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COMBINING ABILITY FOR GRAIN YIELD AND OTHER AGRONOMIC CHARACTERS IN INBRED LINES OF MAIZE (*ZEA MAYS* L.)

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ABSTRACT

Combining ability analysis was done using 15 F_1 hybrids and their parents obtained from a diallel mating for grain yield, plant height and ear length, days to maturity and 1000 kernel weight. Both general combining ability and specific combining ability effects were significant for all traits. Crosses × year interaction was highly significant for plant height and days to maturity. GCA × year interaction was highly significant for grain yield, plant height and days to maturity. SCA × year interaction was significant only for days to maturity.

Key Words : ***Zea mays*** L., GCA, SCA

The aim of a plant breeder is to identify parents that will combine well and produce productive progenies. The success in identifying such parents mainly depends on the gene action that controls the trait under improvement. The breeding method, efficiency of selection and the final success are dependent on the germplasm chosen. Combining ability studies provide the information on the genetic mechanism controlling quantitative traits and enable us to select suitable parents for further improvement or use in hybrid combinations for commercial purpose. General combining ability (GCA) is a good estimate of additive gene action, whereas specific combining ability (SCA) is a measure of non-additive gene action [1, 2].

Study on diallel crosses of 20 maize varieties over locations [3] showed that general combining ability by location interaction (GCA × L) was significant for days to silk, plant and ear heights, and kernel rows per ear. Specific combining ability by location interaction (SCA × L) was significant for days to silk, plant and ear heights. Similar results were observed by other researchers [2-4].

A study on heterosis and combining ability of CIMMYT's tropical white late maize germplasm revealed highly significant GCA effect for grain yield, days to silk and plant height, whereas SCA effect was not significant [5]. Crosses by environment interaction (crosses × E) was significant only for days to silk and GCA by environment interaction (GCA × E) was significant for plant height and days to maturity. GCA by environment interaction was not significant for grain yield. Similar reports were made in other studies [6, 7]. Several researchers emphasized the importance of crosses × env. GCA × env., and SCA × env. in their studies with quantitative traits in maize [8, 9]. Significant GCA and SCA effects on grain yield were reported by several researchers [10-16].

The objective of this study was to study the combining ability for grain yield and other agronomic traits in maize (*Zea mays L.*).

MATERIALS AND METHODS

Six inbred lines of maize, namely A1-28, A1- 71, A1-151, A1-175, A1-178 and A1-204 were crossed in a diallel fashion (excluding reciprocal crosses), to obtain the 15 F_1 hybrids. The F_1 hybrids along with their parental lines were tested in 1994 and 1995 crop seasons at the Research Farm of the Alemaya University of Agriculture, Ethiopia.

The planting of the single crosses along with their parental lines was arranged in a randomized complete block design with four replications. Four-row plots with row-length of 5 meters and spaced 75 cm apart and 30 cm between hills were used. Two seeds were planted per hill, except the end hills where three seeds per hill were planted and thinned to one plant per hill. Two plants were conserved in the end hills upto harvest. Thinning was done when seedlings were about three to four leaf stage. The final stand of the crop was approximately 44,444 plants/hectare. Cultural practices as recommended to keep the crop plants free of weed competition were followed as and when necessary. P_2O_5 and N were applied at the rates of 46 and 87 kg/hectare respectively.

All data were recorded from the central two rows. Days to maturity was recorded when the kernels attained physiological maturity by observing the black layer formation. At harvest, ears were harvested and kernels were shelled. The grain yield was then adjusted to 12.5% moisture level and recorded in tons/hectare.

Data was analyzed for randomized complete block design and mean squares due to general combining ability (GCA) and specific combining ability (SCA) were calculated on an IBM computer using diallel cross analysis procedure [17].

RESULTS AND DISCUSSION

Grain yield

The combined analysis of variance for two years showed that the mean squares for grain yield due to crosses × year interaction was not significant (Table 1). Similar results were reported by scientists in their studies of heterosis and combining ability of CIMMYT's maize germplams [5, 6]. Vasal *et al.* [6, 18] found significant crosses × year interaction for grain yield. Mean squares due to general combining ability and specific combining ability were highly significant. The ratio between GCA:SCA was less than unity (0.68) showing that non-additive gene action was more important in controlling grain yield. Highly significant GCA effect for grain yield was also reported in other studies [5-7, 14, 15, 18].

Table 1. ANOVA for combining ability for different traits in Maize

Source of variation	Degrees of freedom	Mean squares			Days to maturity	1000 kernel weight
		Grain yield	Plant height	Ear lenght		
Rep. within years	6	0.29	83.3	14.1	0.31	269
Years	1	0.07	34543.3	1337.4	22.88	1200
Crosses	20	30.7*	7527.2	3461.6*	62.03*	15559*
GCA	5	22.7*	12690.0*	7204.0*	185.65*	10706*
SCA	15	33.36*	5806.2*	4375.4*	20.82*	17186*
Year × Crosses	20	0.39	219.6*	12.0	1.66*	420
GCA × Year	5	0.97*	258.7*	16.34	1.72*	371
SCA × Year	15	0.19	20.6	10.6	1.64*	436
Error	120	0.29	37.0	15.5	0.29	29

*Significant at 5% level

GCA × year interaction was significant for grain yield, whereas SCA × year interaction was non-significant. Similar results were obtained by other researchers in their study on quantitative traits in maize [6, 9, 15, 18, 19].

The mean grain yield for the F_1 crosses ranged from 4.57 to 10.05 tons/ha and for the parental lines from 2.91 to 5.31 tons/ha (Table 2).

Estimates of general combining ability showed that inbred lines A1-204, A1-151 and A1-28 were good general combiners for grain yield, whereas A1-178 was the poorest (Table 3).

Table 2. Mean performance of F_1 hybrids and their parental lines

Hybrid	Grain yield (tons/ha)	Plant height (cm)	Ear length (cm)	Days to maturity	1000 Kernel weight (g)
A1-28 × A1-71	6.65	197.9	114.4	175.5	385.9
A1-28 × A1-151	6.62	163.9	107.9	175.6	381.8
A1-28 × A1-175	8.41	223.4	125.4	176.3	434.4
A1-28 × A1-178	7.53	217.3	118.8	176.8	417.1
A1-28 × A1-204	8.65	238.8	132.5	175.5	459.2
A1-71 × A1-151	7.51	217.0	122.8	175.8	487.4
A1-71 × A1-175	6.06	188.7	117.6	174.6	381.2
A1-71 × A1-178	4.57	207.6	108.5	175.3	399.5
A1-71 × A1-204	7.20	223.1	135.8	178.0	421.8
A1-151 × A1-175	6.06	206.2	117.8	175.9	362.2
A1-151 × A1-178	8.03	215.9	113.5	176.5	369.5
A1-151 × A1-204	8.53	249.7	139.8	117.9	411.1
A1-175 × A1-178	4.82	196.0	113.8	176.4	379.7
A1-175 × A1-204	10.05	276.7	162.5	181.8	400.8
A1-178 × A1-204	8.82	242.3	153.5	181.8	431.4
A1-28	4.25	173.4	83.9	173.5	356.9
A1-71	4.48	179.4	85.6	174.1	344.4
A1-151	5.31	186.5	96.6	172.4	408.8
A1-175	3.73	190.6	106.5	173.8	310.5
A1-178	2.91	151.9	84.4	175.4	319.6
A1-204	4.70	221.6	130.8	183.8	336.0

Table 3. Estimates of general combining ability of parents for different traits

Entry	Grain yield	Plant height	Ear length	Days to maturity	1000 Kernel weight
A1-28	0.17	–8.4	–7.1	–1.0	7.4
A1-71	–0.50	–7.8	–6.7	–0.9	3.9
A1-151	0.30	–3.7	–3.6	–1.0	12.0
A1-175	–0.26	2.0	3.2	–0.3	–19.2
A1-178	–0.67	–9.1	–5.9	0.1	–12.0
A1-204	0.96	27.2	20.1	3.3	7.9
$SE(g_i)$	0.17	1.93	1.25	0.17	1.90

From the estimates of specific combining ability it can be seen that hybrid combination A1-175 × A1-204 was the best, followed by A1-178 × A1-206 and A1-28 × A1- 175 (Table 4). A1-71 × A1-178 and A1-175 × A1-178 were poor combinations indicating that most probably the lines involved in producing each one of these hybrids belong to the same heterotic pattern.

Plant height

The ANOVA (Table 1) indicated that mean squares for crosses × year interaction for plant height was highly significant. The mean squares for both GCA and SCA were highly significant. The ratio between GCA:SCA was 2.19, showing that additive gene effect was more important for this trait than non-additive gene effect [5-7, 18].

Estimates of general combining ability showed that A1-178, A1-28 and A1-71 were good general combiners, because they tend to reduce plant height and A1-204 was the poorest combiner (Table 3). The estimates of specific combining ability showed that A1-28 × A1-151 was the best combination, followed by A1- 71 × A1-157 (Table 4).

Table 4. Estimates of specific combining ability (s_{ij}) for the 15 F_1 hybrids

Entry	Grain yield	Plant height	Ear length	Days to maturity	1000 Kernel weight
A1-28 × A1-71	0.55	6.25	10.55	1.08	–15.79
A1-28 × A1-151	–0.27	–31.79	0.97	1.33	–28.14
A1-28 × A1-175	2.07	21.83	11.58	1.23	55.77
A1-28 × A1-178	1.60	26.89	14.11	1.18	31.36
A1-28 × A1-204	1.09	12.07	1.77	–3.20	53.44
A1-71 × A1-151	1.29	20.62	15.39	1.37	80.97
A1-71 × A1-175	0.40	–13.47	3.38	–0.48	6.08
A1-71 × A1-178	–0.67	16.58	3.41	–0.41	17.20
A1-71 × A1-204	0.32	–4.29	4.56	–0.80	19.51
A1-151 × A1-175	–0.39	–0.03	0.42	0.88	–21.08
A1-151 × A1-178	1.97	20.84	5.33	0.96	–20.96
A1-151 × A1-204	0.84	18.26	4.48	–0.80	0.72
A1-175 × A1-178	–0.67	–4.85	–1.38	–0.02	20.58
A1-175 × A1-204	2.92	39.33	21.30	2.33	21.67
A1-178 × A1-204	2.11	16.20	21.50	1.16	45.17
SE(S_{ij})	1.49	16.80	10.97	1.49	14.90

Ear length

Mean squares for crosses × year, GCA × yar and SCA × year were non-significant for ear length, and mean square values for both GCA and SCA were highly significant (Table 1). The ratio between GCA:SCA was greater than unity (Table 1), indicating that additive gene action was more important in conditioning this trait than non-additive gene action.

Estimates of general combining ability effects (Table 3) showed that all inbred lines, except A1-204 were good general combiners for ear length. The best specific combination was A1-175 × A1-178 with S_{ij} of –1.38 (Table 4).

Days to maturity

From the ANOVA (Table 1) it can be seen that there were highly signifiant differences between the crosses. Mean squares for crosses × year, GCA × year and SCA × year were highly significant. The ratio between GCA:SCA was 8.92 (Table 1). This indicated that additive gene action was more important for days to maturity than non-additive gene action. In a study of heterosis and combining ability of CIMMYT's maize germplasm, scientists reported similar results [5, 7].

The estimates of general combining ability effects (Table 3) revealed that A1-204 was the poorest general combiner for days to maturity, followed by A1-178. All the other lines had the tendency to reduce days to maturity.

Estimates of specific combining ability (Table 4) showed that most of the hybrid combinations had positive values of specific combining ability (S_{ij}) effects. The best specific combination for days to maturity was AL-28 × A1-204.

1000-Kernel weight

The combined ANOVA showed that the mean squares due to crosses was highly significant (Table 1), Crosses × year, GCA × year and SCA × year interactions were non-significant. The GCA:SCA ratio was 0.62, showing that non-additive gene effect was more important than additive gene action in controlling this trait.

A1-151 was the best general combiner, followed by A1-204 and A1- 28 with general combining ability effect estimates of 12.07, 7.9 and 7.4 respectively (Table 3). The poorest general combiner was A1-175.

Most hybrid combinations had positive estimates of specific combining ability effects for 1000 kernel weight, with the highest positive value obtained by hybrid combination A1-71 × A1-151 (80.98), followed by A1-28 × A1-175 (55.77).

Based on the over all performance of the F_1 hybrids and parental lines, it was possible to select some lines with good general combining ability and yield potential and hybrids with good specific combining ability for grain yield and good yield levels (Table 5). A1-204, A1-151 and A1-28 were selected for their good GCA and yield potential. These lines could be used as a component of synthetic variety formation and/or in the future improvement of maize. The hybrids, A1-175 × A1-204, A1-178 × A1-204, A1-28 × A1-204, A1-151 × A1-204 and A1-28 × A1-175 were found to be good specific combiners. These hybrids may be used as single cross commercial hybrids after verifying the results on a larger area (plot). It is interesting to see that inbred line A1-204 is one of te components of three of the five selected F_1 hybrids, indicating that it has high heritable potential for grain yield.

Table 5. Selected F_1 hybrids and parental lines for their general performance

Genotype		Estimates of GCA	Estimates of SCA	Grain yield (tons/ha)
Fl hybrids :	1. A1-175 × A1-204	-	2.93	10.05
	2. A1-178 × A1-204	-	2.11	8.82
	3. A1-28 × A1-204	-	10.9	8.65
	4. A1-151 × A1-204	-	0.84	8.53
	5. A1-28 × A1-175	-	2.07	8.41
Parents:	1. A1-204	0.960	-	4.70
	2. A1-151	0.303	-	5.31
	3. A1-28	0.174	-	4.25

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