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Estimates of Gene Action for Seed and Seedling Traits in Indigenous Maize (*Zea mays* L.) Germplasm of Himachal Pradesh

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An effort has been made to identify the maize inbred lines generated from crosses developed through germplasm of Himalayan origin. The analysis of variance for line x tester revealed significant difference among the parents, lines, as well as hybrids for accelerated aging test, osmotic stress test, 100-seed weight and field emergence. On the other hand, testers showed significant differences for accelerated aging test and osmotic stress test. Parents and hybrids revealed significant differences for 100-seed weight and 100-seed volume. The dominance component of variance (σ^2D) was greater than additive component (σ^2A) for all the characters across the years and combined over the years which indicated the dominance of non-additive gene action. The predominance of non-additive gene action for all the traits could be exploited in hybrid development.

Key words: Gene action, maize, additive, non additive, dominance

Maize is one of the world's three primary cereal crops. It occupies an important position in world economy and trade as a food, feed and industrial grain crop. A large number of high yielding hybrids / composites had been developed in India, yet they did not gain popularity among the farmers as their superiority was considerably reduced under stress conditions which commonly existed in farmers' fields. Lack of suitable screening methodology has been one of the major bottlenecks with regard to limited success realized so far. From purely economic view point, the breeder would be better satisfied with varieties which would give higher grain yield under normal as well as moisture stress environments (Sullivan, 1971). For breeders, agro-ecological diversity of environments represents a double edged sword. This diversity complicates breeding and testing of improved genotypes with adequate adaptation but it also permits the identification of extreme environmental conditions that guarantee selection pressure from important stresses. In maize, although many seed vigour tests accelerated aging and osmotic stress test determine the capability of seeds to germinate under stress conditions which reflect high field emergence ultimately leading to high yields. However, results on different vigour tests can be combined together to have better prediction of field emergence under varied sowing conditions. Keeping these situations in view, an attempt was made to develop or identify whether any cross combination show high field emergence and reflects it through and seed trait.

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Materials and Methods

Twenty four inbred lines (S_5 stage) derived from local germplasm collected from different parts of Himachal Pradesh were involved with three broad based testers, *viz*., Early composite, Girija composite and KH-2001 in a line x tester fashion. The experimental material, comprising one hundred entries (72 crosses, 27 parents and one standard check, PMZ-4), were evaluated during *kharif* 2004 and *kharif* 2005 in the Seed Technology laboratory of CSK HPKV, Palampur and the data were recorded for six seed and seedling traits *viz*., accelerated aging test at 40 ±1°C for 96 hours, osmotic stress test (-5 bar by using PEG 6000), germination percentage, 100-seed weight (g), 100-seed volume (ml),seed density(g/ml),and field emergence. Accelerated aging test was conducted as suggested by Byrd and Delouche (1971), osmotic stress test as per the method of Langerwerff (1961), standard germination test was carried out using top of paper method in seed germinater at 25 ± 1°C temperature and 90 ± 5 per cent relative humidity, as per the guidelines of ISTA (1985). Final count was recorded on seventh day and the components of variance were estimated following Singh and Choudhary (1977) and Dabholkar (1992).

Results and Discussion

Hybrids revealed variability for all the traits, while lines did not show variability for germination percentage, whereas, testers were different for accelerated aging test, osmotic stress test and field emergence over the years. Performance of parents

Table 1. Analysis of variance (line x tester) for seed and seedling traits in maize during 2004 and 2005

Character	Source df	Mean squares							
		Replications	Parents	Lines	Testers	Lines vs Testers	Hybrids	Parents vs Hybrids	Error
	Year	1	26	23	2	1	71	1	98
Accelerated ageing test	2004	23.11	80.15*	83.99*	47.09*	57.79	99.54*	58.28	10.04
	2005	137.45*	44.18*	44.91*	51.17*	13.39	61.56*	9.34	5.12
Osmotic stress test	2004	7.84	50.69*	51.86*	56.17*	12.94	86.14*	34.95	9.37
	2005	15.03	48.28*	50.61*	44.48*	1.71	58.08*	2.44	6.13
100-seed weight	2004	0.34	10.45*	10.96*	8.23	3.27	35.04*	34.37*	2.43
	2005	0.061	14.35*	15.12*	11.96*	1.37	26.13*	69.98*	1.95
100-seed volume	2004	2.55	8.80*	9.20*	6.79	3.34	25.91*	40.74*	2.03
	2005	0.36	9.08	9.79	5.29	0.23	16.26	58.23	12.78
Germination (%)	2004	1.45	2.34	2.58	0.67	0.29	4.55*	30.19*	2.27
	2005	5.49	2.49	2.40	4.50	0.63	4.51*	0.063	1.54
Field emergence	2004	36.85	61.13*	66.51*	14.31	30.98	61.86*	78.23	10.03
	2005	37.66	44.20*	35.94*	160.67*	1.26	50.70*	118.28	10.16

*Significant at P<0.05

(lines and testers) and their hybrids was not consistent over the years for majority of traits except germination percentage as revealed by their significant interaction with years. None of the seed and seedling traits revealed significant line vs. tester mean squares, indicating thus the non divergence of testers from lines. Further, absence of average heterosis for all the traits, except 100-seed weight, was revealed by the insignificant estimates of parents vs. hybrid mean squares. Venugopal *et al.* (2002), Zdunic *et al.* (2002) and Srivastava and Singh (2002) have also reported similar results. Significant differences among hybrids observed for all the traits revealed the varying performance across combinations with respect to all the traits studied.

Table 2. Analysis of variance (line x tester) for seed and seedling traits in maize as combined over years

Source of variation	df	Accelerated aging test	Osmotic stress test	100-seed weight	100-seed volume	Germination percentage	Field emergence
Year	1	128.25*	3.10	0.27	0.17	7.49	292.40*
Replication	2	80.32*	11.39	0.20	1.46	3.39	37.25
Parents	26	66.52*	63.13*	16.61*	11.65*	2.62	57.79*
Lines	23	66.98*	63.48*	18.27*	12.98*	2.61	56.82*
Testers	2	62.88*	84.68*	3.50	1.75	4.08	86.71*
Lines vs Testers	1	63.34	12.03	4.43	0.94	0.023	22.39
Hybrids	71	81.46*	88.63*	51.19*	34.54*	8.50*	64.52*
Parent vs Hybrids	1	222.13*	9.50	101.20*	98.19*	17.44	754.50*
Parent x Year	26	57.80*	35.80*	8.20*	6.22*	2.20	47.53*
Lines x Year	23	61.93*	38.97*	7.81*	6.02*	2.35	45.62*
Testers x Year	2	35.38*	15.97	16.69*	10.33*	1.08	88.26*
(line vs tester) x Year	1	7.72	2.61	0.21	2.72	0.89	9.89
Hybrid x Year	71	79.63*	55.59*	9.97*	7.63*	0.55	48.04*
(Parent vs hybrid) x Year	1	370.12	28.02	3.01	0.78	13.32	146.35*
Error	196	7.58	7.75	2.19	1.65	1.91	10.10

*Significant at P<0.05

Seed and seedling traits, SCA variance (σ^2sca) was higher in magnitude than the corresponding GCA variance (σ^2gca) for all the characters. The dominance component of variance (σ^2D) was invariably greater than additive component (σ^2A) for all the characters, thereby indicating the predominant role of non-additive gene action in the inheritance of these traits. The relative importance

Table 3. Estimates of genetic components of variance for different seed and seedling traits during 2004

Character	σ^2 gca (Lines)	σ^2 gca (Tester)	σ^2 gca (Average)	σ^2 sca	σ^2 A	σ^2 D	(Average degree of dominance (σ^2 Dσ^2A)	h^2 ns (%)	Contribution (%)		
									Lines	Testers	Line X Tester
Accelerated ageing test	19.06	-0.32	1.836	26.81	7.34	107.26	3.82	5.92	57.69	1.35	40.96
Osmotic stress test	-2.16	3.07	2.492	38.01	9.97	152.03	3.90	5.79	27.54	7.64	64.82
100-seed weight	0.44	-0.57	-0.460	16.44	-1.84	65.77	-	-	34.74	0.60	64.65
100-seed volume	0.06	-0.41	-0.360	12.35	-1.44	49.40	-	-	33.38	0.71	65.90
Germination percentage	-0.15	0.00	-1.646	1.43	-0.07	5.72	-	-	28.04	3.01	68.95
Field emergence	6.17	-0.23	0.478	19.31	1.91	77.25	6.36	2.11	45.67	1.77	52.56

of interaction in determining the performance of single crosses has also been reported earlier by Katna *et al.* (2002) on the basis of significant SCA variance. Very low estimates of heritability (ns) observed for all these seed and seedling traits, further confirm the pronounced effect of non-additive gene action on the expression of these traits. The average degree of dominance indicated over-dominance (>1) for accelerated aging test, osmotic stress test and field emergence during 2004 and 2005. Heritability (ns) was low for all the quality traits studied.

Table 4. Estimates of genetic components of variance for different seed and seedling traits during 2005

Character	σ^2 gca (Lines)	σ^2 gca (Tester)	σ^2 gca (Average)	σ^2 sca	σ^2 A	σ^2 D	(Average degree of dominance ($\sigma^2 D/\sigma^2 A$)	h^2_{ns} (%)	Contribution (%)		
									Lines	Testers	Line X Tester
Accelerated ageing test	2.70	0.86	1.062	25.19	4.25	100.76	5.04	3.87	37.56	4.40	48.04
Osmotic stress test	8.46	-0.41	0.572	17.87	2.29	71.49	5.59	2.85	51.84	1.08	47.07
100-seed weight	0.07	-0.33	-0.284	12.31	-1.14	49.23	-	-	33.28	1.15	65.57
100-seed volume	0.07	-0.08	-6.480	7.56	-0.26	30.25	-	-	33.16	2.14	64.70
Germination percentage	-0.09	0.00	1.302	1.51	-0.05	6.04	-	-	29.90	2.81	67.29
Field emergence	5.17	1.58	1.976	14.13	7.90	56.51	2.67	10.58	44.44	6.34	49.22

The range of per cent contribution of lines was from 27.54 (osmotic stress test) to 57.69 (accelerated aging test) in 2004; 29.90 (germination percentage) to 51.84 (osmotic stress test) during 2005 and from 29.02 (germination percentage) to 57.51 per cent (field emergence) when pooled over years. Per cent contribution of tester ranged from 0.60 (100-seed weight) to 7.64 per cent (osmotic stress test) during 2004, 1.08 (osmotic stress test) to 6.34 per cent (field emergence) during 2005 and 0.03 (100-seed weight) to 3.05 per cent (germination percentage) when combined over years. The per cent contribution of line x testers towards variability was high for maximum characters as compared to either lines or testers during 2004, 2005 and combined over the years. Hence, higher contribution of the line x tester interaction was observed for all the traits in comparison to lines, while contribution of the testers was the lowest towards the overall variability of hybrids for different characters, which is indicative of the fact that upon crossing there is a possibility of creating sufficient genetic variability for these traits.

Table 5. Estimates of genetic components of variance for different seed and seedling traits in maize as combined over years

Character	σ^2 gca (Lines)	σ^2 gca (Lines x Tester)	σ^2 gca (Tester)	σ^2 gca (Tester x year)	σ^2 gca (Average)	σ^2 sca	σ^2 sca x year	σ^2 A	σ^2 D	Contribution (%)		
										Lines	Testers	Line X Tester
Accelerated ageing test	-0.53	11.41	-1.49	1.76	-1.38	3.95	24.03	-5.54	55.96	49.75	0.15	50.10
Osmotic stress test	4.43	-1.28	-1.41	2.74	-0.76	9.81	23.04	-3.03	65.69	43.69	2.24	54.09
100-seed weight	0.03	0.23	-0.63	0.17	-0.55	21.41	3.67	-2.21	50.15	34.03	0.03	65.95
100-seed volume	0.11	-0.05	-0.46	0.21	-0.40	13.87	3.02	-1.59	33.78	33.94	0.10	65.96
Germination percentage	-0.10	-0.02	0.01	-0.01	-0.003	4.14	-0.60	-0.01	7.09	29.02	3.05	67.92
Field emergence	6.44	-0.77	-1.33	2.00	-0.47	-2.48	17.96	-1.87	30.96	57.51	0.44	42.05

Sinceσ2A is negative hence average degree of dominance and h^2_{ns} (%) not calculated

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