Indian J. Genet., **61**(1): 34-36 (2001)

Combining ability studies for some morphophysiological and biochemical traits related to drought tolerance in maize (*Zea mays* L.)

Shreenivasa A. Desai* and R. D. Singh

Division of Genetics, Indian Agricultural Research Institute, New Delhi 110 012

(Received: November 1998; Revised: October 2000; Accepted: November 2000)

Abstract

The material from a 7 × 7 half diallel cross involving relatively drought tolerant inbreds of maize was raised under rainfed condition. Analysis of variance revealed significant differences for gca and sca effects for ten characters studied. Among the parents, Ib 1073, Ib1143 and Ib 1155 were found to have negative gca effect for days to 50 per cent tasseling, day to 50 per cent silking and anthesis-silking interval. On the other hand, for plant height, ear height and grain yield per plot, they had positive gca effects. The crosses viz., IB 1073 × Ib 1143 and Ib 1073 × Ib1155 were found to have negative sca effects for days to 50 per cent tasseling, days to 50 per cent silking and anthesis-silking interval. These crosses also exhibited positive sca for plant height, ear height, number of leaves per plant and grain yield per plot.

Key Words : Maize, drought tolerance traits, diallel cross, combining ability.

Introduction

Food production in the country has been oscillating among peaks and troughs, depending upon the natural precipitation and other soil and environmental factors. Maize is one of the most important cereal crops in India and in the world. In India, more than 80 per cent area under maize grown in *kharif* depends on the rain, hence vulnerable to vagaries of monsoon. One of the most important factors affecting maize yield under rainfed condition is the drought during crop season for short or long periods. The extent of yield reduction depends upon the degree, duration and timing of drought occurrence. Understanding of morphological, physiological and biochemical basis of drought tolerance is a pre-requisite for efficient selection of genotypes and breeding for moisture stress conditions.

Exploitation of genetic differences in traits contributing to drought tolerance may be a means of improving maize crop for drought prone areas. It is essential to know the genetic architecture of traits related to drought tolerance and their mode of inheritance.

Materials and methods

The experimental material for the present investigation was derived from a 7 × 7 inbred half diallel cross. Inbreds selected [Ib 1058, Ib 1073, Ib 1084, Ib 1088, Ib 1100, Ib 1143 and Ib 1155] for the diallel cross possessed different degree of tolerance to drought situations. The experimental material was raised in a randomized complete block design, with three replications during *kharif* 1996 at the Division of Genetics, Indian Agricultural Research Institute, New Delhi. Each plot comprised of a single 5m long row, spaced at 75 cms apart and plants within rows 20 cms apart. The experiment was conducted under stress environment with no irrigation and half the recommended dose of fertilizers. During the crop season water stress occurred at the time of anthesis, silking, pollination and grain filling stages of the crop growth. The material was evaluated for ten morpho-physiological and biochemical characters associated with drought tolerance. The data on proline content and relative water content were recorded in the laboratory. However, all other characters were recorded in the field. The combining ability analysis was carried out as per the method II, model I of Griffing [1].

Results and discussion

An examination of magnitude of mean squares for general and specific combining ability for morpho-physiological and biochemical characters under rainfed conditions (Table 1) as well indicated significant differences among the gca as well as sca effects. It was concluded that both additive and non-additive components of genetic variance were involved in the

*Present address: All India Co-ordinated Wheat Improvement Project, Dr. Sanjaya Rajaram Wheat Laboratory, Main Research Station, University of Agricultural Sciences, Dharwad 580 005.

Table 1. Combining ability analysis of variance for morpho-physiological and biochemical characters in maize under rainfed conditions

Source	d.f.	Mean squares				
		Days to 50% tasseling	Days to 50% silking	Anthesis - silking interval	Plant height	Ear height
GCA	6	2.60*	4.20*	5.41*	33.53*	116.2*
SCA	21	1.37*	2.24*	2.30*	72.18*	46.6*
Error	54	0.43	0.83	0.20	15.03	9.0

(Table 1 contd.)

Source	d.f.	Mean squares				
		No. of leaves/ plant	Canopy air temperature difference	Relative water content	Proline content	Grain yield per plot
GCA	6	8.17*	0.41*	35014*	662829*	0.030*
SCA	21	5.69*	0.69*	15103*	108236*	0.020*
Error	54	0.22	0.13	1941	3351	0.005

*Significant at 5% level

inheritance of these traits. The significant differences for gca and sca variances for different traits have been reported earlier [2-5].

General combining ability effects: The gca estimates showed that the best general combining inbreds for grain yield were Ib 1073 and Ib 1155 (Table 2). Among the parents studied Ib 1073 and Ib1143 were found to have negative gca effects for days to 50 percent tasseling and days to 50 per cent silking and anthesis-silking interval, indicating their usefulness for bringing out earliness in crosses. These crosses also had higher negative values for canopy air temperature difference, indicating that these inbreds preserve cooler canopy temperature than the air temperature. Consequently, it is concluded that the lines with cooler canopy temperature yield more than the lines warmer canopy temperature [6]. On the other hand, for plant height, ear height and relative water content these inbreds exhibited positive gca effects. All the inbreds except IB 1088 had positive gca estimates for proline content. Thus inbreds Ib 1073, Ib 1143 and Ib 1155 were good general combiners for many of the drought tolerant traits and should be of great help in breeding superior genotypes for drought tolerance. Earlier workers have reported some of the parents to be a good general combiners for different traits [3, 7].

Specific combining ability effects: The two crosses Ib 1073 × Ib 1143 and Ib 1073 × Ib 1155 were found to have negative sca effects for days to 50 per cent tasseling, days to 50 per cent silking and anthesis - silking interval under stressed condition (Table 3). These crosses also had negative sca effects for canopy air temperature difference, thereby keeping their canopy temperature cooler than air temperature. These crosses had positive sca for plant height, ear height, number of leaves per plant, proline content and grain yield per plot, indicating their usefulness in hybrid breeding programme for drought tolerance.

Table 2. Estimates of general combining ability effects for morpho-physiological and biochemical characters in maize under rainfed conditions

Parents	Days to 50% tasseling	Days to 50% silking	Anthesis silking interval	Plant height	Ear height
1. Ib 1058	0.31	0.30	−0.01	−3.47*	−7.00*
2. Ib 1073	−0.92*	−1.25*	−0.34*	1.50	1.83
3. Ib 1084	0.05	0.45	0.40*	1.32	0.84
4. Ib 1088	0.34	0.56*	0.28	1.02	−1.94*
5. Ib 1100	0.68*	0.52	−0.59*	−0.15	1.20
6. Ib 1143	−0.47*	−0.59*	−0.12	1.74	2.69*
7. Ib 1155	0.01	0.01	−0.01	−0.92	3.66*
S.E.	0.20	0.28	0.14	1.20	0.93

(Table 2 contd.)

Parents	Mean squares				
	No. of Leaves/ plant	Canopy-air temperature difference	Relative water content	Proline content	Grain Yield Per plot
1. Ib 1058	−0.14	0.09	−0.93*	17.43	−0.05*
2. Ib 1073	0.53*	−0.35*	1.29*	34.03	0.12
3. Ib 1084	0.13	−0.05	1.00*	82.66	−0.07*
4. Ib 1088	−0.35*	0.13	−1.83*	−168.77*	0.00
5. Ib 1100	−0.32*	0.31*	−0.96*	−39.46	0.07*
6. Ib 1143	0.07	−0.16*	−0.78*	76.51	0.01
7. Ib 1155	0.08	0.04	1.60*	−2.38	0.06*
S.E.	0.15	0.11	0.02	56.50	0.02

Ib - Inbred; * - Significant at 5% level

A comparison of the combining ability effects of parents and their corresponding crosses indicated that the gca effects of the parents were reflected in the sca effects of crosses for most of the characters studied. The results are in accordance with the earlier workers [5, 7, 8-10].

The above findings suggested that the inbreds Ib 1073, Ib 1143 and Ib 1155 were good general combiners for most of the characters associated with drought tolerance and could be of great help in breeding elite genotypes for drought tolerance. Similarly the crosses viz., Ib 1073 × Ib 1143 and Ib 1073 × Ib 1155 performed well under drought condition. Consequently there exists a fair possibility to exploit these crosses through suitable breeding methodology.

Table 3. Estimates of specific combining ability effects for morpho-physiological and biochemical characters in maize under rainfed conditions

Crosses	Days to 50% tasseling	Days to 50% silking	Anthesis silking interval	Plant height	Ear height	No. of leaves/ plant	Canopy-air tempera-ture difference	Relative water content	Proline content	Grain yield
Ib 1058 × 1073	1.29*	1.67*	0.38*	–0.95	10.44*	–0.57	0.59	–21.21*	–54.3	–0.10
Ib 1058 × 1084	0.32	0.30	–0.03	6.27*	4.73	–0.37	–0.11	21.25*	113.7	0.03
Ib 1058× 1088	–0.97	–.15	–0.18	2.87	–2.09	0.60	–0.58	20.80*	293.1	0.13*
Ib 1058 × 1100	–1.31*	–1.44	–0.14	1.79	1.84	0.51	–0.54	19.07	250.5	0.09
Ib 1058 × 1143	1.18*	1.33	0.16	4.62*	–0.12	0.49	–0.33	16.81*	268.2	–0.02
Ib 1058 × 1155	1.36*	1.07	–0.29*	–0.79	–2.06	–1.51*	–0.90*	19.94*	387.4	0.02
Ib 1073 × 1084	1.55*	1.85*	–0.31*	12.43*	–0.77	–0.64	0.50	–26.21*	31.8	–0.03
Ib 1073 × 1088	0.25	1.07	0.22	4.40*	9.41*	0.00	0.02	–23.21*	43.5	–0.03
Ib 1073 × 1100	0.25	0.78	0.53*	5.69*	2.20	–0.09	–0.47	–23.44*	103.9	0.07
Ib 1073 × 1143	–0.94	–1.44	–0.51*	8.35*	2.78	1.79*	–1.68*	–24.18*	572.6*	0.19*
Ib 1073 × 1155	–0.75	–1.70*	–0.95*	14.11*	4.41	1.51*	–1.12*	–21.95*	468.1*	0.20*
Ib 1084 × 1088	0.62	1.04	0.42*	0.42	7.83*	0.40	0.75*	21.00	139.9	0.10
Ib 1084 × 1100	–0.05	–0.26	–0.21	5.27*	5.46*	0.71	0.04	21.95*	416.2*	0.12
Ib 1084 × 1143	–1.90*	–2.15*	–0.25	6.37*	0.47	0.22	–0.34	21.47*	118.3	0.14*
Ib 1084 × 1155	0.l29	0.26	–0.03	–0.87	–41.70	–0.52	0.45	20.77*	–227.7*	–0.11
Ib1088 × 1100	0.66	0.63	–0.03	–3.17*	–2.73	0.28	0.50	20.75*	26.7	–0.05
Ib 1088 × 1143	1.47*	2.07*	0.60	4.83*	11.75*	–0.47	0.87*	19.53*	–257.5	–0.04
Ib 1088 × 1155	–1.34*	–1.52	–0.18	9.49*	–8.09*	–0.71	0.53	22.79*	–165.3	0.09
Ib 1100 × 1143	0.14	0.11	–0.13	–0.58	3.01	0.59	21.99*	–309.5	0.06	0.06
Ib 1100 × 1155	0.32	0.19	–0.14	–9.86*	2.01	0.19	0.86*	18.76*	–178.6	0.01
Ib 1143 × 1155	2.14	2.96*	0.82	18.66*	–1.78	–0.96*	0.96*	18.62*	436.3*	–0.21*
S.E.	0.59	0.82	0.13	1.51	2.69	0.43	0.61	3.96	164.3	0.07

*Significant at 5% level

References

1. **Griffing B.** 1956. Concept of general and specific combining ability in relation to diallel crossing systems. Aust. J. Biol. Sci., **9**: 463-493.
2. **Rao J. M. N., Satyanarayana E., Saikumar R. and Anuradha K.** 1991. Gene effects and heterosis of grain yield and some associated quantitative traits in maize (*Zea mays L.*). Abstracts of Golden Jubilee symposium on Genetic Research and Education: Current Trends and the Next fifty years. Feb 12-15, 1991, **2**: 392.
3. **Subba Rao M.** 1992. Genetic studies on drought tolerance in maize (*Zea mays L.*) Unpubl. Ph.D. Thesis, P. G. School, Indian Agricultural Research Institute, New Delhi.
4. **Mathur R. K. and Bhatnagar S. K.** 1995. Partial diallel cross analysis for grain yield and its components characters in maize (*Zea mays L.*). Ann. Agric. Res., **16**: 324-329.
5. **Ribaut I. M., Hoisington J. A., Deutsch C., Jiang D. and Gonzalez-de-Leon.** 1996. Identification of quantitative traits loci under drought conditions in tropical maize. I. Flowering parameters and the anthesis-silking interval. Theor. Appl. Genet., **92**: 905-914.
6. **Kirkham M. B., Suksayretrup K., Wassom C. E. and Kanemasu E. T.** 1984. Canopy temperature of drought resistance and drought sensitive genotypes of maize. Maydic., **29**: 287-303.
7. **Vinod Kumar.** 1996. Genetic studies on yield, yield components nd some morpho-physiological traits associated with drought tolerance in maize (*Zea mays L.*) Unpubl. Ph.D. thesis, P.G. School, Indian Agricultural Research Institute, New Delhi.
8. **Nawar A. A. and El-Hasary A. A.** 1984. Evaluation of eleven testers of different genetic sources of corn. Egyptial J. Genet. Cytol., **13**: 227-237.
9. **Brar G. P. S. and Labana K. S. L.** 1991. Partitioning of quantitative variability for grain yield and its components in maize. In: Abstracts of Golden Jubilee Symposium on Genetic Research and Education: Current Trends and Next Fifty years. Feb. 12-15, 1991, New Delhi, #2#: 385.
10. **Mahajan V., Khehra A. S. and Malhotra V. V.** 1991. Combining ability studies for silking and maturity in diverse seasons in maize. J. Res., PAU, Ludhiana. **28**: 315-319.