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EFFECT OF SELECTION ON THE COMPONENTS OF GENETIC VARIABILITY FOR GRAIN YIELD AND ITS COMPONENTS UNDER TWO PLANT DENSITIES IN MAIZE (*ZEA MAYS* L.)

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ABSTRACT

Using the NC I design crossing system, full-sib and half-sib families were developed in the original and selected populations of the maize composite Vijay. The progenies from each population were grown under low and high plant densities (53,200 and 88,850 plants/ha, respectively) and the genetic parameters for grain yield and its components estimated separately as well as pooled under two densities. The selected population of Vijay registered 16.3% gain in the grain yield over the original one in the pooled analysis. Nonsignificant differences between the estimates of σ^2_A in original and selected populations for grain yield indicated that selection had not brought about any change in additive genetic variability for this trait. In general, the estimates of σ^2_A were relatively lower under high plant density for majority of characters, thus showing that genetic advance selection would be lower under high plant density than under low density. The expected genetic gain in the selected population, but as there was no significant change in the components of genetic variance, therefore, continued response to selection can be expected. Selection under normal plant population is expected to be more efficient as high plant density led reduction of additive variance.

Key words: Selection, genetic variance, components, NC design I, *Z. mays*.

In random mating populations, genetic advance under selection is proportional to the proportion of additive genetic variance to the total variance as well as population mean. Improvement in mean performance results from change in frequency of desirable alleles which may also effect the magnitude of genetic variances. It is, therefore, important to know how genetic variance changes under selection. It is possible that genetic variance may increase in early selection cycles if initial frequencies of favourable alleles are low. However,

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it is more likely that genetic variance would decrease in the later generation and, thus, limit the rate of response [1]. It may also change very slowly for characters like yield which are controlled by many loci, each with small effect.

Plant population has been reported to increase grain yield to a certain level by several workers in maize. Poor response at very high plant densities has been reported [2]. Information on the estimates of genetic parameters under various population densities may help the breeder to develop breeding strategies for evolving varieties suitable for high plant population. The information on the influence of plant densities on the components of genetic variance is rather scanty. The present investigation, therefore, aims to know how genetic parameters are influenced after selection and by varying plant population levels.

MATERIALS AND METHODS

The basic material for present investigation comprised the original composite Vijay released in 1967 and its improved version obtained after three cycles of full-sib selection. The improved version of Vijay passed through three cycles of selection with the selection intensity of 22, 22 and 4% in the first, second and third years, respectivelv. Selection was mainly for grain yield, earliness and plant height. From this base material, full-sib and half-sib families were developed following design I of [3], both in the original and selected populations of Vijay. In each population, 90 plants were taken at random and each of these males was crossed with five randomly selected females or seed parents. At harvest, four cobs on the female parent with adequate seed set were selected to constitute a single male group (half-sib family). Out of 90 male groups, 64 complete sets were used in the investigation. The resulting 64 half-sib and 256 full-sib families in each of the populations were grown in two environments of low (53,200 plants/ha) and high (88,885 plants/ha) plant densities. The experiments under low and high plant densities were conducted in the two adjoining blocks in the same field. The experimental area under each environment was divided into 32 blocks. Sixteen of these blocks were randomly assigned to 64 male groups of the original population of Vijay and the remaining 16 blocks to 64 male groups of the selected population of Vijay. Each progeny was replicated twice in the blocks and progenies within the replication were randomized. Each progeny had a 4 m long single-row plot. The data were recorded on 8 randomly taken competitive plants in each plot for grain yield, ear length, ear diameter and number of kernel rows per ear. The analysis of the design was carried out following [3, 4].

RESULTS AND DISCUSSION

The population mean along with standard errors of the original and selected populations of Vijay are presented in Table 1 separately for low and high plant densities,

Table 1. Population means ($\bar{X}$) and their standard errors in individual and pooled over environments for the original and selected populations of maize composite Vijay under low and high plant densities

Character	Population	Low density		High density		Pooled	
		$\bar{X}$	S.E.	$\bar{X}$	S.E.	$\bar{X}$	S.E.
Grain yield/plant (g)	Original	78.33	0.78	54.92	0.60	66.62	0.74
	Selected	91.32	0.56	63.71	0.34	77.51	0.34
Ear length (cm)	Original	15.04	0.04	12.78	0.05	13.91	0.03
	Selected	16.32	0.05	15.92	0.05	16.12	0.03
Ear girth (cm)	Original	12.53	0.04	11.81	0.04	12.17	0.03
	Selected	13.76	0.03	12.65	0.03	13.20	0.02
Kernel rows/ear	Original	13.36	0.04	12.68	0.04	13.02	0.02
	Selected	13.55	0.03	12.98	0.03	13.26	0.02

and pooled over the two densities. The selected population showed 16.6 and 16.0% gain in grain yield over the original one under low and high plant densities, respectively. In the pooled analysis, the selected population had superiority of 16.3%. Significant (12%) improvement of Vijay selected over the original component Vijay for grain yield has been reported [5]. The selected population was also superior to the original one for various yield components. In general, the mean performance for yield and its components was lower under high plant density in both populations. Decrease in plant yield as a result of increase in population density has also been reported earlier [6, 7].

The estimates of the components of genetic variance in the original and selected populations of the composite Vijay are given in Table 2 (individual plant population densities) and Table 3 (pooled analysis over two population densities). Additive variance (σ^2_A) decreased in the selected population for most of the characters. However, significant reduction was observed in the selected population for ear length under low (8.93) and high (2.75) plant populations, and for kernel rows only under high plant density (0.84). The pooled analysis (Table 3) also showed significant reduction in additive variance in the selected versus the original population for ear length (4.33) and kernel rows (0.58). Nonsignificant differences between the estimates of σ^2_A in the selected and original populations for grain yield indicated that selection did not cause any change in the additive genetic variability for this trait. These findings are in conformity with the results of many workers. For example, no apparent reduction in genetic variability from recurrent selection had been reported [8, 9]. The magnitude of nonadditive variance (σ^2_D) increased in the selected population over the original one for all the characters studied, however, it was significantly higher only for kernel rows. Increased nonadditive effects after two cycles of reciprocal recurrent selection had also been reported earlier [10]. Some of the variance components had negative signs. However, since variance is always positive, the true value of Lindsey et al. [11] reported that negative estimates may result from sampling error or lack of random mating while making the half-sib groups. The study of interaction of genetic variance with environment revealed that both σ^2_A and σ^2_D were influenced by the test environments. The value of σ^2_{AE} was significant for ear length and ear girth in both populations, whereas σ^2_{DE} was significant for grain yield and ear length in the selected and the original populations, respectively. The differences in the magnitude of σ^2_{DE} interaction between the original and the selected populations were significant for ear length and ear girth. No significant differences for σ^2_{DE}, however, were observed between the two populations. Greater interaction of environment with additive than that with nonadditive effects were reported from some previous studies [12].

Table 2. Estimates of σ^2_A and σ^2_D variances in the original and the selected populations of maize composite Vijay under low and high plant densities and differences between the estimates of the two populations

Character	Plant density	Population	$\sigma^2_A \pm SE$	$\sigma^2_D \pm SE$
Grain yield	Low	Original	108.3 ± 53.2*	164.7 ± 80.2*
		Selected	187.3 ± 64.3*	27.9 ± 84.2
		Difference	79.0 ± 83.5	136.8 ± 116.4
	High	Original	110.0 ± 50.4*	519.0 ± 116.0**
		Selected	19.8 ± 16.3	42.6 ± 29.3
		Difference	90.2 ± 53.0	476.4 ± 119.7**
Ear length	Low	Original	9.31 ± 2.02**	- 8.09 ± 2.05
		Selected	0.38 ± 0.28	1.12 ± 0.49*
		Difference	8.93 ± 2.04**	—
	High	Original	2.82 ± 0.74**	- 1.45 ± 0.83
		Selected	0.07 ± 0.19	1.19 ± 0.41*
		Difference	2.75 ± 0.75**	—
Ear girth	Low	Original	1.29 ± 0.35**	- 0.75 ± 0.41
		Selected	1.03 ± 0.31**	0.01 ± 1.27
		Difference	0.26 ± 0.46	—
	High	Original	0.99 ± 0.28**	- 0.54 ± 0.34
		Selected	0.85 ± 0.26**	- 0.11 ± 0.33
		Difference	0.14 ± 0.38	—
Kernel rows	Low	Original	0.65 ± 0.25*	0.40 ± 0.35
		Selected	0.12 ± 0.15	1.27 ± 0.29**
		Difference	0.53 ± 0.29	0.87 ± 0.45
	High	Original	0.90 ± 0.29**	- 0.01 ± 0.37
		Selected	0.06 ± 0.12	1.12 ± 0.26**
		Difference	0.84 ± 0.31*	—

The estimates of genetic components of variance under low and high plant densities in both the original and selected populations are presented in Table 4. The estimates of σ^2_A significantly decreased in high plant density than in low plant density for ear length (6.49) in the original and for grain yield (167.48) in the selected populations. The magnitude of σ^2_D increased significantly under high plant density for grain yield in the original population, but there was no significant shift in the selected population. Reduction in genetic variance at high plant population levels has also been reported [13–15]. Reduction in additive genetic

Table 3. Pooled estimates of components of variance (σ^2_A and σ^2_D) and their interactions with density environments (σ^2_{AE} and σ^2_{DE}) for the original and selected populations of composite Vijay of maize

Character	Population	$\sigma^2_A \pm SE$	$\sigma^2_D \pm SE$	$\sigma^2_{AE} \pm SE$	$\sigma^2_{DE} \pm SE$
Grain yield	Original	79.4 ± 53.5	- 131.1 ± 24.5	5.0 ± 85.2	- 445.8 ± 46.0
	Selected	64.0 ± 21.4*	- 45.0 ± 57.0	- 103.8 ± 40.8	672.4 ± 106.5**
	Difference	15.4 ± 57.6	—	—	—
Ear length	Original	4.38 ± 1.19**	- 2.70 ± 0.27	1.68 ± 0.42	1.72 ± 0.48**
	Selected	0.05 ± 0.23	3.38 ± 0.43**	0.17 ± 0.05	- 1.87 ± 0.17
	Difference	4.33 ± 1.21**	—	1.51 ± 0.42**	—
Ear girth	Original	0.35 ± 0.24	0.20 ± 0.28	0.79 ± 0.22**	- 0.86 ± 0.27
	Selected	0.85 ± 0.27**	0.84 ± 0.33*	0.09 ± 0.03**	- 0.89 ± 0.08
	Difference	0.50 ± 0.35	0.64 ± 0.43	0.69 ± 0.22*	—
Kernel rows	Original	0.63 ± 0.23**	0.45 ± 0.30	0.14 ± 0.09	- 0.25 ± 0.18
	Selected	0.05 ± 0.13	1.98 ± 0.26**	0.01 ± 0.02	- 0.19 ± 0.08
	Difference	0.58 ± 0.26*	1.53 ± 0.39**	0.13 ± 0.09	—

variability and increase in the estimates of σ^2_D under high plant density suggest that genetic advance through selection may be lower under high plant density than under low plant density. Hence, selection should be made under low/normal plant density for evolving high yielding genotypes. Lack of response to selection at high plant density may be primarily due to the long history of selection of varieties under medium to low plant densities and yield per unit area could be raised by increasing plant population to a certain level only. Furthermore, increased population densities result in several morphological changes which tend to limit the use of high population densities.

Table 4. Estimates of additive genetic (σ^2_A) and dominance (σ^2_D) variances under low and high plant densities of the original and selected populations of composite Vijay of maize

Character	Population	Plant density	$\sigma^2_A \pm SE$	$\sigma^2_D \pm SE$
Grain yield	Original	Low	108.3 ± 53.2*	164.7 ± 80.2*
		High	110.0 ± 50.4*	519.0 ± 115.9**
		Difference	1.7 ± 73.3	354.3 ± 141.0*
	Selected	Low	187.3 ± 64.3**	27.9 ± 84.3
		High	19.8 ± 16.3	42.6 ± 30.0
		Difference	167.5 ± 66.3**	14.6 ± 89.5
Ear length	Original	Low	9.31 ± 2.02**	- 8.09 ± 2.05
		High	2.82 ± 0.74**	- 1.45 ± 0.83
		Difference	6.50 ± 2.02**	—
	Selected	Low	0.38 ± 0.28	1.12 ± 0.49
		High	0.07 ± 0.19	0.19 ± 0.41*
		Difference	0.31 ± 0.33	—

(Contd.)

Table 4 (contd.)

Character	Population	Plant density	σ^2_A ± SE	σ^2_D ± SE
Ear girth	Original	Low	1.29 ± 0.35**	– 0.75 ± 0.41
		High	0.99 ± 0.28	– 0.54 ± 0.34
		Difference	0.20 ± 0.44	—
	Selected	Low	1.03 ± 0.31**	0.01 ± 1.27
		High	0.85 ± 0.26**	– 0.11 ± 0.33
		Difference	0.18 ± 0.40	—
Kernel rows	Original	Low	0.65 ± 0.25	0.40 ± 0.35
		High	0.90 ± 0.29	– 0.01 ± 0.37
		Difference	0.25 ± 0.28	—
	Selected	Low	0.12 ± 0.15	1.27 ± 0.29**
		High	0.06 ± 0.12	1.12 ± 0.26**
		Difference	0.06 ± 0.19	0.15 ± 0.38

Almost similar magnitude of heritability in the original (21.6%) and selected (21.7%) populations for grain yield (Table 5) indicated that three cycles of selection did not change additive genetic variability for this trait. The expected genetic advance for grain yield was 7.76% in the original and 5.98% in the selected populations. This compares well with the realized gain of 5.43%, showing that the prediction was reasonably reliable. The expected gain, however, in the selected population of the composite Vijay was slightly lower than in the original composite Vijay. As there is no significant change in genetic variance, continued response to selection can be expected. In general, the data show that increase in plant population per unit area results in the decrease the magnitude of σ^2_A and increase σ^2_D. No significant change in σ^2_A from the original to the selected populations was reflected by the similar heritability values in the two cases. Positive improvement in mean value of the selected population over the original one suggests that continuously effective selection can be made under normal population densities.

Table 5. Estimates of heritability and expected genetic advances for full-sib selection in the original and selected populations of composite Vijay of maize

Character	Population	Heritability (%)	Expected genetic advance (%)
Grain yield	Original	21.6	7.8
	Selected	21.7	6.0
Ear length	Original	70.9	15.8
	Selected	2.3	0.2
Ear girth	Original	22.4	2.8
	Selected	36.8	5.2
Kernel rows	Original	29.7	4.8
	Selected	3.7	0.4

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