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COMBINING ABILITY FOR SOME DROUGHT TOLERANT CHARACTERS IN MAIZE (*ZEA MAYS* L.)

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ABSTRACT

In a 7-parent diallel of drought tolerant and susceptible inbreds of maize raised under rainfed conditions over two years, only gca variance was significant for chlorophyll content, only sca for pollen shed period and for other traits both gca and sca variances were significant. The sca variances were predominant for grain yield/plant and stomata number/mm^2 of leaf area, whereas gca variances were predominant for germination leaf area/plant, root length, root weight and root number. The inbreds H-98, CM-205, V55-B and the crosses, V50-B x CM-205, V20-B x V50-B, V57-B x A-654 and V20-B x V57-B, were identified as the best inbreds and crosses, respectively, for grain yield and drought tolerant characters.

Key words: *Zea mays*, diallel cross, drought tolerance, combining ability.

Yield in maize is adversely affected by erratic rainfall and consequently drought is faced at many of the critical stages of the crop growth. Studies on drought tolerant characters in maize are few. The present study was undertaken to determine general and specific combining ability of various morphological, physiological and biochemical characters associated with drought tolerance, in seven inbred lines in maize.

MATERIALS AND METHODS

The experimental material comprised 28 genotypes, involving one (CM-205) drought susceptible, six (V20-B, V50-B, V55-B, V57-B, H-98 and A-654) drought tolerant inbred lines of maize and their 21 F_1s developed in a diallel cross. The material was raised in randomized complete block design, with four replications during Kharif, 1985 and 1986 at Regional Research Station, Bajaura of the H.P.K.V. Each plot comprised three 5 m long rows spaced at 75 cm and plants within rows at 20 cm. The experiments were conducted under stress environment with no irrigation and half the recommended doses of fertilizers. During both the crop seasons water stress occurred during tasselling, silking, pollination and grain filling stages of crop growth.

The material was evaluated for 10 morphological, physiological and biochemical characters associated with drought tolerance. The data on germination of inbreds and hybrid seeds at 15 atmospheric pressure in mannitol solution, stomata number per unit leaf area and proline and chlorophyll contents per gram of fresh weight of leaf tissue were recorded in the laboratory. However, leaf area per plant, root length, root weight, root number, pollen shed period and grain yield per plant were recorded in the field.

The combining ability analysis was carried out as per Method 2 Model 1 of Griffing [1]. The pooled analysis over environments was carried out by the method of Singh [2].

RESULTS AND DISCUSSION

Due to heterogeniety of error variances pooled analysis was not done for leaf area per plant, root number, proline content and chlorophyll content. Differences for general combining ability (gca) and specific combining ability (sca) variances were significant (Table 1) for grain yield, stomata number, germination, root length and root weight in both the years and pooled analysis, whereas for leaf area, root number and proline content the differences were significant for gca and sca in both the years. But for chlorophyll content, only gca variance in 1986 were significant. Significant differences for gca and sca variances for different traits have also been reported earlier [3–5].

Table 1. **Combining ability analysis (mean squares) for 1985, 1986, and pooled over both years**

Year	Source	d.f.	Grain yield per plant	Leaf area per plant	Stomata number per mm^2	Germination at 15 atm. pressure	Root length	Root weight	Root No.	Proline content	Chlorophyll content	Pollen shed period
1985	gca	6	109.1*	2.49*	159.8*	565.1*	8.02*	64.1*	9.2*	0.023*	0.378*	—
	sca	21	135.8*	1.27*	196.8*	183.9*	2.79*	44.1*	6.1*	0.022*	0.008	—
	Error	81	74.4	0.28	13.5	53.9	1.65	22.4	3.7	0.001	0.007	—
1986	gca	6	175.2*	1.55*	198.1*	581.8*	4.57*	151.6*	22.8*	0.013*	0.338*	0.66
	sca	21	215.5*	1.04*	203.9*	201.1*	2.93*	37.7*	12.6*	0.023*	0.030*	1.76*
	Error	81	65.4	0.47	11.9	15.9	1.32	15.2	6.6	0.000	0.012	1.12
Pooled	gca	6	194.7*	—	347.4*	1078.7*	3.23*	153.5*	—	—	—	1.08
	sca	21	225.8*	—	400.0*	372.7*	2.99*	58.1*	—	—	—	3.00*
	Year	1	3580.0*	—	2.4	4.8	0.01	84.9*	—	—	—	0.94
Gca x	year	6	115.4	—	2.3	8.3	2.36	42.2*	—	—	—	0.69
Sca x	year	21	114.9*	—	0.3	12.3	2.73*	13.7	—	—	—	0.24
	Error	162	4.8	—	5.7	11.3	5.00	1.4	—	—	—	2.09

$^*P \geq 0.05$.

The gca x year interaction was significant for root length, whereas sca x year interaction was significant for grain yield and root length, indicating the influence of environment on the two variances for these traits. The significant sca x year interaction for grain yield has also been reported earlier [6].

GENERAL COMBINING ABILITY EFFECTS

The gca estimates showed that the best general combining inbreds for grain yield were, H-98 in 1985 and pooled analysis, and A-654 and CM-205 in 1986 (Table 2). Inbred V50-B

Table 2. Estimates of general combining ability (gca) effects of the parents during 1985, 1986, and pooled over both years

Parent	Year	Grain yield per plant	Leaf area per plant	Stomata number per mm^2	Germination	Root length	Root weight	Root No.	Proline content	Chlorophyll content	Pollen shed period
V20-B	1985	-2.24	-0.95*	-3.28*	-9.21*	-0.84*	0.03	0.47	0.82*	-0.18*	—
	1986	0.24	-0.30	-3.36*	-8.85*	0.12	-6.55*	-2.08*	0.03*	-0.12*	0.81
	Pooled	-1.00	—	-3.32*	-9.03*	-0.36	-3.26*	—	—	—	0.39
V55-B	1985	-1.23	0.17	6.57*	10.51*	0.44	-3.81*	-0.72	0.08*	0.09	—
	1986	-3.31	-0.17	7.27*	8.65*	-0.77*	-4.70*	-1.44	0.05*	0.14*	-0.21
	Pooled	-2.26	—	6.91*	9.58*	-0.16	-4.25*	—	—	—	-0.19
V57-B	1985	-2.42	-0.41*	-1.58	7.74	-0.14	0.71	0.68	0.00	-0.06*	—
	1986	-4.53	-0.38	-1.71*	8.89*	0.10	2.96*	0.37	-0.01	-0.05*	0.18
	Pooled	-1.31	—	-1.64*	7.92*	-0.02	1.83	—	—	—	0.02
V50-B	1985	-5.26*	-0.05	0.28	-5.87*	0.83	0.58	0.27	-0.05*	0.24*	—
	1986	-3.30	-0.13	0.68*	-6.90*	0.47	1.90	1.97*	-0.05*	0.21*	-0.07
	Pooled	-4.59*	—	0.49	-6.39*	0.65*	1.20	—	—	—	-0.39
H-98	1985	9.38*	0.39*	4.84*	-5.59*	-0.13	-0.29	0.33	0.04*	0.19*	—
	1986	1.74	0.08	4.57*	-3.29*	-0.61	1.43	-0.83	0.04*	0.15*	0.01
	Pooled	5.56*	—	4.70*	-4.44*	-0.37	0.57	—	—	—	0.02
A-654	1985	0.44	0.30	-2.14	-3.93	-0.51	-0.81	-1.35*	-0.02*	0.02	0.02
	1986	4.97*	0.05	-1.41*	-4.68*	-0.03	0.32	0.01	-0.03*	0.02	-0.16
	Pooled	1.45	—	-1.78*	-4.30*	-0.27	-0.25	—	—	—	0.05
CM-205	1985	1.68	0.56*	-4.69*	6.35*	0.36	3.66*	1.26*	-0.07*	-0.37*	—
	1986	5.74*	0.86*	-6.03*	6.98*	0.71*	4.65*	2.81*	-0.03	-0.35*	0.53*
	Pooled	2.02	—	-5.36*	6.66*	0.54*	4.16*	—	—	—	0.10
SE ($\hat{g}i$)	1985	± 2.66	0.16	1.13	2.26	0.39	1.46	0.60	0.00	0.03	—
	1986	± 2.49	0.21	0.11	1.23	0.36	1.20	0.79	0.01	0.03	0.21
	Pooled	± 1.79	—	0.76	0.82	0.27	0.95	—	—	—	0.23

*$P \geq 0.05$.

was poor combiner. For leaf area per plant, inbred H-98 in 1985 and CM-205 in both the years were good general combiners. The best inbreds for lesser number of stomata were V20-B, CM-205, A-654 and V57-B in both the years and on pooled basis. Inbreds showing best gca for germination in both the years and in pooled analysis were V55-B, V57-B and CM- 205. The best combiners for root length were V50-B on pooled basis, and CM-205 in 1986 and pooled basis; for root weight V57-B in 1986; and for root number CM-205 in both the years and V50-B in 1986. The best inbreds for proline content in both the years were V20-B, V55-B and H-98; and for chlorophyll content V55-B, V50-B and H-98. Inbred CM-205 was the best combiner during 1985 for pollen shed period. Thus inbreds H-98, CM-205, V55-B and V57- B were good general combiners for many of the drought tolerant traits and should be of help in breeding superior genotypes for drought tolerance. Earlier workers have reported some of the parents to be good general combiners for different traits [7, 8].

SPECIFIC COMBINING ABILITY EFFECTS

The cross V50-B x CM-205 recorded high sca effects for grain yield in both the years and pooled analysis, proline content in both the years and chlorophyll content in the year 1985, but in respect of germination it recorded significantly negative effects (Table 3). The combination V20-B x V50-B exhibited significant sca effects in year 1985 for grain yield and root number, and for root weight in the year 1986 and pooled analysis. The cross exhibited negative effects for stomata number and proline content in both the years. The cross V57-B x A-654 resulted in high sca effects for root weight in both the years and pooled analysis, and during 1985 for grain yield and root length. But in respect of germination the cross exhibited negative sca effects. The cross V20-B x V57-B showed high effects during 1986 and pooled analysis for grain yield and root weight, and during 1985 for leaf area per plant. Crosses showing high sca effects for grain yield and some drought tolerant characters did not necessarily involve the parents with high gca effects. The crosses V50-B x CM-205, V20-B x V50-B, V57-B x A-654, V20-B x V57-B, V55-B x H-98, V50-B x A-654, H-98 x CM-205 and A-654 x CM-205, which had high sca effects for many of the characters studied, involved parents with negative or low gca effects indicating that gca is not an indicator of specific cross effects.

The inbred lines showing high gca for leaf area and chlorophyll content did not show best specific cross effects for these characters [8]. Mating of parents having high gca effects for stomata number, germination and root weight produced the crosses with high sca effects [9]. The crosses involving parents with high and low gca effects for grain yield produced hybrids with high specific cross effect [10].

Keeping in view the above findings it is suggested that in the inbreds V55--B, V57-B, H-98 and CM-205 were good general combiners for most of the characters associated with

Table 3. Estimates of specific combining ability (sca) effects for the best specific crosses in 1985, 1986 and pooled over both years

Cross	Year	Grain yield per plant	Leaf area per plant	Stomata No. per mm^2	Germination	Root length	Root weight	Root No.	Proline content	Chlorophyll content	Pollen shed period
V50-B x CM-205	1985	15.8*	0.59	–4.93	–16.46*	–0.04	–0.55	–1.42	0.27*	0.17*	—
	1986	14.6*	0.22	–4.02	–9.09*	0.09	–1.22	1.15	0.30*	0.13	–0.84
	Pooled	13.2*	—	–4.49*	–12.78*	0.03	–0.88	—	—	—	–0.87
V20-B x V50-B	1985	17.6*	0.40	–13.04*	–0.91	0.89	5.58	2.98*	–0.09	0.02	—
V57-B x A-654	1985	12.7*	0.79*	3.78	–22.28*	2.53*	10.21*	–0.77	0.03	0.01	—
V20-B x V57-B	1986	20.1*	0.41	–13.87*	4.24	–0.89	7.17*	3.85	–0.22*	0.02	–0.65
	Pooled	11.1*	—	–14.26*	1.11	–0.83	5.76*	—	—	—	0.04
V55-B x H-98	1986	24.7*	0.17	14.72*	5.62	1.53	0.10	2.51	0.07*	–0.09	0.24
	Pooled	11.0*	—	14.33*	3.61	0.47	–1.22	—	—	—	0.50
V50-B x A-654	1986	15.4*	0.27	–1.66	–9.93*	1.86	–3.64	3.26	0.07*	0.09	1.27*
H-98 x CM-205	Pooled	12.3*	—	–9.14*	12.22*	0.34	6.61*	—	—	—	–0.79
A-654 x CM-205	1986	26.6*	1.49*	8.59*	–3.82	1.44	–0.64	–0.51	–0.09*	0.12	–1.53*
	Pooled	13.9*	—	8.63*	–4.88*	0.84	1.83	—	—	—	1.81*
SE ($\hat{S}ij$)	1985	± 6.6	0.40	2.81	5.60	1.16	4.25	1.74	0.06	0.08	—
	1986	± 7.3	0.62	3.11	3.58	1.03	3.49	2.31	0.03	0.09	0.62
	Pooled	± 5.2	—	2.22	2.38	0.77	2.75	—	—	—	0.68

*$P \geq 0.05$.

drought tolerance and could be of help in breeding superior genotypes for drought tolerance. The crosses V50-B x CM-205, V20-B x V50-B, V57-B x A-654 and V20-B x V57-B performed well under drought conditions. Consequently, there exists a possibility to utilize these crosses through appropriate breeding methodology.

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