The Pharma Innovation Journal 2020; 9(1): 189-191

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2020; 9(1): 189-191

www.thepharmajournal.com
Received: 16-11-2019
Accepted: 18-12-2019

Devraj Lenka
Professor, Department of Plant Breeding and Genetics, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Bibhu P Singh
P.G. Scholar, Department of Plant Breeding and Genetics, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Devidutta Lenka
P.G. Scholar, Department of Plant Breeding and Genetics, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Swapan K Tripathy
Professor, Department of Agricultural Biotechnology, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Corresponding Author:
Swapan K Tripathy
Professor, Department of Agricultural Biotechnology, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Inter-relationship of morpho-economic traits in a set of maize inbred lines under deficit moisture condition

Devraj Lenka, Bibhu P Singh, Devidutta Lenka and Swapan K Tripathy

Abstract
A set of 35 maize inbreds were evaluated in the field to study association analysis of agro-economic component traits with grain yield. At both genotypic and phenotypic level, cob diameter, kernel rows/cob followed by number of kernels/row, total number of grains/plant, cob length and 100-grain weight revealed strong significant positive association with grain yield/ha. Cob length and cob diameter showed significant positive inter-relationship and both these component traits also maintained strong positive correlation with number of kernel rows/cob, number of kernels/row and total number of grains/plant. Information of such correlated response would certainly help the selection process much easier for genetic improvement of grain yield in maize. However, days to silking (DS) and anthesis-silking interval (ASI) exhibited strong negative association with grain yield indicating delay in silking and that even after anthesis would decrease grain yield in maize.

Keywords: Association analysis, yield and yield related traits, moisture stress, maize

Introduction
Maize (*Zea mays* L.) is the third staple food next to rice and wheat in Asia; and it possesses the highest yield potential among the cereals. Water stress is one of the main environmental stresses responsible for reduction of crop productivity as it affects growth through various physiological and metabolic processes of plant (Bray, 1993) [4], vital biochemical processes. Moisture stress is very common in the areas, where, maize is predominantly grown under rain fed condition. Most of the world maize area is grown under rain fed conditions & it is more susceptible to drought than other cereals (Hall *et al*., 1981) [5]. Effect of drought stress include delayed silking & female sterility caused by abortion (Moss & Downey, 1971) [8] resulting into a larger reduction in grain yield. It was estimated that annual yield loss due to drought may approach 24 million tonnes equivalent to 17 % of a normal year's production in a developing world. But, the demand for maize in developing world is estimated to be nearly double by 2050 (Rosegrant et *al*., 2009) [11]. Hence, there is need to reorient the breeding strategy and it is seems to be most vital for drought resistance in the context of present climate change scenario.
Seed yield in maize is a complex trait and it is determined by mutual relationship among the component morpho-economic traits. In this context, study of the mode and extent of inter-relationship of different component traits and their direct and indirect effects on seed yield can provide the basis for effective selection. Many often unfavorable linkages among the agro-economic traits do exist resulting in genetic slippage and limited genetic advance. Moreover, study of path analysis is more important over correlation, in that, it partitions the total correlation coefficients with yield into various direct and indirect effects. Therefore, an attempt has been made to estimate the correlation and path coefficients of morpho-economic traits at both phenotypic and genotypic level to formulate an effective selection strategy in maize.

Materials and Methods
A set of 35 maize inbreeds were evaluated at EB-II section of the Department of Plant Breeding and Genetics, College of Agriculture, OUAT, Bhubaneswar in field condition during Rabi 2018-19. The experiment was laid out in a randomized block design (RBD) with two replications. Each entry was represented by 2 lines of 4 meters row length having 60 cm spacing between rows and 20 cm between plant to plant within a line after thinning. Fertilizers were applied at the rate of 120 kg N, 60 kg P_2O_5 and 60 kg K_2O per hectare in the form of Urea, SSP and MOP respectively along with FYM @ 12 cart loads/ha and Zinc Sulphate 25kg/ha. Normal agronomic practices and plant protection measures were applied to raise a normal crop.

Drought stress was imposed by with-holding irrigation before 10 days of flowering and stopped for about one month and the irrigation was resumed when soil moisture reached permanent wilting point at a depth of 40-60 cm. Plant height(PH), ear height(EH), cob length (CL), cob diameter (CD), Shelling percentage (SP), kernel rows per cob(KR/C), kernels/row(K/R), total number of grains/plant(TG/P) and 100-seed wt (100-WT) were recorded on five randomly selected competitive plants per replication per inbred line. The mean of five plants were computed for statistical analysis. The characters like days to 50% anthesis (DA), days to 50% silking (DS), days to 75% dry husk (DH), moisture percentage (MP)and grain yield/ ha (GY/Ha) were calculated on plot basis. Anthesis-silking interval (ASI) was calculated by counting the days between date of silking and anthesis.

Routine statistical procedures were followed for analysis of variance and covariance (Singh and Choudhury, 1976) [3]. The correlation coefficients for each pair of characters were computed following Al-Jibouri *et al*. (1958) [1] and the path coefficients (direct and indirect effects) were calculated as per Dewey and Lu (1959) [2].

Results and Discussion

Either linkage or pleiotropy is considered to be the genetic basis of character association. Association arising from coupling phase of linkage resist selection pressure more than that arising from repulsion phase of linkage. In addition to this, pleiotropic effects also contribute to strong association of characters. Such associations are of practical use if characters associated are both desirable and complementary. Very often selection for yield per se is not reliable and therefore, indirect selection through component traits becomes important for the ultimate output. Hence, studies on character associations not only help to understand physical linkages but also provide informations on nature and direction of selection.

Estimation of phenotypic correlations between grain yield and component characters as well as *inter se* association provides information for choice of characters in selection programme. The strength of character association as measured by estimates of co-efficient of correlation depends upon the composition of the test materials, characters studied, previous selection history and the environment under which the breeding materials were tested. The results of nature and magnitude of association of characters both at genotypic and phenotypic level are presented in Table 1.

A close correspondence between genotypic and phenotypic correlations observed in the present investigation indicates lesser masking effect of environment for character expression. In general, genotypic correlation coefficients were higher than corresponding phenotypic values for most of the character combinations and this agrees with earlier findings of Kumar and Satyanarayana (2001) [7] and Hepziba *et al.* (2013) [6]. At both genotypic and phenotypic level, cob diameter(CD), kernel rows/cob(KR/C) followed by number of kernels/row(K/R), total number of grains/plant, cob length(CL) and 100-grain weight(100-WT) revealed strong significant positive association with grain yield/ha(GY/Ha). Similar results were found by Parimala *et al*, (2011) [9], Seyedzavar *et al*. (2015) [12], Reddy and Jabeen (2016) [10]. In contrast, days to 75% dry husk (DH) seems to have very weak non-significant correlation with grain yield and hence, selection based on such component trait may not offer any dividend for genetic improvement of grain yield in maize. Further, it clearly reveals that all the significantly and positively correlated yield components are also highly inter-correlated among themselves. For instance, cob length and cob diameter showed significant positive inter-relationship and both these component traits also maintained strong positive correlation with KR/C, K/R and TG/P. Therefore, intensive selection in the positive side of any one of these traits can automatically improve other component trait(s) leading to increase in grain yield/ha.

In the present investigation, days to anthesis (DA), days to silking (DS), anthesis-silking interval (ASI) and moisture percentage(MP) showed negative correlation with grain yield/ha. Among these, days to silking (DS) and anthesis-silking interval (ASI) exhibited strong negative association with grain yield indicating delay in silking and that even after anthesis would decrease grain yield in maize. Thus, the interrelationship among yield and yield related traits emanated from this study would certainly help in selection process for genetic improvement in maize.

Table 1: Phenotypic (r_p) and genotypic (r_g) correlation co-efficients among 16 characters in 35 selected maize inbreds.

Characters	Correlation	DS	ASI	DH	PH	EH	SP	MP	CL	CD	KR/C	K/R	TG/P	100. WT	GY/Ha
DA	r_p	0.455**	-0.187	0.278	-0.030	-0158	-0.130	-0.476**	0.010	-0.210	-0.115	-0.045	-0.170	-0.327	-0.108
	r_g	0.451**	-0170	0.292	-0.033	-0.175	-0.141	-0.554**	0.020	-0.247	-0.133	-0.052	-0.183	-0.339	-0.117
DS	r_p		0.787**	0.231	-0.361*	-0.410*	-0.337*	-0.057	-0.486**	-0.610**	-0.578**	-0.451**	-0.503**	-0.685**	-0.626**
	r_g		0.803**	0.225	-0.374*	-0.427*	-0.384	-0.041	-0.498**	-0.641**	-0.631**	-0.473**	-0.522**	-0.709**	-0.650**
ASI	r_p			0.053	-0.374*	-0.333	-0.290	0.272	-0.530**	-0.521**	-0.548**	-0.462	-0.433**	-0.528**	-0.612**
	r_g			0.043	-0.388*	-0.344*	-0.300	0.330	-0.552**	-0.536**	-0.597**	-0.483	-0.454**	-0.562**	-0.638**
DH	r_p				0.156	0.042	0.235	0.152	0.292	0.150	0.191	0.359*	0.286	-0.056	0.228
	r_g				0.161	0.399*	0.244	0.201	0.306	0.149	0.201	0.362*	0.295	-0.047	0.237
PH	r_p					0.789**	0.371*	0.081	0.545**	0.606**	0.527**	0.572**	0.464**	0.485**	0.616**
	r_g					0.791**	0.376*	0.089	0.551**	0.623**	0.556**	0.589**	0.473**	0.494**	0.623**
EH	r_p						0.474**	-0.016	0.500**	0.635**	0.578**	0.438**	0.406*	0.475**	0.611**
	r_g						0.478**	-0.019	0.503**	0.651**	0.608**	0.448**	0.413*	0.488**	0.617**
SP	r_p							-0.163	0.447**	0.616**	0.618**	0.640**	0.605**	0.381**	0.666**
	r_g							-0.186	0.452**	0.631**	0.652**	0.652**	0.611**	0.391**	0.673**
MP	r_p								-0.004	0.038	-0.013	-0.015	0.145	0.075**	-0.052
	r_g								-0.007	0.045	-0.008	-0.030	0.169	0.037**	-0.048
CL	r_p									0.883**	0.833**	0.808**	0.795**	0.683**	0.843**
	r_g									0.914**	0.887**	0.830**	0.810**	0.704**	0.852**
CD	r_p										0.933**	0.857**	0.869**	0.779**	0.927**
	r_g										0.986**	0.882**	0.882**	0.837**	0.951**
KR/C	r_p											0.814**	0.865**	0.692**	0.909**
	r_g											0.863**	0.903**	0.761**	0.962**
K/R	r_p												0.866**	0.624**	0.851**

	r_g												0.884**	0.660**	0.876**
TG/P	r_p													0.626**	0.851**
	r_g													0.644**	0.868**
100. WT	r_p														0.764**
	r_g														0.787**

N.B: *, ** Significance at $P_{0.05}$ and $P_{0.01}$

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