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Combining Ability Analysis for Yields and Its Components in Pearl Millet (*Pennisetum glaucum* L.)

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ABSTRACT

Present investigation was carried out in Kharif 2022 to assess the magnitude than the general combining ability (GCA) effects for all the characters, indicating the preponderance of non-additive gene action for characters under study. The results indicate the presence of substantial variability in the selected materials for the study. The estimated components of variance for specific combining ability (SCA) effects were larger in magnitude than the general combining ability (GCA) effects for all the characters, indicating the preponderance of non-additive gene action for these characters. The estimates of GCA effects showed that the parents 418 R and 1358 R were good combiner for all the traits studied except number of grains/cm^2 and fodder yield/ plant, respectively. The hybrids MS- 88004 A x 418 R and MS-863 A x 260 R were found superior with high SCA effects for seven important traits including grain yield as well as fodder yield per plant. Whereas, the crosses namely; MS-98222 A x 1358 R, MS-841 A x UCC-23 R, MS-841 A x 1404 R and MS-94555 A x 268 R registered higher SCA effects for the six important economic traits, including grain yield per plant. The crosses namely; MS-98222 A x 1358 R, MS-841 A x UCC-23 R, MS-841 A x 1404 R and MS-94555 A x 268 R registered higher SCA effects for six important economic traits, including grain yield per plant. These crosses were identified as superior and can be effectively utilized for hybrid breeding program.

Key words: *Combining ability, Grain yield components, Hybrid and Pennisetum glaucum.*

Introduction

Taxonomically, *Pennisetum glaucum* (Pearl Millet) belongs to the family Poaceae, sub family Penicoideae, section Pennicillarium and possesses 2n=2x=14 chromosomes. India is the largest producer of pearl millet (*Pennisetum glaucum* L.), both in terms of area (9.1 Mha) and production (7.3 MT) with and average productivity of 840 Kg/ha (Anonymous, 2010) during in last five years (2017-2021). Nearly 50% of the millet area is under hybrids cultivars. The bajra hybrids are being developed by utilizing different cytoplasmic sources. The practical utility of these newly developed cytoplasmic male sterile sources depends on the combining ability and vigor expressed by the hybrids. Hence, the basic objective for any breeding programme is to select the parents with good combining ability to develop superior hybrids. This study aims at estimating the combining ability and understanding the nature of gene action for a set of male sterile and promising inbred lines.

Materials and Methods

Six male sterile lines and 10 inbred lines were chosen for the study. The materials were obtained from the pearl millet unit, National Agriculture Research Project, Aurangabad, Maharashtra. Among the six male sterile lines used as female parents were MS-98222 A, MS-88004 A, MS-841 A, MS-94444 A, MS-94555 A and MS-863 A. The 10 inbreds used as testers were 1553 R, UCC-23 R, 119 R, 1358 R, 260 R, 154 R, 268 R, 1404 R, 122 R and 418 R. The resultant hybrids along with their parents and standard checks RHRBH- 9808 and AHB-1666 were raised in randomized block design with two replications at Crop Research Centre, School of Agriculture, ITM University, Gwalior & Research Farm, Institute of Agricultural Sciences, Banaras Hindu University during *Kharif*, 2022. Each hybrid was accommodated in two rows with a row spacing 45 cm and plant to plant spacing 15 cm. All the recommended cultural practices were followed to raise an agronomically well managed crop. Observations were recorded on five randomly selected plants for 11 characters *viz.* days to 50% flowering, days to maturity, plant height (cm), total number of tillers, total productive tillers, 1000 grain weight, number of grains / cm^2, ear head girth, ear head length, grain yield per plant, fodder yield per plant. The general combining ability effects (GCA) of parent and specific combining ability effects (SCA) of the hybrids were worked out as suggested by Kempthorne (1957).

The analysis of variance for combining ability using line x tester mating design for all the 11 characters is furnished in Table 1. and combining ability effects for grain yields and its components of pearl millet are furnished in Table 2. The variance due to males were significant for plant height, number of grains/cm^2, ear head length, grain yield/plant and fodder yield/plant. The female variance were significant for all the characters except days to 50% flowering, number of effective tillers/plant and ear head length whereas variance due to crosses were significant for all the characters except 1000 grains wt. and number of grains/cm^2. These results indicated the presence of substantial variability in the selected materials for the study. The estimated components of variance for SCA were larger in magnitude than GCA for all the characters, indicating the predominance of non-additive gene action in control of these characters. Navaleet *et al.*, (1991) and Dhuppe *et al.,* (2006) also reported similar results.

The predominance of variance due to SCA over GCA showed that the non-additive gene action was involved in governing the inheritance of all the traits studied. The findings are in conformity with the results reported earlier for days to 50% flowering (Kandasamy, 1991 and Balakarishnan and Vijendra Das, 1996), plant height, total tillers, total productive tillers, ear length and ear girth (Karthigeyan, 1994).

The estimates of GCA effects indicated that the parents 418 R and 1358 R were good combiners for all the traits studied except number of grains/cm^2 and fodder yield/plant respectively. The parent MS-863 A and MS-88004 A were other good combiners for eight traits each. While out of 11 characters the parent MS-841 A and 1404 R were good combiner for seven and six characters respectively (Sprague and Tatum, 1942). Thus, an overview of the mean performance and GCA effects of parents revealed that the MS- 863 A, MS-88004 A, MS-841 A and testers 418 R, 1358 R and 1404 R were identified as good parents for further breeding program (Table 3).

The hybrids MS-88004 A x 418 R and MS-863 A x 260 R were found with superior desirable SCA effects for 7 important traits including grain yield as well as fodder yield per plant. The cross combinations namely MS-98222 A x 1358 R, MS-841 A x UCC-23 R, MS-841 A x 1404 R and MS-94555 A x 268 R registered desirable SCA effects for the six important economic traits, including grain yield per plant (Table 4). Based on *per se* performance of ten crosses namely MS-94555 A x 268 R, MS-841 A x 1404 R, MS-88004 A x 418 R, MS-98222 A x 1358 R, MS-841 A x UCC-23 R, MS-841 A x 1358 R, MS-863 A x UCC-23 R, MS-88004 A x 1358 R, MS-863 A x 1404 R andMS-863 A x 260 R along with desirable GCA effects of parents and significant SCA effects, these crosses were identified as superior hybrids and can be effectively utilized for hybrid breeding program.

Results and Discussion

These results indicated the presence of substantial variability in the selected materials for the study. The estimated components of variance for specific combining ability (SCA) effects were larger in magnitude than the general combining ability (GCA) effects for all the characters, indicating the preponderance of non-additive gene action for these characters. The estimates of GCA effects showed that the

parents 418 R and 1358 R were good combiner for all the traits studied except number of grains/cm^2 and fodder yield/ plant, respectively. The hybrids MS-88004 A x 418 R and MS-863 A x 260 R were found superior with high SCA effects for seven important traits including grain yield as well as fodder yield per plant. Whereas, the crosses namely MS-98222 A x 1358 R, MS-841 A x UCC-23 R, MS-841 A x 1404 R and MS-94555 A x 268 R registered higher SCA effects for six important economic traits, including grain yield per plant.

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Table 1. Analysis of Variance for Linex Tester for Yield and Yield Component Traits

Source	Mean Square											
	df	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	Total no. of Tillers	No.of effective tillers	1000 grain Wt.(g)	No.of grains/ cm^2	Ear head girth (cm)	Ear head length (cm)	Grain yield/ plant(g)	Fodder yield/ plant(g)
Lines	5	3.85**	7.53**	675.99**	0.17	0.12	4.32**	3.21*	0.11	4.00**	36.48**	34.33**
Testers	9	4.19**	1.72	157.84**	0.32	0.02	0.95	8.64**	0.17	5.94**	21.27**	94.26**
Linesx Testers	45	2.61**	2.89**	181.46**	0.33	0.06	1.74*	8.19**	0.12	5.76**	26.15**	61.80**
Error	75	1.57	1.50	15.93	0.07	0.02	0.16	1.25	0.03	0.86	2.57	4.02
GCA	-	0.6116	0.7192	100.25	0.045	0.013	0.62	1.17	0.03	1.03	6.58	13.20
SCA	-	2.06	2.78	331.07	0.50	0.080	3.17	13.89	0.1751	9.80	47.15	115.58

Note: *Significantat 5% level, **Significant at 1% level

Table 2. Analysis of Variance for Combining Ability for Yield and Yield Component Traits

Source	Mean Square											
	df	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	Total no.of Tillers	No. of effective tillers	1000 grain Wt.(g)	No. of grains/ cm^2	Ear head girth(cm)	Ear head length (cm)	Grain yield/ plant(g)	Fodder yield/ plant(g)
Replication	1	1.53	0.06	67.11**	0.03	0.01	0.57	4.16	0.016	1.09	7.21**	0.20
Males	9	1.38	1.36	275.13**	0.05	0.02	0.62	2.87*	0.07	2.66**	19.84**	66.01**
Females	5	1.54	2.68*	212.68**	2.47*	0.08	2.39*	4.95**	0.42	0.74	28.64**	8.92**
Cross	59	2.95**	3.02**	219.77**	1.40*	0.06	0.84	7.84**	0.13	5.64**	26.28**	63.15**
Error	75	1.37	1.50	15.93	0.07	0.02	0.16	1.25	0.03	0.86	2.57	4.01

Note:*Significantat 5% level,**Significant at 1% level

Table 3. Lines and Testers with high Mean and Significant GCA effects

Characters	MS-863A		MS-88004A		MS-841A		1358R		1404R		418R	
	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA
Days to 50% Flowering	50.5	-0.68*	52.5	-0.37*	52.5	0.23	50.5	-1.17**	51	0.33	49	-0.92*
Days to maturity	89.5	0.62*	90.5	-0.58	88	-0.72*	89	-0.45*	89	0.15	89	-0.40*
Plant height	201.5	0.83*	210	5.03**	201.5	-11.5**	182.5	-4.20**	212.5	4.88**	210	3.62*
Total no. of Tillers	2.70	-0.03	3.0	0.16*	3.95	0.12*	2.85	0.33**	3.20	0.18*	3.15	0.23*
No. of effective tillers	1.75	0.07*	1.60	-0.02	2.10	0.09*	1.70	0.8*	1.70	0.03	1.65	0.07*
1000 grain Wt	11.35	0.73**	9.80	0.25*	10.50	-0.14	11.25	-0.23*	11.25	-0.11	11.0	-0.22*
Number of grains/cm	21	0.41	19	0.51*	21	0.11	19	-0.74*	19	-0.41	18	-0.49
Ear head girth	2.5	0.04	2.5	0.05*	2.7	0.10*	2.6	-0.10*	2.55	-0.27**	2.55	0.13**
Ear head length	19.10	0.40*	20.70	0.42*	19.75	0.40*	22.10	0.81*	21.20	0.52*	21.25	1.25**
Grain yield/plant	36.90	1.94*	36.35	-0.59	39.75	1.45*	36.95	1.85**	35.75	1.58*	33.35	1.32*
Fodder yield/plant	54.35	-1.16*	55.50	1.27**	55.0	-0.32	50.75	-0.37	63.95	6.02**	62.10	2.65**

Note: *Significant at 5% level, **Significant at 1% level

Table 4. Hybrids with high Mean and Significant SCA effects

Characters	MS-98222 A × 1358R		MS-88004 A × 418R		MS-841 A × UCC-23R		MS-841A×1404R		MS-94555 A × 268R		MS-863 A × 260R	
	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA	Mean	SCA
Days to 50% Flowering	49.5	-1.52*	48.5	-0.63	50	-0.57	50.5	-0.48	47	-2.18**	49.5	-0.50
Days to Maturity	87	-1.42*	86	-1.58*	89	-0.12	89	-0.20	87	-2.17**	88	-0.60
Plant Height	217.5	6.25	197.5	-5.83	226.5	13.92**	202.5	3.72	222.5	-8.18*	218	7.04*
Total no. of Tillers	4.10	0.55**	3.90	0.51**	4.10	0.78**	3.95	0.66**	3.90	0.74**	3.20	0.35*
No. of effective tillers	2.20	0.35**	2.0	0.29**	1.90	0.21*	1.85	0.15*	2.25	0.49**	1.70	0.02
1000 grain Wt	10.95	-1.42**	13.0	1.90**	13.85	-0.08	11.45	0.64*	10.40	-0.05	13.15	1.74**
Number of grains/cm	18	-0.46	17	-2.51	17	-2.53*	24	2.23*	24	-3.73**	19	-0.33
Ear head girth	2.95	0.42**	2.70	0.003	3.05	0.51**	2.3	0.08	2.45	-0.34**	3.1	0.37*
Ear head length	19.75	-0.64	24.90	2.47**	20.95	0.33	24.60	4.28**	19.10	1.80*	23.35	1.52*
Grain yield/ plant	42.40	3.44*	42.15	6.11**	40.05	4.10*	43.10	5.58**	45.10	8.93**	41.0	3.20*
Fodder yield/plant	62.65	-1.39	63.75	4.70*	66.85	10.94**	56.75	3.62	54.35	1.29	69.25	9.95**

Note: *Significant at 5% level, **Significant at 1% level

Conclusion

The population under study displayed substantial variability indicating a positive selection for hybrid development. 10 cross combinations viz. MS-94555 A x 268 R, MS-841 A x 1404 R, MS-88004 A x 418 R, MS-98222 A x 1358 R, MS-841 A x UCC-23 R, MS-841 A x 1358 R, MS-863 A x UCC-23 R, MS-88004 A x 1358 R, MS-863 A x 1404 R andMS-863 A x 260 R with good GCA as well as SCA can be utilized for hybridization in a breeding program. The crosses MS-98222 A x 1358 R, MS-841 A x UCC-23 R, MS-841 A x 1404 R and MS-94555 A x 268 R are suggested to be further tested & evaluated for hybrids as there is a significant increase in yield.

Conflict of Interest

No case of conflict will be established in case any of the authors cites the materials present in this research paper. All the authors have contributed in the formation of this research manuscript.

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