breeders work with some yield components related to yield in the selection programs and it is very important to determine relative importance of such characters contributing to grain yield directly or indirectly. 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-effect relationship as well as effective selection. by determining association between maize grain yield and yield components and between yield components themselves as well as recognition of the parameters that have significant effect on yield, is a prerequisite plan for a meaningful breeding programme. Path analysis, a statistical technique that partitions correlations into direct and indirect effects, differentiates between correlation and causation (Afifi and Clark, 1984). This technique is independent of units of measurement therefore the relative importance between causal relationships may be determined (Li, 1975; (Pantone *et al.*, 1989).

Path coefficient analysis provides more information among variables than do correlation coefficients since this analysis provides the direct effects of specific yield components on yield, and indirect effects via other yield components (Garcia del Moral *et al.*, 1991).

Objectives

- To determine yield components through path coefficient analyses
- To study the relationship between different morphological traits and yield
- To work out path coefficients, so as to find out the relative contribution of different metric traits to the final grain yield

Material and Methods

The experiments were conducted at the National Maize Research Program (NMRP), Rampur, Chitwan, Nepal during September 2013. The eleven maize genotypes were used in this experiment (Table 1). The geographical location of the trials was 27º 37' N latitude, 84º 25' E longitude at an altitude of 256 meter above sea level and has a sub-tropical climate (Thapa and Dangol, 1988). Weather condition during the period of experiment at NMRP, Chitwan, Nepal is shown in Fig. 1.

Table 1: List of maize genotypes used in this experiment**.**

S.N.	Genotype
1	POP445
2	S97TEYGAAYB(3)
3	POP445/POP446
4	POP45/POP-17
5	Rampur Composite/Pool-17
6	Arun-2
7	Farmer’s Variety
8	ZM 627
9	ZM621/Pool-15
10	EEYC1
11	Pool-27

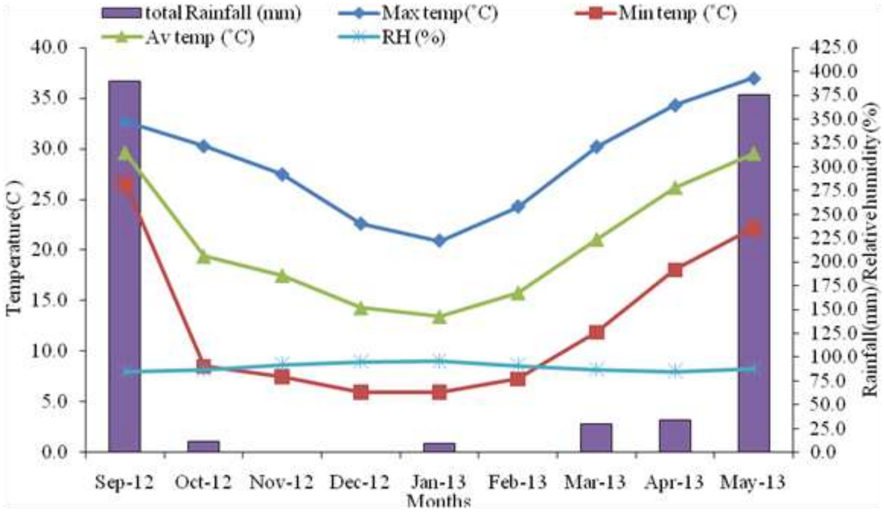

Fig. 1: Weather condition during the period of experiment at NMRP, Chitwan, Nepal

The experimental design was randomized complete block design (RCBD) with three replications. Each plot consisted of a row 5 m long with an inter and intra row plant spacing of 0 .75m × 0.25 m. Area of individual plots in each replication was 15 m². All plots were fertilized with 120: 60: 40 N: P_2O_5: K_2O kg/ha in the form of urea, di-ammonium phosphate (DAP), and murate of potash (MoP). Half of N and full dose of P_2O_5 and K_2O were applied as basal dose. The remaining half of the N was applied in two splits at knee-high and pre-tasseling/silking stages. The rest of cultural practices were done as per recommendation of NMRP, Rampur, Chitwan, Nepal. The traits namely, plant height, ear height, tussling, silking SPAD chlorophyll, number of Ear girth, Number of kernel rows per ear, Number of row ear^{-1}, Hundred kernels weight and grain yield were recorded. Data were analyzed through GENSTAT packages applying 5% level of significance.

Grain yield (kg/ha) at 15% moisture content was calculated using fresh ear weight with the help of the below formula:

$$\text{Grain yield}\left(\frac{\text{kg}}{\text{ha}}\right) = \frac{\text{F.W.}\left(\frac{\text{kg}}{\text{plot}}\right)(100-\text{moisture},\%)\text{x S x }10{,}000}{85\text{ x Harvested area}(\,m^2)}$$

Where,

F.W. = Fresh weight of ear in kg per plot at harvest

Moisture (%) = Grain moisture content at harvest

85= Required moisture percentage 15%

S= Shelling co-efficient (0.80)

Harvested area= net harvested plot size, m^2

Results

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-effect relationship as well as effective selection. Path analysis plays an important role in determining the degree of relationship between yield and its components.

The contents on Table 2 shows that direct effect of number of kernel rows per ear on grain yield per plant had the highest positive value (0.833) as compared to all other trait has been taken in to consideration. Plant height and days to 50% tasseling ranked second and third important yield component based on direct effect in path analysis. Correlation coefficient of ear girth were positive and highly significant with grain yield per plant while its direct effect on grain yield was negative. Negative direct effect of this trait was nullified by positive indirect contribution via other yield component.

Number of kernel rows per ear showed the highest, positive and high direct contiribution on grain yield per plant followed by plant height while days to 50%tessling exhibited moderate direct contribution. Positive and low direct contribution on grain yield per plant were shown by SPAD chlorophyll, ear length, ear height, number of kernel per row. Days to 50% silking showed negative and high direct effect on grain yield per plant.

Number of kernel rows per ear had positive , low indirect contribution(less than 0.20) to ward grain yield per plant via days to 50%tessling, plant height, ear height, SPAD chlorophyll, number of kernel row and ear length. However it showed negative indirect contribution via days to 50%silking and ear girth on grain yield per plant respectively.

Plant height had low positive indirect contribution via number of kernel rows per ear, SPAD chlorophyll, ear length, ear height , number of kernel per row but low negative indirect effect via days to 50% tessling, days to 50% silking and ear girth on grain yield per plant. Ear height exerted moderate positive effect via plant height on grain yield per plant while days to 50% silking, SPAD chlorophyll, ear girth, number of kernel rows per ear, number of kernel per row, ear length had low and positive indirect contribution via plant height on yield per plant. Days to 50% tessling showed low and negative indirect effect via plant height on grain yield per plant.

Days to 50%tessling exhibited positive and moderate indirect contribution via number of kernel rows per ear, positive and low indirect contribution via ear length, number of kernel per row, ear height while negative high indirect contribution via days to 50% silking and negative and low indirect contribution via SPAD chlorophyll, ear girth , plant height on grain yield per plant. Days to 50% silking exhibited moderate positive indirect contribution via days to 50% tessling on grain yield per plant. Ear length, number of kernel per row, number of kernel rows per ear, ear height, ear girth had low and positive indirect contribution via days to 50% tessling on grain yield per plant.

SPAD chlorophyll had positive and low indirect effect via plant height , number of kernel rows per ear , days to 50% silking, ear height, number of kernel per row on grain yield per plant while negative and low indirect contribution via days to 50% tessling and ear girth on grain yield per plant. Ear height , plant height , number of kernel per row, ear girth , number of kernel rows per ear had positive and low indirect effect via SPAD chlorophyll while days to 50% tessling , days to 50% silking and ear length had low and negative indirect contribution via SPAD chlorophyll on grain yield per plant.

Ear length exhibited positive and moderate indirect contribution via number of kernel rows per ear, positive and low indirect contribution via days to 50% tessling , plant height , number of kernel per row, ear height on grain yield per plant except SPAD chlorophyll, All the studied traits are positive and low indirect contribution via ear length on grain yield per plant.

Ear height showed positive and moderate indirect effect via plant height. It exhibited positive and low indirect effect via SPAD chlorophyll, number of kernel per row, no of kernel rows per ear, days to 50% tessling and ear length on grain yield per plant while it contributed negative and moderate indirect effect via days to 50% silking and negative low indirect effect via ear girth on grain yield per plant. All studied trait showed positive and low indirect effect via ear height on grain yield per plant.

Number of kernel per row exhibited positive and high indirect contribution via number of kernel rows per ear on grain yield per plant. Positive and low indirect effect via plant height, ear length, SPAD chlorophyll, days to 50%tessling on grain yield per plant while number of kernel per row exhibited negative moderate and low indirect contribution via days to 50% silking and ear girth on grain yield per plant respectively. All studied trait had positive and low indirect contribution via number of kernel per row on grain yield per plant.

Days to 50%silking had positive high and moderate indirect contribution via number of kernel rows per ear and days to 50%tessling on grain yield per plant respectively. Days to 50% tasseling exhibited positive and low indirect effect via ear length, number of kernel per row, plant height, ear height on grain yield per plant. While it had negative and low indirect effect via SPAD chlorophyll and ear girth.

Days to 50%tessling exhibited high indirect contribution to all other traits except SPAD chlorophyll exhibited low indirect effect via. days to 50%silking on grain yield per plant.

Table 2: Path coefficient analysis of growth and yield attributing traits in maize at NMRP, Rampur, Chitwan, Nepal.

DTT	DTS	PH	EH	SPAD	EG	NKRE	NKR	EL
0.250644	0.243375	-0.00025	0.071183	-0.03409	0.049377	0.100759	0.103516	0.151389
-0.5677	**-0.58465**	-0.04911	-0.22626	0.043849	-0.11108	-0.24614	-0.24789	-0.35605
-0.00037	0.031184	**0.371233**	0.234248	0.129189	0.104688	0.025615	0.063481	0.141069
0.015435	0.021033	0.034295	**0.05435**	0.028914	0.01125	0.004891	0.008152	0.011468
-0.01972	-0.01088	0.050464	0.077146	**0.145011**	0.033933	0.015226	0.037848	-0.0045
-0.00907	-0.00875	-0.01298	-0.00953	-0.01077	**-0.04604**	-0.02228	-0.02334	-0.02039
0.335014	0.350848	0.057502	0.075003	0.087504	0.40335	**0.833367**	0.515021	0.371682
0.021352	0.021921	0.008841	0.007755	0.013494	0.026212	0.031951	**0.0517**	0.032313
0.060413	0.060913	0.038008	0.021105	-0.0031	0.04431	0.04461	0.062514	**0.100022**

Residual effect =0.087

DTT= Days to 50% tasseling, DTS= Days to 50% silking, PH= Plant height, EH= Ear height, SPAD= SPAD chlorophyll, EG= Ear girth, NKRE=Number of kernel rows per ear, NKR= Number of row ear^{-1}, EL= Ear length

Discussion

Success of any breeding programme depends on the efficiency of selection. For successful selection it is necessary to study the nature of association of characters with other relevant traits. Path coefficient analysis provides better means for selection by resolving the correlation coefficient of yield and its components into direct and indirect effects. The present investigation was therefore, aimed to estimate the direct and indirect effects of different character on grain yield per plant.

Path coefficient analysis is the most widely used biometrical technique in plant breeding. The information obtained from this technique, also helps in making selection based on component characters of yield. It helps in understanding the cause of association between two variables. It determines the direct effect of various characters on yield and also indirect effects through other components characters and provides the selection of superior genotypes

In present investigation , path analysis using grain yield per plant as dependent variable revel that no of kernel rows per ear exerted maximum positive direct effect on grain yield per plant, followed by plant height , days to 50% tessling, SPAD chlorophyll and ear length. Plant height had significant positive association with grain yield per plant, this is supported by Ahamed *et al.* (2001) and it also exerted positive direct effect on grain yield per plant.

Ear height had a positive direct effect on grain yield as indicated by El-Nagouly et al. (1983) and Rahman et al. (1995). Hence this traits could be relied upon for selection of genotypes to improve genetic yield potential of maize. Days to 50% silking had non-significant positive correlation with grain yield per plant and also had negative direct effect on grain yield indication poor importance on yield improvement. This result is supported by Kumar *et al.* (2006).

Ear girth was positively and highly significantly correlated with grain yield per plant. The direct effect of ear girth on grain yield per plant appears to be negative. Indirect effect via other components was observed to be positive. It is therefore, evident that other character most be consider at the time of selection based on ear girth. Ear girth had a negative indirect effect on grain yield. Further it was evident that 92.30% of the yield attributing character was utilized in this analysis as amount of model remainder effect was 0.087(8.7%) of yield variation are controlled by unknown factor.

Conclusion

Breeding strategy in maize mainly depends upon the degree of associated characters as well as its magnitude and nature of variation. Grain yield is a complex quantitative trait that depends on a number of factors. Efficiency of selection in any breeding programme mainly depends upon the knowledge of association of the characters. For formulating selection indices for genetic improvement of yield, the cause effect of the trait is very essential and can be done by path analysis. The direct and indirect effects of specific yield components could be precisely identified and applied in breeding programs of maize by determining of inter-relationship among grain yield and yield components by the help of path coefficient analysis. Therefore in order to improve grain yield in maize genotype, effective selection can be practiced for parameter having high direct effect and the character through which indirect effect mainly influenced to the grain. The number of kernels rows per ear influence grain yield per plant directly and pre dominantly followed by plant height. further, they have positive and highly significant association in grain yield indicating positive role on grain yield per plant indirectly in a substantial magnitude through most of other yield components. thus selection of genotype with more number of kernels per row having maximum plant height is a pre requisite for improving grain yield.

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