Pak J Sci Ind Res 1999 42 (3)141-144

COMBINING ABILITY ANALYSIS IN MAIZE (*ZEA MAYS* L.)

K K Paul* and S C Debanth

Department of Agriculture Science, Santahar Government College, Santahar, Bogra, Bangladesh

(Received 22 October 1996; accepted 23 September 1998)

Combining ability analysis was carried out in maize (*Zea mays* L.) in a 7x7 diallel, excluding reciprocals. Both the general (GCA) and specific combining ability (SCA) effects were significant for all the characters studied namely days to pollen shedding, days to silk, plant height, ear height and biomass weight per plant. Combining ability analysis indicated that additive gene action was more important than non-additive gene action and the best general and specific combiners were selected. Lines #7721 and #7785 showed significantly desirable GCA effects for days to pollen shedding and days to silk, S 2-9, for plant height, S 16-2, for ear height and #1018 and S16-2 for biomass weight per plant. The number of crosses showing desirable significant SCA effects for days to pollen shedding, days to silk, plant height, ear height and biomass weight per plant were 7, 4, 6, 6 and 8 respectively.

Key words: Diallel, Maize, General Combining Ability (GCA).

Introduction

As a leading cereal with high per hectare yield, maize can play an important role in reducing the world food crisis. Lodging and delay in maturity in local maize genotypes reduce per heactare yields in Bangladesh. Hence, breeding for low plant and ear heights and early flowering are important objectives in a maize breeding programme. The present study was carried out to indentify genetically superior F1 hybrids from a combining ability analysis of a 7x7 diallel cross of parental inbreds suitable for cultivation in Bangladesh. This analysis will help in setting guidelines for the early assessment of the breeding potential of these parental lines with respect to pollen shedding, silking dates, plant height, ear height and biomass weight per plant.

Materials and Methods

Seven maize inbreds S 35-3, S 2-9, #103, #1018, S 16-2, #7771, and #7785, developed at the Department of Genetics and Plant Breeding of Bangladesh Agricultural University, Mymensingh, Bangladesh, were collected from the maize breeding project (CGRCI) and diallel was developed by mating all possible combinations (excluding reciprocals) to generate 21 hybrids during the rabi-season of 1990-91. During the rabi-season of 1991-92, 28 entries comprising seven parents and their 21 hybrids were grown in a randomized block design with three replications at the experimental farm at Bangladesh Agricultural University, Mymensingh. Recommended agronomical practices were followed. The experimental plot consisted of single row of 5m length with row to row spacing of 0.75m and plant to plant spacing of 0.25m. Data on days to pollen shedding, days to silk, plant height, ear height, and biomass weight per plant were taken on ten plants and averaged for the purpose of satistical analysis. Data on days to pollen shedding and days to silk were recorded as the number of days from planting to pollen shedding and to the emergence of silk in 50% of the plants in the plot, respectively. Plant height was measured in centimeters from the base of the plant to the base of the tassel. Ear height was measured in centimeters from the base of the plant to the node bearing the upper most ear. Biomass weight per plant was taken in grams after harvest (grain + individual dry weight). Combining ability analysis was carried out according to Method -2 Model -1 of Griffing (1956a) and the relative importance of GCA and SCA was calculated by the ratio, $202\ g/(20^2 g + 0^2 s)$ following Baker (1978) for a fixed effect model, where $0^2 g$ and $0^2 s$ are the equivalent components of GCA and SCA, respectively.

*Author for correspondence

Results and Discussion

Analysis of variance of the data revealed significant variations among the crosses and parents for all traits measured. The mean squares due to GCA and SCA were also significant for all characters (Table 1). The variance due to GCA contains only additive variance and interaction of the additive type, additive x additive etc.

The SCA variance involves dominance variance and all types of epistatic interactions including additive x additive and other types (Griffing 1956b; Arunachalam 1976). Thus both additive and non-additive components of variation were important for the traits studied in the present work. Importance of both additive and non-additive gene action in the inheritance of plant and ear height was also observed by Widstrom *et al* (1993). The values of $20^2 g/(20^2 g + 0^2 s)$ for all characters were low, indicating importance of GCA effects (i.e. predominant

role of additive gene effects) in the inheritance of these characters (Table 2). Predominant additive genetic variance in the inheritance of plant and ear heights was also observed by Russel (1976) and Nawar *et al* (1980). Widstrom *et al* (1993) reported dominant role of additive genetic variance for earliness. The estimates of GCA and SCA effects of parents and crosses are presented in Tables 3 and 4, respectively.

Table 1

Analysis of variance for combining ability for different characters in A7x7 diallel cross of maize

Characters	Mean Squares		
	GCA (d.f.=6)	SCA (d.f.=21)	Error (d.f.=54)
Days to pollen shedding	42.42*	24.91*	2.32
Days to silk	40.75*	25.85*	3.24
Plant height	545.63*	338.29*	120.75
Ear height	196.19*	155.20*	52.24
Biomass weight plant^{-1}	775.23*	1990.65*	179.20

*Significant at 0.01 level.

Table 2

Relative importance of GCA and SCA {$20^2g/(20^2g+0^2s)$} with variance components of GCA (0^2g) and (0^2s) for different characters in maize

Characters	6^2g	6^2s	$26^2g/(26^2g+6^2s)$
Days to pollen shedding	4.455	22.590	0.282
Days to silk	4.167	22.610	0.269
Plant height	47.208	217.541	0.302
Ear height	15.994	102.960	0.237
Biomass weight plant^{-1}	64.002	1811.440	0.066

In this paper, parents were classified as good, average and poor combiners based on their GCA effects. Parents with desirable GCA effect (significantly different from zero) were considered as good combiners while parents showing insignificant estimates were classified as average combiners. Poor combiners had significant but undersirable GCA effects. The interpretations are given below character-wise.

For days to pollen shedding, negative estimtes were considered desirable, since those were observed to be associated with earliness. The estimated GCA effects ranged from - 3.21 in #7785 to 2.34 in S16-2. Four parents differed significantly from zero with regards to GCA effects. Parent # 7785 was the best combiner followed by # 7771. The poorest combiner was S 16-2 followed by S 35-3. The remaining parents were average combiners and exhibited insignificant GCA effects for this trait. The SCA effects ranged from -11. 16. to 5.34 for the crosses S 35-3, # 1018 and # 1018 x # 7771 respectively. Among the crosses, S 35-3 x # 1018, S 35-3 x S16-2, S2-9 x # 103, S 2-9 x S16-2, # 1018 x S16-2, S 16-2 x # 7785 and # 7771 x # 7785 showed significantly negative SCA effects indicating good hybrid combinations for earliness.

For days to silk as for days to pollen shedding, negative estimates were also considered desirable, since less days to silk

Table 3

Estimates of general combining ability (GCA) effects of the parents for different characters in a diallel cross of maize

Parents	Characters				
	Days to pollen shedding	Days to silk	Plant height	Ear height	Biomass weight plant^{-1}
S 35-3	1.52*	1.50**	-6.64	-3.65	-9.33*
S 2-9	1.16	1.13	-9.40**	-0.05	-9.49*
# 103	0.46	0.84	3.12	1.55	-5.97
# 1018	-0.02	-0.04	-0.54	-3.99	10.82*
S 16-2	2.34**	2.39**	-5.83	-5.42*	13.81*
# 7771	-2.65**	-2.67**	9.01*	4.43	-0.74
# 7785	-3.21	-3.15**	10.28**	7.13**	0.90
C.D.(gi)					
at 0.05 level	0.94	1.11	6.80	4.47	8.28
at 0.01 level	1.25	1.48	9.06	5.96	11.02

*Significantly different from zero at 0.05 level.
**Significantly different from zero at 0.01 level.

Table 4

Estimates of specific combining ability (SCA) effects of the hybrids for different characters in a diallel cross of maize

Parents	Characters				
	Days to pollen shedding	Days to silk	Plant height	Ear height	Biomass weight/plant
S35-3xS2-9	1.65	1.67	2.57	-9.12	-15.57
S35-3x#103	1.28	1.30	18.61*	15.19*	-35.26**
S35-3x#1018	-11.16**	-11.14**	13.80	10.70	38.38**
S35-3xS16-2	-2.86*	-2.91*	6.74	8.04	-17.86
S35-3x#7771	3.79*	3.81*	-25.02**	-16.11**	44.91**
S35-3 x#7785	2.69*	2.64	0.26	0.99	-41.15**
S2-9x#103	-2.34*	2.32	-27.58**	-14.89**	78.28**
S2-9x#1018	2.53*	2.56*	-1.84	-3.11	-22.32
S2-9x S16-2	-6.83**	-6.88**	21.81*	6.38	-20.08
S2-9x#7771	2.51*	2.53*	2.94	1.93	-23.57*
S2-9x#7785	0.39	0.34	-16.13	-5.57	49.89**
#103x#1018	2.50*	2.52	-2.25	-2.55	-53.50**
#103x S16-2	-1.53	0.00	8.53	-1.05	-15.09
#103x#7771	0.80	0.82	22.85*	9.93	3.70
#103x#7785	1.36	1.96	25.98**	21.13**	30.21**
#1018x S16-2	-4.65**	-4.69**	5.37	-3.77	50.38**
#1018x#7771	-5.34**	5.37**	-17.76*	-4.64	61.79**
#1018x#7785	5.24**	5.19**	-19.91*	-11.83*	50.35**
#S16-2x#7771	4.65**	4.60**	-24.07**	-14.23*	-1.61
#S16-2x#7785	-7.88*	8.41**	-22.25**	-13.01*	-16.74
#7771x#7785	-2.46*	-2.51	11.53	-12.67*	-77.23**
C.D (Sij)					
at 0.05 level	2.32	2.74	16.83	11.07	20.50
at 0.01 level	3.10	3.66	22.42	14.73	27.28

*Significantly different from zero at 0.05 level.
**Significantly different from zero at 0.01 level.

are associated with early maturity. The estimates of GCA effects ranged from -3.15 to 2.39 for the parents # 7785 and S 16-2 respectively. Among the parents, # 7785 and # 7771 were the only lines having significantly negative GCA effects, indicating good combiners for early silking days. S 35-3 and S 16-2 were the poor combiners. The SCA effects varied from - 11.14 for the cross S 35-3 x # 1018 to 8.14 for S16-2 x # 7785 of 21 crosses, S 35-3 x # 1018 (poor x average), S 35-3 x S16-2 (poor x poor) S2-9 x S16-2 (average x poor) and # 1018 x S 16-2 (average x poor) showed significantly negative SCA effects.

Negative estimates for plant height were desirable since they were correlated with shorter plant height. The estimates for GCA effects for plant height varied from -9.40 for the parent S 2-9 to 10.28 for # 7785. Line S 2-9 was the only good combiner having the highest negative GCA effect. Lines # 7771 and # 7785 had significantly positive GCA effects and were considered the poor combiners. The SCA effects varied from -27.58 to 25.98 for the crosses S 2-9 x # 103 and # 103 x # 7785 respectively. Crosses S 35-3 x # 7771 (average x poor), S 2-9 x # 103 (good x average), # 1018 x # 7771 (average x poor), # 1018 x # 7785 (average x poor), S 16-2 x #7785 (average x poor) and S 16-2 x # 7785 (average x poor) showed significant and negative SCA effects. These hybrids were desirable for exploiting non-additive gene action for their significantly negative SCA effects.

As with plant height, negative estimates were also considered desirable for ear height. The estimates of GCA effects varied from -5.42 in S 16-2 to 7.13 in # 7785. Two parents differed significantly from zero with regard to GCA effects; one (S 16-2) had negative and other (#7785) positive estimates. The SCA effects ranged from -16.11 to 21.13 for the

crosses S 35-3 x # 7771 (average x average) and # 103 x # 7785, respectively. The crosses, S 35-3 x # 7771 (average x average), S 2-9 x # 103 (average x average), # 1018 x # 7785 (average x poor), S 16-2 x # 7771 (good x average), S 16-2 x # 7785 (good x poor) and # 7771 x # 7785 (average x poor) exhibited significantly negative SCA effects.

Conclusion

A comparison of the combining ability of the parents and corresponding crosses indicates that, in most of the cases, the GCA effects of the parents were not reflected in the SCA of the crosses for all characters. Thus in most cases, crossing two good combiners did not necessarily result in a good specific combination and the same was also true for the poor combiners. Similar results were also reported by Debnath and Sarkar (1987). It can be concluded from these results that both additive and non-additive gene actions were very important in the inheritance of these studied characters. Most of the parents were the good combiners for early maturity which avoids the environmental hazards. Plant and ear height showed negative SCA effects indicating the utility of the shortness of plants in increasing maize production and reducing cost for stacking in Bangladesh. Biomass per plant through photosynthesis increases grain yield solving food and feed problem in Bangladesh.

References

Arunachalam V 1976 Evaluation of diallel crosses by graphical and combining ability methods. *Indian J Genet* **36** 358-366.

Baker R J 1978 Issues in diallel analysis. *Crop Sci* **18** 533-536.

Debanth S C, Sarker K R 1987 Diallel analysis of plant and ear height in Maize. *Acta Agron Hung* **36** 77-78.

Griffing B 1956a A generalised treatment of the use of diallel cross in quantitative inheritance. *Heredity* **10** 31-50.

Griffing B 1956b Concept of general and specific combining ability in relation to diallel crossing system. *Aust J Biol Sci* **9** 463-493.

Nawar A A, Gomaa M E, Rady M S 1980 Heterosis and combining ability in Maize. *Egypt J Genet Cytol* **9** 225-267.

Russel W A 1976 Genetic effects and genetic effect x year interaction at three gene loci in sublines of a maize inbred line. *Can J Genet Cytol* **18** 23-33.

Widstrom N W, Bondari K, McMillion W W 1993 Heterosis among insect resistant maize populations. *Crop Sci* **33** (5) 989-994.