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Combing Ability Analysis for Quantitative Characters in Forage Maize (*Zea mays* L.)

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ABSTRACT: Combining ability for various quantitative traits *viz.*, plant height, leaf length, leaf width, number of leaves per plant, leaf: stem ratio and green fodder yield per plant was studied through (5 × 10) line × tester mating design. Highly significant gca and sca variances for most of the traits indicated that sufficient variability existed for gca effect in the parents and that for the sca effect in the crosses. Higher and significant sca variances suggested a higher non-additive gene action for these traits. Parents IC 7701 among females and MA 4207 among males were found to be the best general combiners for green fodder yield per plant. The hybrids *viz.*, IC 7701 × OM 6354, IC 130882 × GDRFG 1644, IC 130913 × OM 6357 and IC 130950 × OM 6345 were found to be the best specific crosses for green fodder yield per plant and, therefore, these crosses can be further exploited for selection of hybrids and transgressive segregants.

Keywords: Combining ability, green fodder yield, line × tester, maize, male, female, crosses.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereals of the world. It has worldwide significance as human food, animal feed and as a raw material for large number of industrial products. It is a versatile miracle crop. It is highly cross pollinated crop. Maize being a C_4 plant has the highest potential of per day carbohydrate productivity. Maize exhibits remarkable adaptability across various environments can be grown in all three seasons (winter, summer, monsoon) having high palatability fodder value (Singh *et al.*, 2015).

Combining ability analysis is used in crop plants for identifying the superior parents for obtaining superior hybrid combinations (Le *et al.*, 2020). Besides, it also helps in characterization of nature and magnitude of gene action for various characters of economic importance. The concept of general and specific combining ability is an especially useful testing procedure that involves the study and comparison of the performance of homozygous inbred lines in cross combinations (Mamatha *et al.*, 2022). The knowledge of gene action for characters helps in employing suitable breeding methodology for their improvement (Kumar *et al.*, 2023).

MATERIALS AND METHODS

The present study was conducted at the B.A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) during *rabi*-2023 season with the objective of getting information on combining ability and nature of gene action for fodder yield and its component characters in forage maize. Five lines (African Tall, IC 7701, IC 130882, IC 130913, IC 130950) were crossed with ten testers (IC 130976, IC 130987, IC 131016, MA 4207, NP96K 2415, OM 6345, OM 6354 , OM 6357, OM 6377, GDRFG 1644) in line × tester fashion. The experimental material with 50 F_1s and 15 parents (5 lines + 10 testers) was planted in RBD with three replications. Each experimental plot consisted of two rows of 4.5 m length each. The inter-row and intra- row spacing's were 30 cm and 15 cm, respectively.

For recording observations, five competitive plants were randomly selected from each treatment in each replication and the average value per plant was computed for various quantitative traits *viz.*, plant height, leaf length, leaf width, number of leaves per plant, leaf : stem ratio and green fodder yield per plant. Analysis of variance and estimation of combining ability effect were made for general combining ability to find out good general combiner parents and specific combining ability to find out best crosses as per Kempthorne (1957).

RESULT AND DISCUSSION

A General combining ability

Analysis of variance for combining ability (Table 1) revealed that the gca variances were significant for the characters *viz.*, plant height, leaf length, leaf width, number of leaves per plant, leaf : stem ratio and green fodder yield per plant. This indicates that sufficient variability exists for gca effect in the parents. This also suggests that both additive and non-additive gene actions were important for the inheritance of all the traits and all the traits used in the study could be improved by proper choice of the parents, their hybridization and by adopting suitable selection methods. The variance ratiofor general combining ability to specific combining ability (σ^2gca /σ^2sca) indicating the role of both additive and non-additive gene action in the inheritance of characters was used in present study. This study suggested that improvement of these traits could be possible by simultaneous exploitation of both additive and non- additive components. The information regarding gca effect of the parents is of prime importance as this would help in identification of suitable parents. The estimates of gca effect revealed that the female parent IC 7701 was found good general combiner for green fodder yield per plant as well as for leaf : stem ratio. Among the male parents, MA 4207 was a good general combiner for green forage yield (Table 2). Similar results for green forage yield and other characters have also been reported in maize by Parmar *et al.* (2008); Abadi *et al.* (2011).

B. Specific combining ability

Analysis of variance for combining ability (Table 1) also revealed that the sca variances were highly significant for all the characters. This indicates that sufficient variability exists for the sca effect in the crosses. This also suggests that both additive and non-additive gene actions were important for the inheritance of all the traits and all the traits used in the study could be improved by proper choice of the parents, their hybridization and by adopting suitable selection methods. The higher magnitude of sca variances were observed for all the characters. Among crosses, four hybrids *viz.*, IC 7701 × OM 6354, IC 130882 × GDRFG 1644, IC 130913 × OM 6357 and IC 130950 × OM 6345 exhibited significant positive sca effect for green forage yield per plant. Among these four hybrids, IC 130882 × GDRFG 1644 also showed significant positive sca effect for leaf width and number of leaves per plant while IC 130950 ×OM 6345 showed significant positive effect for plant height (Table 3). The results are in conformity with those obtained earlier by Sharma *et al.* (2004); Premlatha and Kalamani (2010); Sundararajan and Kumar (2011).

Table 1: Analysis of variance for combining ability for different characters.

Sources	Plantheight	Leaf length	Leaf width	No. of leaves/plant	Leaf : stem ratio	Green fodder yield/ plant
σ^2gca	**23.85***	**1.66***	**0.03***	**0.15****	**0.004****	**179.00***
σ^2sca	**106.83****	**8.04****	**0.14****	**0.47****	**0.01****	**737.35****
Error	107.76	14.55	0.19	0.34	0.01	966.62
σ^2gca/ σ^2sca	0.22	0.21	0.22	0.33	0.91	0.24

*Significant at 5 % level, **Significant at 1 % level.

Table 2: General combining ability effect of parents for different characters.

Parents	Plantheight	Leaf length	Leaf width	No. of leaves/plant	Leaf : stem ratio	Green fodder yield/plant
Lines						
African Tall	2.73	-1.88	-0.26	-0.42	**0.10****	7.79
IC 7701	-7.81	-1.43	0.04	-0.07	**0.04****	**27.60****
IC 130882	**10.65****	0.90	**0.63***	0.17	-0.01	**-15.83****
IC130913	-2.36	3.74	0.00	**-0.39****	**-0.04***	**-14.96****
IC 130950	-3.21	-1.32	-0.41	**-0.44****	**-0.09****	-4.61
gi	1.90	0.70	0.08	0.11	0.01	5.68
Testers						
IC 130976	6.43	-0.34	0.02	**0.61****	**0.08****	**-27.18****
IC 130987	**-15.99****	**-2.21***	**-0.39****	**0.59****	**0.1****	-14.72
IC 131016	7.11	1.46	**0.29***	-0.16	**-0.07****	6.16
MA 4207	5.90	0.24	**-0.34****	-0.09	0	**27.84****
NP96K 2415	2.17	-0.32	0.04	**0.64****	**0.05***	-7.03
OM 6345	-5.78	**2.14***	0.07	**-0.85****	**-0.08****	-7.82
OM 6354	1.05	0.9	0.18	-0.22	**-0.04***	11.2
OM 6357	**-11.87***	0.96	-0.14	-0.01	**-0.04***	14.4
OM 6377	3.51	-1.08	0.02	**-0.42****	**0.04***	-8.92
GDRFG 1644	7.47	-1.77	**0.23***	-0.1	**-0.04***	6.07
gj	2.68	0.99	0.11	0.15	0.02	8.03

Table 3: Specific combining ability effect of crosses for different characters.

Crosses	Plantheight	Leaf length	Leaf width	No. of leaves/plant	Leaf : stem ratio	Green fodder yield/plant
African Tall × IC 130976	6.43	0.83	-0.25	0.60	-0.03	-27.93
African Tall × IC 130987	**-15.99****	-0.17	0.23	-0.05	0.01	31.11
African Tall × IC 131016	7.11	**5.59***	0.25	0.16	0.04	27.03
African Tall × MA 4207	5.90	-0.49	**-0.52***	0.16	**0.13****	24.82
African Tall × NP96K 2415	2.17	**4.60***	**0.94****	0.56	**-0.11***	27.29
African Tall × OM 6345	-5.78	-2.79	0.07	-0.61	0.06	3.38
African Tall × OM 6354	1.05	-2.28	-0.21	0.03	0.05	**-49.15****
African Tall × OM 6357	**-11.87***	-1.75	-0.26	**-0.98****	0.00	-7.17
African Tall × OM 6377	3.51	-1.64	0.02	0.56	**-0.12****	8.97
African Tall × GDRFG 1644	7.47	-1.88	-0.26	-0.42	-0.03	**-38.35***
IC 7701 × IC 130976	11.63	**-4.72***	**-0.62***	**1.01****	**0.14****	33.76
IC 7701 × IC 130987	-6.06	-2.52	-0.28	-0.47	0.01	23.57
IC 7701 × IC 131016	4.31	0.47	0.28	0.28	**-0.09***	0.35
IC 7701 × MA 4207	**-13.23***	**4.56***	0.40	**-0.92****	**0.10***	-13.72
IC 7701 × NP96K 2415	9.10	1.25	-0.37	0.55	0.04	7.88
IC 7701 × OM 6345	-10.58	2.00	0.06	-0.63	-0.07	**-46.20***
IC 7701 × OM 6354	-7.02	0.17	0.28	**-0.72***	-0.07	**38.38***
IC 7701 × OM 6357	**20.79****	-0.50	-0.40	**1.93****	-0.03	32.92
IC 7701 × OM 6377	-6.82	0.74	**0.61***	-0.52	-0.04	**-42.90***
IC 7701 × GDRFG 1644	-2.13	-1.43	0.04	-0.51	0.02	-34.02
IC 130882 × IC 130976	**-25.02****	1.94	0.21	**-1.39****	-0.004	-21.87
IC 130882 × IC 130987	**20.35****	0.20	-0.45	0.43	-0.02	11.40
IC 130882 × IC 131016	0.19	0.20	-0.39	-0.158	-0.05	-5.85
IC 130882 × MA 4207	**16.65****	-1.52	0.33	0.58	**-0.09***	10.51
IC 130882 × NP96K 2415	-8.62	-3.62	-0.44	**-0.76***	0.04	-23.09
IC 130882 × OM 6345	-6.43	-3.61	-0.41	0.20	-0.01	16.70
IC 130882 × OM 6354	1.46	**5.43***	0.05	-0.09	0.03	-2.29
IC 130882 × OM 6357	**-12.39***	1.30	0.17	-0.17	0.00	-32.89
IC 130882 × OM 6377	**18.46****	-1.20	0.31	-0.09	0.05	5.36
IC 130882 × GDRFG 1644	-4.65	0.90	**0.63***	**1.46****	0.04	**42.04***
IC 130913 × IC 130976	**14.19***	**5.32***	-0.02	0.64	-0.06	16.60
IC 130913 × IC 130987	-3.17	0.85	-0.04	-0.08	-0.02	**-48.86****
IC 130913 × IC 131016	-3.53	-1.82	0.31	0.069	-0.03	-12.48
IC 130913 × MA 4207	-4.81	-1.80	-0.16	-0.06	**-0.13****	0.78
IC 130913 × NP96K 2415	-6.75	-4.18	-0.10	**-0.80***	**0.15****	-21.96
IC 130913 × OM 6345	6.64	**5.90****	0.46	0.50	0.05	-14.83
IC 130913 × OM 6354	1.60	-2.19	0.02	0.14	0.01	-9.66
IC 130913 × OM 6357	4.41	-3.52	0.27	-0.34	-0.01	**51.28****
IC 130913 × OM 6377	**-13.13***	-2.28	**-0.72****	-0.20	**0.09***	19.73
IC 130913 × GDRFG 1644	4.56	3.74	0.00	0.15	-0.05	19.41
IC 130950 × IC 130976	-7.23	-3.35	**0.69****	**-0.85***	-0.04	-0.56
IC 130950 × IC 130987	4.87	1.65	**0.54***	0.17	0.01	-17.22
IC 130950 × IC 131016	-8.09	**-4.42***	-0.44	-0.35	**0.13****	-9.04
IC 130950 × MA 4207	-4.50	-0.74	-0.05	0.25	-0.01	-22.38
IC 130950 × NP96K 2415	4.10	1.96	-0.02	0.45	**-0.11***	9.89
IC 130950 × OM 6345	**16.15****	-1.50	-0.19	0.54	-0.02	**40.95***
IC 130950 × OM 6354	2.91	-1.12	-0.13	0.65	-0.03	22.72
IC 130950 × OM 6357	-0.94	**4.48***	0.22	-0.43	0.04	**-44.14***
IC 130950 × OM 6377	-2.02	**4.38***	-0.21	0.25	0.02	8.84
IC 130950 × GDRFG 1644	-5.26	-1.32	-0.41	**-0.67***	0.02	10.92
Sij	5.99	2.20	0.25	0.34	0.04	17.95
Significant positive crosses	6	8	5	3	6	4
Significant negative crosses	6	2	3	8	6	6

CONCLUSIONS

The female parent IC 7701 was found good general combiner for green fodder yield per plant as well as for leaf: stem ratio while the male parent, MA 4207 was a good general combiner for green forage yield. Among crosses, four hybrids *viz.*, IC 7701 × OM 6354, IC 130882 × GDRFG 1644, IC 130913 × OM 6357 and IC 130950 × OM 6345 exhibited superior performance in terms of fodder yield.

FUTURE SCOPE

The information on general combining ability of parents can be of much help in development of synthetic variety and information on specific combining ability of hybrids helpful in development of hybrid variety.

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