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Genetic Correlation among Various Quantitative Characters in Maize (*Zea mays* L.) Inbred Lines

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ABSTRACT

Thirty maize (*Zea mays* L.) inbred lines were grown in a randomized complete block design with three replications to assess the genetic correlation among 13 quantitative traits. A positive correlation with grain yield/plant was recorded for plant height (r = 0.41), ear length (r = 0.54), ear diameter (r = 0.74), number of grains/row (r = 0.47), number of grains/ear (r = 0.45) and 1000-grain weight (r = 0.41). Days to 50% tasselling and days to 50% silking were negatively correlated with yield/plant while days to 50% maturity, ear height, number of ears/plant and number of kernel rows/ear were positively but insignificantly correlated with yield/plant. Ear diameter was the character that most contributed to high yield/plant (r = 0.74) followed by ear length (r = 0.54). A strong positive correlation was observed for grain yield/plant with plant height (r = 0.41), ear length (r = 0.54), ear diameter (r = 0.74), number of grains/row (r = 0.47), and number of grains/ear (r = 0.45) indicating that selection for these characters could help improve grain yield in maize inbred lines.

Keywords: association of yield attributes, exotic hybrids, homozygous lines, selfing

INTRODUCTION

The objective of this study was to establish an association between 13 quantitative characters in maize inbred lines and yield. Crop yield is a complex character controlled by several interacting genotypic and environmental factors. The interrelationships that exist between yield and its contributing components can significantly improve the efficiency of crop breeding programs through the use of proper selection indices. Direct selection for yield is often deceptive as it is highly influenced by fluctuating environmental components. Correlation coefficient analysis is useful in the selection of several traits simultaneously influencing yield. Genetic correlation analysis exploits the degree of association among important quantitative traits and by utilizing genetic correlations between traits, secondary traits can be used to improve primary ones that are difficult to measure (Malik *et al*. 2005; Talebi *et al*. 2007; Malosetti *et al*. 2008; Menkir 2008; Kashiani *et al*. 2010). Keeping in view many other factors, the genetic base of the material under study and the effects of environment are very important while studying the genetic correlation among various quantitative characters in crop species. Such studies could lead plant breeders to select traits that contribute towards the character(s) of concern, and ultimately their improvement through hybridization. Studies on correlation are quite old and extensive but, unfortunately, there is hardly any rule set on how much a character contributes towards the expression of other character(s) in a plant population. In maize, grain yield was shown to be negatively correlated with days to silking and tasselling (Umakanth *et al.* 2000; Malik *et al.* 2005), although other published results contradict this (Ahmad 1997; Rather *et al.* 1999). Plant height was strongly associated with grain yield (Singh and Dash 2000; Umakanth *et al*. 2000; Malik *et al*. 2005), although Rather *et al.* (1999) reported the association of plant height with grain yield to be non-significant. Ear length and ear diameter (Khatun *et al.* 1999; Singha and Prodhan 2000) as well as number of kernels/row and number of kernel rows/ear (Khakim *et al.* 1998; Khatun *et al.* 1999) were also positively correlated with grain yield.

MATERIALS AND METHODS

Inbred line development

As part of a long-term program aimed at the development of maize inbred lines, an experiment was conducted at the Hajee Mohammad Danesh Science and Technology University where near-homozygous (98.4%) inbred lines (sixth generation of selfing) were developed from 10 different single cross exotic hybrid varieties to create a source population (Hallauer *et al*. 2010). The exotic hybrids (‘Durga’, ‘Pacific-984’, ‘900M Gold’, ‘Kanak’, ‘CP-818’, ‘900M’, ‘NK-40’, ‘Bijoy’, ‘Seed tee-740’ and ‘NT-6323’) were used to produce 30 inbred lines named as ML-01 to ML-30, which were produced through continuous selfing of each segregating generation of each hybrid. 100 plants were randomly selected from each hybrid progeny and the selected plants were crossed with a mixture of pollen collected from all 10 hybrids to ultimately produce 1000 selfed seed stocks. Ten plants were selected from each progeny line and the selected plants were selfed but at the time of harvesting only one desirable cob was collected from each line to advance the next generation. The inbred development program was commenced in 2005 and by early 2011 nearly homozygous (F_6) inbred lines were developed. Only in winter in Bangladesh is it suitable for maize seed production, therefore, the winter of each year was chosen to raise the crop in the field. The selfing process was continued up to the 6th generation. At the end of selfing, three phenotypically superior inbred lines were selected and 100 selfed progenies against each of the hybrids. In each generation the selfed plants were allowed to grow under natural conditions without applying any plant protection measure, although necessary agronomic management practices such as irrigation, weeding and fertilizer application were allowed to raise the selfed plants (Quayyam 1993). Natural hazards viz., cold, hail storm, prevalence of insects and pests, etc. had played a predominant role in evolve the desirable inbred lines throughout the selfing process. Cross pollination either by insects or wind was

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Short Communication

Table 1 Genetic correlation coefficients among various characters of thirty maize inbred lines.

Traits	DT	DS	DM	PH	EH	EL	ED	EPP	KRPE	GPR	GPE	TGW
DS	0.92^{**}											
DM	0.57^{**}	0.59^{**}										
PH	-0.45^{*}	-0.40^{*}	0.04^{ns}									
EH	0.32^{ns}	0.31^{ns}	0.28^{ns}	0.02^{ns}								
EL	-0.04^{ns}	-0.02^{ns}	0.26^{ns}	0.21^{ns}	0.51^{**}							
ED	-0.27^{ns}	-0.24^{ns}	0.01^{ns}	0.17^{ns}	-0.11^{ns}	0.24^{ns}						
EPP	0.04^{ns}	0.08^{ns}	0.09^{ns}	0.03^{ns}	0.07^{ns}	-0.07^{ns}	0.01^{ns}					
KRPE	-0.49^{**}	-0.51^{**}	-0.38^{*}	0.06^{ns}	-0.63^{**}	-0.13^{ns}	0.65^{**}	-0.05^{ns}				
GPR	-0.51^{**}	-0.46^{ns}	-0.04^{ns}	0.20^{ns}	0.01^{ns}	0.18^{ns}	0.26^{ns}	-0.02^{ns}	0.17^{ns}			
GPE	-0.68^{**}	-0.63^{**}	-0.30^{ns}	0.20^{ns}	-0.39^{*}	0.01^{ns}	0.51^{**}	-0.06^{ns}	0.73^{**}	0.73^{**}		
TGW	0.55^{**}	0.49^{**}	0.47^{**}	-0.07^{ns}	0.38^{*}	0.32^{ns}	0.37^{*}	0.26^{ns}	-0.02^{ns}	-0.14^{ns}	-0.15^{ns}	
YPP	-0.34^{ns}	-0.32^{ns}	0.14^{ns}	0.41^{*}	0.19^{ns}	0.54^{**}	0.74^{**}	0.06^{ns}	0.33^{ns}	0.47^{**}	0.45^{*}	0.41^{*}

** Significant at 1% level of probability, * Significant at 5% level of probability, ns = not significant.

DT = Days to 50% tasseling, DS = Days to 50% silking, DM = Days to maturity, PH = Plant height (cm), EH = Ear height (cm), EL = Ear length (cm), ED = Ear diameter (cm), EPP = Ears per plant, KRPE = Kernel rows per ear, GPR = Grains per row, GPE = Grains per ear, TGW = Thousand grain weight and YPP = Yield per plant

protected through bagging both the tassel and cob of each of the selected plants. The plants that were susceptible to pests and insects and less vigorous were discarded in every generation although a total of 10,000 plants were selfed to check for inbreeding depression. As the number of generations of self pollination increases, individual plant progenies became more and more homogeneous and homozygous; consequently, in the latter phases of selfing, selection was exercised primarily among the progenies rather than within progenies. When variation in phenotypic expression of any of the selected traits was not observed, this indicated a homogenous population i.e., all the plants seemed morphologically alike and uniform. On the other hand, homozygosity in selfed progenies was estimated by the following formula (Hallauer *et al*. 2010).

Increase homozygosity = 1- (1/2)n

where n = number of selfing generations.

Sample preparation, data collection and analyses

Thirty maize inbred lines were grown in a randomized complete block design with three replications during the 2010-2011 winter season. The seeds of each entry were sown in one row 5 m long with a spacing of 0.75 m × 0.20 m between rows and plants, respectively. Fertilizers were applied at the rate of N 120, P_2O_5 80, K_2O 80, S 20, Zn 5 and B 1 kg/ha in the forms of urea, triple super phosphate, murate of potash, gypsum, zinc sulphate and borax, respectively. All other intercultural operations were done as and when necessary to raise the crop uniformly. Observations were recorded on a whole-plot basis for days to 50% tasselling, days to 50% silking and maturity. Ten randomly selected plants/entry in each replication were used for recording observations on plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of ears/plant, number of kernel rows/ear, number of grains/row, number of grains/ear, 1000-grain weight (g) and yield/plant (g). Genetic correlations were estimated by the covariance values for all traits according to the formulae described by Falconer and Mackay (1996) as follows:

$$r_G = \frac{\sigma_{G(X,Y)}}{\sqrt{\sigma^2_{G(X)} \cdot \sigma^2_{G(Y)}}}$$

where:

r_G = Genetic correlation between the traits X and Y

$\sigma_{G(X,Y)}$ = Genotypic covariance between the traits X and Y

$\sigma^2_{G(X)}$ = Genotypic variance of the trait X

$\sigma^2_{G(Y)}$ = Genotypic variance of the trait Y.

RESULTS AND DISCUSSION

Genetic correlation coefficients between studied traits illustrated in **Table 1**. Positive and significant ($P \leq 0.05$) correlation of days to 50% tasseling were observed with days to 50% silking, days to maturity and 1000-grain weight but the traits that showed a significant negative genetic correlation with plant height, number of kernel rows/ear, number of grains/row and number of grains/ear, while non-significant correlations were measured in ear height, number of ears/plant, ear length, ear diameter and yield/plant. Malik *et al*. (2005) observed a positive and significant correlation of days to 50% tasseling with days to 50% silking but they reported a negative and significant correlation of the trait with 100-kernel weight. Besides, non-significant correlations of days to 50% tasseling were observed with ear height, ear length, ear diameter, number of ears/plant and grain yield. Faruq *et al*. (2011) reported no correlations of days to 50% tasseling with ear height, number of ears/plant, 1000-grain weight and grain yield. Kashiani *et al*. (2010) reported positive and significant correlation of days to tasseling with plant height and days to silking. Kashiani and Saleh (2010) found a positive correlation of days to tasseling with days to silking, but a negative correlation with ear diameter, number of kernels/row and number of kernel rows/ear. Days to 50% silking was positively correlated with days to maturity and 1000-grain weight but negatively correlated with plant height, number of kernel rows/ear and number of grains/ear while no correlation with ear height, ear length, ear diameter, number of ears/plant, number of grains/row and yield/plant. Altenbas and Algan (1993) reported number of kernels/row to be positively correlated with days to silking, Tiwari and Verma (1999) found cob yield while Umakanth *et al*. (2000) and Malik *et al*. (2005) reported grain yield to be negatively correlated with days to silking. Ojo *et al*. (2006) observed a positive and significant correlation of days to 50% silking with plant height. Days to maturity was positively correlated with days to 50% tasseling, silking and 1000-grain weight, but negatively correlated with number of kernel rows/ear. Among all characters, only days to 50% tasseling and silking were negatively correlated with plant height but there was a positive correlation between plant height and yield/plant. Singh and Prodhan (2000) also reported grain yield to be positively correlated with plant height. Burak and Magoja (1991), Umakanth *et al*. (2000) and Malik *et al*. (2005) found maximum positive correlation between plant height and grain yield. Ear height had a positive relationship with ear length and 1000-grain weight. It was negatively correlated with number of kernel rows/ear but was not correlated with the remaining traits studied. Kashiani *et al*. (2010) found a negative correlation of ear height with days to 50% silking. Ear length was positively correlated with ear height and yield/plant. Malik *et al*. (2005) reported a positive correlation of ear height with plant height, number of kernels/row, 1000-kernel weight and yield/plant. Nemati *et al*. (2009) also reported a positive and significant correlation of ear length with number of kernels/row, and number of kernels/ear. Ear diameter was positively correlated with number of kernel rows/ear, number of grains/ear, 1000-grain weight and yield/plant. These results are in agreement with the findings of Nemati *et al*. (2009) and Kashiani and Saleh (2010). A correlation between number of ears/plant with all other traits was not established. Martin and Russel (1984) only found grain yield to be positively correlated with number of ears/plant, but Malik *et al*. (2005) reported no correlation of number of ears/plant with other traits under study. Number of kernel rows/ear was positively correlated with ear diameter and number of grains/ear and negatively correlated with days to 50% tasseling, days to 50% silking, maturity and ear height. Number of grains/row was positively correlated with number of grains/ear and yield/plant, negatively correlated with days to 50% tasseling and non-significant with days to 50% silking, days to maturity, plant height, ear height, ear length, ear diameter, number of ears/plant, number of kernel rows/ear and 1000-grain weight. Rehman *et al*. (1995) however reported number of kernels/row to be positively correlated with grain yield. Malik *et al*. (2005) observed a positive correlation of number of kernels/row with plant height, ear height and grain yield. Number of grains/row was positively correlated with plant height, ear diameter and number of kernel rows/ear (Kashiani and Saleh 2010), and grain yield (Ojo *et al*. 2006; Nemati *et al*. 2009). A negative correlation was found between plant height and grain yield, therefore, yield components are interrelated and develop sequentially at different growth stages, although a correlation might not provide a clear picture of the importance of each component in determining grain yield (Sreckov *et al*. 2011). Number of grains/ear was positively correlated with ear diameter, number of kernel rows/ear, number of grains/ear and yield/plant, while negatively correlated with days to 50% tasseling, days to 50% silking, maturity, ear height, ear diameter and yield/plant. A high correlation of number of grains/ear with grain yield was reported by other researchers (Mohammadi *et al*. 2003; Ojo *et al*. 2006; Nemati *et al*. 2009; Kashiani *et al*. 2010). No negative correlation was established between 1000-grain weight and other yield-contributing characters. Shalygina (1990) reported 100-kernel weight to be very closely correlated with grain yield. A similar observation was also reported by Iqbal and Chuhan (2003). The main goal was to develop superior inbred lines that will have the ability to produce out-performed hybrids over existing hybrids with respect to a number of traits (Abou-Deif *et al*. 2012). In working towards this goal, particular attention has been paid to increase grain yield through estimating correlation at the genetic level for the yield-contributing traits in the developed maize inbred lines.

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