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Genetic Potential, Variability and Heritability of Various Morphological and Yield Traits among Maize Synthetics

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Research Article

Abstract

Breeders are interested in screening and development of open pollinated population in maize. In the current study a set of four maize populations, *i.e.* PSEV-3-2ES, Pop 2004-BS, Pop 2006 and Jalal 2003 were evaluated for genetic potential and variability. Breeding material was evaluated in randomized complete block design with three replications. Analysis of variance results showed highly significant differences (P≤ 0.01) for all the traits. The highest values for plant height (169.1 cm), ear height (75.13 cm), leaves plant^{-1} (11.33), flag leaf area (106.5 cm^2), grain rows ear^{-1} (13.67) and grain yield (5927 kg ha^{-1}) were recorded for Jalal-2003. Broad sense heritability (h^2bs) ranged from 0.29 to 0.95 for various traits. Among the tested populations Jalal-2003 proved to be superior for most of the traits studied. The present study revealed a considerable amount of genetic variation and heritability estimates that could be manipulated for further improvement in maize breeding.

Keywords: Genetic potential; Genetic variation; Population; Variability; Heritability.

1. Introduction

Maize (*Zea mays* L.) belong to family Poaceace and is primarily a cross pollinated species, a feature that has contributed to its broad morphological variability and geographical adaptability. It has a wide adaptation, and is able to grow in regions ranging from semi arid with annual rainfall of 20 to 25 cm, to those where annual rainfall may exceed 400 cm. Morphologically corn exhibits a greater diversity of phenotypes than perhaps any other grain crop [1,2] , and is extensively grown in temperate, subtropical and tropical regions of the world. The range of cultivation of maize crop stretches from 50° N 40° S latitude and at altitude from sea level to 3300 meters. In Pakistan, during 2006-07 maize was sown on an area of 1016.9 thousand hectares with annual yield 3037 kg ha^{-1} and average production 3088.4 thousand tons [3]. There is a great range of escalating maize production in the country with sole objective to achieve the level of self-reliance in food grains. The major limiting factor for low yield per unit area is the unavailability of suitable and inexpensive maize hybrids thus, forcing the farmers to plant open pollinated maize varieties or populations

Among the various traits, grain yield in maize is the most important and complex quantitative traits controlled by numerous genes [4]. Yield being a complex trait, is considerably influenced by different contributing yield components like ear height, plant height and 1000-grain weight [5]. The yield of hybrids obtained from inbred lines that have high grain yield is high. Likewise, the yield of hybrids obtained from inbred lines that have low grain yield is low [6,7]. It was attempted to select hybrid maize parent lines that give the highest yield using discriminate analysis techniques [8]. Grain yield is directly and positively associated with ear weight and ear circumference. Improvements in yield can be achieved by selection for grain yield [8], plant height and ear height [9]. The additive genetic variance component is the most important component of genetic variability for all traits [8,10].

Genetic variability, which is a heritable difference among cultivars, is required at an appreciable level within a population to facilitate and sustain an effective long term plant breeding program. Progress from selection has been reported to be directly related to the magnitude of genetic variance in the population.

The magnitude of genetic variability provides useful information with regard to the possibility and extent of improvement that may be expected in the characters through breeding and selection. The main objective of the present investigation was to estimate of genetic variance, heritability, for some morphological and yield traits of four maize populations and utilization of the available population in future maize breeding programs.

2. Materials and Methods

The study of genetic potential and genetic variability of various parameters in maize was conducted at the University of Agriculture Peshawar during summer 2006. Four maize genotypes/ populations' viz. PSEV-3-2ES, Pop 2004-BS, Pop 2006 and Jalal 2003, possessing a wide genetic background were procured from maize breeding section Cereal Crops Research Institute (CCRI) Pirsabak, Nowshera. Populations were evaluated in randomized complete block design with three replications. Each plot consisted of two rows of five-meter long with row spacing and plant spacing of 75 and 25 cm, respectively. A Basal fertilizer dose of 120 kg N and 50 kg P_2O_5 was applied in the form of DAP and urea. A full dose of P_2O_5 and half of N was applied at the time of sowing. The remaining half of the N was given when the plants reached knee-height. Thinning was carried out when plants were 10-15 cm tall. Standard cultural practices were adopted from sowing till harvest.

2.1 Data collection and statistical analysis

Data were recorded on plant height, ear height, tassel length, branches tassel^{-1}, leaf plant^{-1}, flag leaf area, grain rows ear^{-1}, and grain yield. All the data were analyzed using computer software MSTATC to test the differences among maize genotypes in various traits. Means were separated by LSD test when ANOVA showed a significant difference among the populations.

2.2 Estimates of genetic components

The estimate of genetic components and heritability for each trait was calculated using the following formula according to Feher (1987) [11].

$$\text{Heritabilty}(\text{bs}) = \delta 2g/\delta^2 p$$

Where

$$\text{Genetic variance } (\delta 2g) = MSG - MSE/r$$

$$\text{Phenotypic variance } (\delta 2p) = MSG/r$$

MSG = Genetic mean squares from the analysis of variance (ANOVA)
MSE = Error mean squares of ANOVA
r = number of replications

3. Results

3.1 Plant and ear height

Analyzed data regarding plant and ear height showed highly significant difference ($P \leq 0.01$) among the populations. The coefficient of variation for plant and ear height was 2.38 and 3.20 respectively (Table 1). Among the population highest plant height (169.1 cm) was recorded for Jalal-2003 and minimum plant height (149.3c) PSEV-3-2ES. Jalal-2003 showed highest Ear height (75.13 cm) while, minimum ear height (68.2 cm) was observed for PSEV-3-2ES (Table 2). Heritability for plant height 0.83 and for ear height was 0.61 (Table 3).

3.2 Tassel length (cm) and branches tassel^{-1}

Among the populations highly significant genetic difference ($P \leq 0.01$) was observed for tassel length and branches tassel^{-1} (Table 1). The coefficient of variation for Tassel length and Branches tassel^{-1} was 1.38 and 8.11 respectively. Maximum tassel length (46.13 cm) was recorded for Jalal-2003 and minimum tassel length (40.4) Popn-2006. Among the populations tested, maximum number of tassel branches (15.67) was recorded for PSEV-3-2ES while the minimum number of tassel branches (10.33) was recorded in Popn-2004-BS (Table 2). Heritability for Tassel length (cm) and Branches tassel^{-1} was 0.95

Table 1. ANOVA and coefficient of variation for traits in four maize populations evaluated during 2006 at the University of Agriculture Peshawar.

	Mean Squares				
Traits	**Genotypes**	**Error**	**Reps**	**F-ratio**	**CV%**
Plant height (cm)	223.822**	14.192	14.863	15.77	2.38
Ear height (cm)	31.342**	5.439	0.363	5.76	3.20
Tassel length (cm)	19.381**	0.364	4.653	53.18	1.38
Branches tassel^{-1}	16**	1	0.333	16.00	8.11
Leaves per plant	0.306**	0.139	0.25	2.20	3.17
Flag leaf area (cm^2)	280.75**	10.124	21.997	27.73	3.35
Grain rows ear^{-1}	0.44**	0.011	0.001	40.61	1.79
Grain yield (Kg ha^{-1})	675941.208**	19935.969	19935.969	33.90	2.70

** Highly significant at 0.01 % probability level

Table 2. Mean values for plant height (cm), ear height (cm), tassel length (cm), branches tassel^{-1}, leaves plant^{-1}, flag leaf area (cm^2) for four maize population evaluated at the University of Agriculture Peshawar.

Genotypes	Plant height (cm)	Ear height (cm)	Tassel length (cm)	Branches tassel^{-1}	Leaves plant^{-1}
PSEV-3-2ES	149.3c*	68.2b	45.2a	15.67a	11.67a
Popn-2004-BS	160.2b	73.53a	43.12b	10.33b	12a
Popn-2006	153.7bc	74.87a	40.4c	11.67b	12a
Jalal-2003	169.1a	75.13a	46.13a	11.67b	11.33a
LSD	7.527	4.659	1.205	1.998	0.7449

Table 3. Mean values for flag leaf area, grain rows ear^{-1}, and grain yield (kg ha^{-1}) in four maize populations during 2006 at the University of Agriculture Peshawar.

Genotypes	Flag leaf area cm (cm^2)	Grains rowsear^{-1}	Grain yield (Kg ha^{-1})
PSEV-3-2ES	96.42b*	12.67c	5070b
Popn 2004-BS	93.94b	12.67c	5077b
Pop2006	82.94c	13.33b	4855b
Jalal 2003	106.5a	13.67a	5927a
LSD	6.357	0.2095	282.1

*Mean values followed by different letters are significantly different at the 0.01 level of probability

and 0.83 respectively, and was classified as high hereditability (Table 3).

3.3 Leaves plant^{-1} and flag leaf area

Genetic differences among the populations for leaves plant^{-1} and flag leaf area were highly significant ($P \leq 0.01$). The coefficient of variation for plant and ear height was 3.17 and 3.35% respectively (Table 1). Maximum leaves plant^{-1} (12) was noted in Popn-2004-BS and Popn-2006, while minimum in Jalal-2003.Among the populations tested, maximum flag leaf area (106.5 cm^2) was recorded for Jalal-2003 while minimum (82.94 cm^2) was recorded in Popn-2006 (Table 2 and 3). For leaves plant^{-1}, heritability was low (0.29) and flag leaf area heritability recorded was high (0.90).

3.4 Grains rows ear^{-1} and grain yield

Data pertaining to the Grains rows ear^{-1} and Grain yield depicted highly significant difference ($P \leq 0.01$) for both these traits among the population tested. The coefficient of variation for grain rows ear^{-1} and Grain yield was 1.79 and 2.70% respectively Table 1. Maximum grain rows ear^{-1} (13.67) was noted in Jalal-2003 while minimum (12.67) in Popn-2004-BS and PSEV-3-2ES. Among the populations tested, maximum grain yield (5927 kg ha^{-1}) was recorded for Jalal-2003 while minimum (4855) was recorded in Popn-2006 (Table 3). Heritability for grain rows ear^{-1} and grain yield were 0.93 and 0.92 respectively (Table 4).

4. Discussion

The characterization and evaluation of the available maize germplasm is a necessary first step to facilitate maize breeding efforts. Variation in the genetic constitution of breeding populations may result in the observed variability, which may be manipulated for further breeding. Plant and ear height play important role in plant lodging. Therefore maize breeders give special attention to these two traits and are interested in developing new populations having less vulnerability to lodging. Low plant height and central or near to central placement of the top ear of the plant is desirable because the plant is less vulnerable to lodging and contribute much to grain yield. Analyzed data regarding plant and ear height showed highly significant difference ($P \leq 0.01$) among the populations. Several researchers have reported significant genetic differences in plant and ear height in maize genotypes [12-14]. Among the populations, highest plant height was recorded for Jalal-2003 and minimum plant height for PSEV-3-2ES. Jalal-2003 showed highest ear height while, in PSEV-3-2ES minimum ear height was observed. High Heritability estimates were observed for plant height and ear height, while moderate Heritability (0.45) and high Heritability (0.99) were reported for plant height by OJo et al. and Mahmood et al respectively [15,16]. High Heritability of both these traits indicates a wide range of variation and genetic differences among the populations. A significant amount of variability for ear and plant height among different maize populations was also observed by Dijak *et al.* [17].

Tassel length (cm) and branches tassel^{-1} are other important parameters used as morphological markers in the characterization of genotypes**.** Among the populations highly significant genetic

Table 4. Genetic variance ($\delta^2 g$), phenotypic variance ($\delta^2 p$) and heritability h^2 (bs) for various traits in maize.

Traits	$\delta^2 g$	$\delta^2 p$	h^2 (bs)
Plant height (cm)	69.88	84.07	0.83
Ear height (cm)	8.63	14.07	0.61
Tassel length (cm)	6.34	6.70	0.95
Branches tassel^{-1}	5.00	6.00	0.83
Leaves per plant	0.06	0.19	0.29
Flag leaf area (cm^2)	90.21	100.33	0.90
Grain rows ear^{-1}	0.14	0.15	0.93
Grain yield (Kg ha^{-1})	218668.41	238604.38	0.92

difference ($P \leq 0.01$) was observed for tassel length and branches tassel^{-1}. The maximum tassel length was recorded for Jalal-2003 and the minimum for Popn-2006. However, among the populations tested, PSEV-3-2ES showed the maximum number of tassel branches while the minimum number of tassel branches was recorded in Popn-2004-BS. Generally, lesser number of tassel branches is desirable to avoid loss of assimilates for excessive pollen production. High Heritability for tassel length and branches tassel^{-1} was observed for both these traits in maize population. Also significant amount of genetic variability for both these traits in maize populations was observed by Dijk *et al.* that support our results [17].

Number of leaves plant^{-1} and greater flag leaf area are considered important in terms of higher amount of photosynthetic production and contribute much yield in maize. Genetic differences among the populations for these traits were highly significant. This shows the greater genetic diversity and variability among the populations for these traits. The maximum leaves plant^{-1} was noted in Popn-2004-BS and Popn-2006, while the minimum in Jalal-2003. Among the populations tested, the maximum flag leaf area was recorded for Jalal-2003, while the minimum was recorded in Popn-2006. For leaves plant^{-1} genetic component of variation was low and hence low heritability was observed. However, for flag leaf area Heritability recorded was high. These results are in line with those of Dijk et al. [17] who observed significant differences while evaluating maize genotypes for different morphological and yield traits.

Both the grain rows ear^{-1} and grain yield are important parameters and contribute significantly to grain yield and ultimately to total grain production. Data pertaining to the grain rows ear^{-1} and grain yield depicted highly significant difference for both these traits among the populations tested. Also a significant genetic difference among the populations for grain rows ear^{-1} and grain yield was observed by Saleem et al. [18]. At the genetic level, it is found that total maize yield is under dominant genetic control in the different maize crosses [4]. Maximum grain rows ear^{-1} was noted in Jalal-2003 while minimum in Popn-2004-BS and PSEV-3-2ES. Among the populations tested, maximum grain yield was recorded for Jalal-2003 while the minimum was recorded in Popn-2006. High Heritability estimates and genotypic difference among the populations were observed which show a clear reflection among the populations at the genetic level. These results are supported by those of Zhang and Jin [4], they also observed highly genotypic difference for both these traits. The results of high Heritability of grain yield are also in accordance with those reported by Singh and Dash (2000) [19]. Grain yield improvement is of the major aims of maize breeding programs [8].

5. Conclusions

The presence of greater genotypic difference and high heritability estimates for various traits among the populations indicates that the populations could be used in future maize breeding programs. Among the tested populations, Jalal-2003 proved to be better in performance for yield and other attributes. The population could be used by local farmers in order to get high yields. Moreover, high genetic variability and heritability estimates for most of the traits show a greater amount of additive gene action thus the populations could be used in future maize breeding programs as a base or a source population for deriving superior inbred lines through recurrent selection, S_1 line selection etc.

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