Inbreeding depression for reproductive and yield related traits in S_1 lines of maize (*Zea mays* L.)

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Abstract

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This research was conducted to determine inbreeding depression in S_1 maize lines for reproductive and yield related traits, at NWFP Agricultural University, Peshawar, Pakistan, in two successive seasons during 2002. Maize variety"Pahari" was selfed for one generation and 63 S_1 lines were evaluated using "lattice square design" with two replications along with the parental population. Days to mid silking and mid pollen shed (anthesis), plant height and ear height (cm), and 200 grain weight (g) showed inbreeding depression with varying degrees. Severe inbreeding depression was observed for yield with the average of 709 kg ha^{-1}. Inbreeding depression for 200 grains weight averaged 19 g, while for plant height and ear height it was calculated as 33 and 16 cm. Inbreeding depression for days to mid silking and pollen shed was lower as compared to morphological and yield components. Silking and pollen shed were delayed by 1.8 and 1.5 days on the average, respectively, as compared to the parental variety. Yield was significantly correlated with all maturity and morphological characters. Maturity characters were positively and significantly correlated with each other, showing good synchronization in maturity characters, while they were negatively and significantly correlated with yield components.

Key words : inbreeding depression, maize (*Zea mays* L.)

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Vol.28 No.6 Nov. - Dec. 2006   **1170**   Jalal, A., *et al*.

Maize is a valuable crop with high yield potential and improvements in average yield can certainly be made if superior and high yielding genotypes are developed. The identification of superior genotypes in a heterogeneous population is one of the major objectives of plant breeders. An ideal evaluation procedure would guarantee positive identification of elite genotypes early in the breeding scheme at a minimum cost. This would allow breeders to discard unpromising materials early and concentrate on desirable genotypes (Kamran *et al.*, 1994). There are several breeding procedures for maize. These methods include mass selection, ear to row, modified ear to row and various methods of recurrent selection including selfed generations of base population. Three methods of recurrent selection, including S$_1$ family selection, full-sib selection and half-sib selection of both the selfed generation and parental generation have been extensively reviewed by Souza *et al.* (1995). In maize, being a cross-pollinated crop, inbreeding is used for bringing homozygosity in the crop. Inbreeding is a term used for mating of an individual to itself by self-pollination. The mating of related individuals increases homozygosity by bringing together identical alleles at a locus. This homozygosity permits the expression of recessive alleles that may have been masked by a dominant allele in the parents.

Due to inbreeding, the homozygosity increases and there is a random fixation of various alleles in different lines, therefore the lines differ in genotype and, ultimately in phenotype. Selection following inbreeding reduces the frequency of deleterious recessive alleles. Only one selfed generation may permit the expression, and then subsequent elimination of deleterious alleles without excessive inbreeding depression in the lines selected for use as a parent for population advancement. Inbreeding is a strategy in cross-pollinated crops for developing pure lines followed by hybridization for the production of superior genotypes (hybrids) (Dhillon *et al.*, 1994).

Materials and methods

The present research was conducted at Malakandher Research Farm, NWFP Agricultural University Peshawar, Pakistan, during two successive growing seasons of 2002. In the first season (spring, 2002), the base population of parental variety "PAHARI" was grown in an area of half an acre, at the time of pollination, approximately 100 ears were selfed. At maturity, ears were individually harvested, threshed and numbered. Ears without apparent abnormalities and enough seed for a replicated experiment were selected. In the next growing season (fall, 2002), 63 S$_1$ lines were evaluated for changes in the agronomic traits, using the original variety "PAHARI" as a check.

The experiment was laid out in 8x8 lattice design with two replications. The S$_1$ lines were grown as single row plots, with row length of 5 m, and row to row and plant to plant distances of 0.75 and 0.20 m, respectively. Two seed per hill were planted; these were thinned to one plant per hill at the 4-5 leaf stage. Fertilizers in the forms of urea and di-ammonium phosphate (DAP) were applied at the rate of 250 and 125 kg/ha, respectively. Standard cultural practices were followed from sowing till harvesting during both seasons.

Dates on which 50% of the plants in a plot were shedding pollen and showing silks coming out, were recorded and converted to days from planting to anthesis and silking. After anthesis, plant height and ear height was measured on 10 randomly selected plants per plot. Two hundred kernels from each line were weighed and the grain yield was measured from fresh ear weight assuming the shelling percentage as 80%, and adjusted to 15% moisture content.

Three estimates of inbreeding depression were made for all traits. The first measure was inbreeding depression in absolute units, calculated as the non-inbred mean minus the inbred generation means. The second was percentage of inbreeding depression, calculated as the non-inbred mean minus the inbred generation means divided by the

non-inbred generation mean and multiplied by 100. The third measure was the rate of inbreeding depression, calculated by dividing the difference between the non-inbred and inbred generation means by the theoretical value of the inbreeding coefficient (F = 50%) for S₁ populations (Lamkey and Smith, 1987). Genotypic and phenotypic correlations between traits were also calculated to know the relationship among these traits.

Results and discussion

The analysis of variance (not shown) indicated significant differences among S₁ lines for all the traits evaluated during this studying. Inbreeding depression for days to mid silking and mid pollen shed indicates that inbreeding depression for both characters varied significantly among S₁ lines. About 60 % of S₁ lines showed inbreeding depression for days to mid silking, while 84% of 63 S₁ lines showed inbreeding depression for days to mid pollen shed (Table 1). Because of the heterozygous nature of maize crop, all S₁ lines were not characterized by a common response to inbreeding. Inbreeding causes genetic variability in a population or line. Changes in inbreeding are complicated by the probability of a changing relationship between the genotype and the environment. Hence, the resulting variability may be desirable or not. Exposure of deleterious alleles tends to increase the number of days to maturity.

Our results are in accordance with those of Sing *et al*. (1967) and Hallaur and Sears (1973) who reported significant inbreeding depression in several maize populations.

Inbreeding depression percentages and rates were calculated for flowering times (Table 1). Both flowering times showed similar inbreeding depression.

Plant height, ear height and 200-grain weight showed considerable inbreeding depression. This may be due to the expression of deleterious alleles at any locus or genotype interaction with the environment, which might have caused a reduction in plant height, ear height and 200-grain weight. Inbreeding depression percentages and rate of inbreeding depression followed similar pattern (Table 1).

Inbreeding depression for yield and 200 grain weight was measured (Table 1). The amount of inbreeding varied significantly among S₁ lines for each of the characters. Yield showed very severe inbreeding depression as well as the 200 grain weight, resulting in a reduction in the grain weight. Inbreeding depression for yield was higher than other characters, which is in conformity to Caragal *et al*. (1971) and Kamran *et al*. (1994). The drastic inbreeding may be attributed to expression of deleterious alleles caused by homozygosity of genotype and environmental interaction. In spite of such severe inbreeding, some S₁ lines were found to be superior to their parents. It might be

Table 1. Inbreeding depression and rate of inbreeding for agronomic traits of 63 S₁ lines of Maize evaluated at NWFP Agricultural University Peshawar, Pakistan, during 2002

Character	No. of lines showing inbreeding depression	Range (Absolute units)	Average	Range	Rate of inbreeding
Days to 50% silking	38	-3.5 - 1.5 days	1.8 days	-6.36 - 2.72	-0.07 - 0.03
Days to 50% pollen shedding	53	-3.5 - 0.5 days	1.5 days	-6.48 - 0.93	-0.07 - 0.01
Plant height	63	7.8 - 65.1 cm	33.27 cm	6.61 - 54.67	0.16 - 1.30
Ear length	59	-6.14 - 28.47 cm	14.85 cm	-12.65 - 58.25	-0.12 - 0.57
200 grain weight	63	1.20 - 31.75 g	19.10 g	2.11 - 55.89	0.02 - 0.63
Yield (Kg ha⁻¹)	57	-1141 - 1396 kg ha⁻¹	608 kg ha⁻¹	-0.50 - 0.61	-22.82 - 27.92

Songklanakarin J. Sci. Technol.

Vol.28 No.6 Nov. - Dec. 2006

Inbreeding depression in S$_1$ line of maize (*Zea mays* L.)

1172

Jalal, A., *et al.*

Table 2. Phenotypic (P) and genotypic (G) correlation coefficients for agronomic traits of 63 S$_1$ lines of Maize evaluated at NWFP Agricultural University Peshawar, during 2002

Parameters		Days to 50% Pollen shedding	Plant height	Ear height	200 grains weight	Yield
Days to 50% silking	P	0.33**	-0.48**	-0.35**	-0.0555	-0.32**
	G	(0.46**)	(-0.49**)	(-0.36**)	(-0.176)	(-0.24**)
Days to 50% Pollen shedding	P		-0.40**	-0.25**	-0.020	-0.119
	G		(-0.56**)	(-0.31**)	(-0.125)	(-0.239)
Plant height	P			0.64**	0.42**	0.43**
	G			(0.60**)	(0.51**)	(0.51**)
Ear length	P				0.22*	0.40**
	G				(0.30*)	(0.44**)
200 grain weight	P					0.51**
	G					(0.64**)

assumed that S$_1$ yield also appears to have increased the frequencies of genes which express themselves better in the inbred than in non-inbred genetic combination. Similar observations have also been reported by Genter and Alexander (1966) and Sullivan and Kannenberg (1987). Inbreeding rates and percentages were directly proportional to their respective values of inbreeding.

Correlation among traits

Maturity, morphological and yield characters were correlated with each other in all possible combinations (Table 2). A negative correlation of maturity characters was observed with yield. On the other hand, yield components and morphological characters showed a positive and significant correlation with yield.

Plant height and ear height were significantly positively correlated with each other (Table 2). Days to mid silking and mid pollen shed were significantly and positively correlated with each other. A strong correlation of silking with pollen shed showed a good synchronization for these characters. These maturity characters showed negative correlations with morphological and yield components. These results are in accordance with Sharma *et al.* (1982), El Saad *et al.* (1994) and Umakanth *et al.* (2000), who also reported a

positive correlation for plant type characters with yield and yield components.

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