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Genetic Analysis in Pearl millet Using Line x Tester Design

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ABSTRACT

Keywords

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Four cytoplasmic male sterile lines were crossed with nine restorers to develop 36 hybrids using line x tester design to study combining ability in pearl millet for twelve different characters and evaluated at main pearlmillet research station, JAU, Jamnagar in *kharif* 2018. Analysis of variance showed highly significant differences among the genotypes for all the traits. Thus, the results quantified the considerable amount of genetic diversity exist among genotypes for the different traits under study. Estimates of σ^2_{sca} were greater than the corresponding σ^2_{gca} for ear head girth, ear head weight, 1000-grain weight, dry fodder yield per plant, grain yield per plant and harvest index, indicated the preponderance of non-additive gene effects. While for rest of the characters, the ratio of $\sigma^2_{gca}/\sigma^2_{sca}$ was found greater than unity, suggested the preponderance of additive gene effects for the express of these traits. Females JMSA₄-20172 and ICMA₁-15666 and males J-2598, J-2605, 92-SB-18 and 72-SB-18 were found good general combiners for grain yield per plant and also some desirable traits. JMSA₅-20175 x J-2598 and JMSA₄-20172 x J-2591 manifested significant and high desirable sca effects for grain yield per plant (Table 5) along with significant positive sca effect for atleast one character, with involving at least one poor and one good general combiners.

Introduction

Pearl millet is a cereal crop that thrives in the arid and semi-arid tropical regions of Asia and Africa. Pearl millet grain is highly nutritive, staple food and the primary source of calories for millions of people who are inhabitants of world's driest and hottest regions of poor farmer communities. It is a highly cross-pollinated crop with protogynous

flowering and has wind borne pollination mechanism, which fulfill one of the essential biological requirements for hybrid development. Pearl millet is commonly known as bajra, cat tail millet, spiked millet and bulrush millet in different parts of the world, which is believed to be originated in Africa. The amino acid profile of pearl millet is more balanced than wheat and rice and many other cereals, and low glycemic index

(Singh *et al.*, 1999 and Sehgal *et al.*, 2004). In heterosis breeding identification and assessment of the parental combinations with respect to their general and specific combining abilities and gene actions involved in the inheritance of grain yield and various component characters are of utmost importance for a successful hybridization programme. Recognition of a potential hybrid combination through the magnitude and direction of heterotic behavior is of paramount importance. So, information on the magnitude and nature of prevalent genetic variation is essentially needed to infer about genetic potential of a particular population.

Materials and Methods

The experimental material comprising by four cytoplasmic male sterile lines (JMSA₄-20172, JMSA₅-20175, JMSA₁-20181, ICMA₁-15666), nine restorers (J-2584, J-2591, J-2598, J-2605, 52-SB-18, 72-SB-18, 92-SB-18, 120-SB-18, their resulting 36 crosses and one standard check GHB-732 were evaluated in Randomized Block Design with three replications during *kharif* 2018. Observations were recorded on 12 characters and their mean values were subjected to analysis of variance and combining ability. The crosses were made during summer 2018 at Main Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar using line x tester mating design.

Results and Discussion

Combining ability analysis

The analysis of variance showed highly significant differences among the genotypes for all the traits. Thus, the results quantified the considerable amount of genetic diversity exist among genotypes for the different traits under study due to presence of highly significant difference among genotypes. The

genotypic variance was further partitioned into different source of variances.

Mean squares due to females were significant for all the studied characters except harvest index among all the characters while, the male parents differed significantly for all the twelve characters under studied. This concluded the presence of genetic diversity in both the females and males parents included in the investigation. The males and females were completely differed from each other for days to 50 % flowering, number of nodes on main stem, ear head girth, plant height, days to maturity and dry fodder yield per plant as evident from significance of mean squares due to females vs males. The differences among parents and crosses and parents vs crosses were also found highly significant for all characters under investigation (Table 1). Similar observations were also made by Patel (2012), Mungra (2014), Acharya (2017), Katba (2017) and Badurkar *et al.*, (2018).

Indication of table 2 shows analysis of variance for combining ability for all twelve studied characters, In which mean squares due to females were significant for days to 50 % flowering, number of nodes on main stem, ear head length, ear head weight, plant height, days to maturity, dry fodder yield per plant and grain yield per plant. While, the mean squares due to males were significant for days to 50 % flowering, ear head length, plant height and days to maturity. This indicated significance contribution of both parents towards total variation due to general combining ability (gca). The mean squares due to females x males were found significant for all the characters studied except ear head length. The estimates of σ^2_{sca} were greater than the corresponding σ^2_{gca} for ear head girth, ear head weight, 1000-grain weight, dry fodder yield per plant, grain yield per plant and harvest index, these resulted in less than

unity ratio of $\sigma^2_{gca}/\sigma^2_{sca}$, indicated the preponderance of non-additive gene effects. Whereas, for the rest of the characters, the ratio of $\sigma^2_{gca}/\sigma^2_{sca}$ was found greater than unity, suggested the preponderance of additive gene effects for the express of these traits. These findings were in accordance with previous studies of Nandaniya (2016), Krishnan *et al.*, (2017), Solanki *et al.*, (2017), Badurkar *et al.*, (2018), Ladumor *et al.*, (2018) and Kumawat *et al.*, (2019).

GCA and SCA effects

The best performing parents (females and males) and cross combinations on the basis of GCA and SCA effects revealed that none of the parents was found good general combiner for all the characters which suggested breeding for these characters would be effective when material is tested over a wide range of environments. Female parent JMSA₄-20172 noticed good general combiner for grain yield per plant including good gca for number of nodes on main stem, ear head length, ear head weight, plant height and dry fodder yield per pant. Another, female parent ICMA₁-15666 was appeared to be good source of gene for grain yield per plant as well as for number of effective tillers per plant, ear head girth, ear head weight, 1000-grain weight and dry fodder yield per plant. Moreover, if we discuss about general combining of male parents, J-2598 found good combiner for grain yield was also recorded good gca effects in favorable direction for number of nodes on main stem, ear head length, ear head weight, plant height and dry fodder yield per plant. J-2605 found good combiner for plant height only other than grain yield. Likewise, parent 72-SB-18 was noted to have greater potential to transmit useful genes for grain yield per plant, days to 50 % flowering, ear head length and days to maturity. Male parent 92-SB-18 manifested good general combiner for grain yield per

plant, number of nodes on main stem, ear head girth, plant height, days to maturity and dry fodder yield per plant (Table 3). Thus, the parents were good general combiner for grain yield per plant also showed good general combining ability for one or more component traits. These findings are in concurrence with results of Jethava *et al.*, (2012), Mungra (2014), Acharya (2017), Badurkar *et al.*, (2018), Gavali *et al.*, (2018) and Kumawat *et al.*, (2019) in pearl millet. In the present investigation, among the parents, J-2598 manifested the maximum positive gca effect for the grain yield per plant followed by JMSA₄-20172 and J-2605 which can be used in further breeding programme to improve yield and it's component characters.

The estimates of sca effect revealed that none of the crosses was consistently superior for all the traits. Out of 36 crosses studied, a number of crosses showed significant sca effects in desired direction for grain yield per plant (6), days to 50% flowering (8), number of nodes on main stem (2), number of effective tillers per plant (4), ear head girth (7), ear head weight (3), plant height (4), days to maturity (5), 1000-grain weight (3), dry fodder yield per plant (1) and harvest index (1) (Table 4).

Out of five top most high yielding cross combinations, only two cross combinations *viz.*, JMSA₅-20175 x J-2598 and JMSA₄-20172 x J-2591 manifested significant and high desirable sca effects for grain yield per plant (Table 5) along with significant positive sca effect for atleast one character, with involving at least one poor and one good general combiners. Other crosses like ICMA₁-15666 x 92-SB-18, ICMA₁-15666 x J-2605 and JMSA₄-20172 x 52-SB-18 having high mean value for grain yield and having significant positive heterobeltiosis and standard heterosis involved good x good, good x good and good x average combiners, respectively.

Table.1 Analysis of variance for experimental design for different characters in pearl millet

Source	d.f.	Days to 50% flowering	Number of nodes on main stem	Number of effective tillers/plant	Ear head length (cm)	Ear head girth (cm)	Ear head weight (g)	Plant height (cm)	Day to maturity	1000-grain weight (g)	Dry fodder yield/plant (g)	Grain yield/plant (g)	Harvest index (%)
Replications	2	0.06	0.04	0.03	10.46*	0.15	15.43	97.33	5.19*	3.16*	83.21	59.57	26.03
Genotypes	48	20.44**	4.57**	0.45**	27.57**	1.40**	1765.28**	3307.08**	36.50**	8.39**	1195.71**	1030.04**	84.56**
Parents (P)	12	34.42**	3.93**	0.32**	41.48**	1.66**	367.44**	4640.19**	40.48**	7.48**	1083.22**	361.98**	65.76**
Females	3	13.19**	5.23**	0.43**	48.73**	0.64**	188.33*	7462.37**	10.53**	4.49**	957.50**	75.68*	2.58
Males	8	38.83**	1.12**	0.18*	43.85**	1.63**	478.77**	2089.70**	43.98**	9.27**	1203.35**	510.11**	97.33**
Female vs Male	1	62.83**	22.47**	1.07	0.80	5.02**	14.04	16577.52**	102.31**	2.01	499.22**	35.79	2.74
Crosses (C)	35	15.82**	3.74**	0.45**	13.24**	1.01**	686.96**	1522.01**	34.39**	5.81**	688.47**	515.49**	50.70**
P. Vs C.	1	14.33**	41.48**	2.31**	361.84**	11.74**	56280.72**	49787.59**	62.58**	109.65**	20299.18**	27056.04**	1495.50**
Error	96	0.56	0.30	0.07	2.69	0.09	63.65	78.19	1.31	1.01	91.57	27.24	15.34

*, ** Significant at 5% and 1 % levels, respectively, when tested against error mean square

Table.2 Analysis of variance for combining ability and various components for different characters in pearl millet

Source	d.f.	Days to 50% flowering	Number of nodes on main stem	Number of effective tillers/plant	Ear head length (cm)	Ear head girth (cm)	Ear head weight (g)	Plant height (cm)	Day to maturity	1000-grain weight (g)	Dry fodder yield/plant (g)	Grain yield/plant (g)	Harvest index (%)
Replications	2	0.36	0.07	0.01	8.22	0.09	6.40	62.08	5.62*	4.62*	150.22	55.86	42.00
Females	3	24.13**	20.95**	0.81	58.53**	1.82	2064.02*	7339.34**	97.71**	11.91	2797.85**	1324.75*	22.70
Males	8	45.81**	3.58	0.12	24.55**	0.54	713.39	2148.65**	73.74**	3.16	621.61	721.44	93.27
Females x Males	24	4.78**	1.63**	0.50**	3.81	1.07**	506.02**	585.95**	13.36**	5.92**	447.07**	345.68**	40.00**
Error	70	0.49	0.32	0.07	2.76	0.07	83.12	82.08	1.31	0.97	100.12	31.11	14.88
σ^2_f		0.88	0.76	0.03	2.07	0.0645	73.37	268.79	3.57	0.41	99.92	47.91	0.29
σ^2_m		3.78	0.27	0.01	1.82	0.04	52.52	172.21	6.03	0.18	43.46	57.53	6.53
σ^2_{gca}		1.77	0.61	0.20	1.97	0.06	66.96	239.07	4.33	0.34	82.54	50.87	2.21
σ^2_{sca}		1.43	0.44	0.15	0.35	0.33	140.96	167.96	4.01	1.65	115.65	104.85	8.37
$\sigma^2_{gca/\sigma^2_{sca}}$		1.24	3.20	1.39	5.66	0.17	0.47	1.42	1.08	0.20	0.71	0.49	0.26

*, ** Significant at 5% and 1 % levels, respectively, when tested against error mean square

Table.3 Estimates of general combining ability effects of parents for different characters in pearl millet

Sr. No.	Parents	Days to 50% flowering	No. of nodes on main stem	No. of effective tillers/plant	Ear head length (cm)	Ear head girth (cm)	Ear head weight (g)	Plant height (cm)	Days to maturity	1000-grain weight (g)	Dry fodder yield/plant (g)	Grain yield/plant (g)	Harvest index (%)
Females													
1	JMSA ₄ 20172	0.57**	1.13**	0.10	2.12**	-0.15*	9.33**	13.06**	0.55*	0.36	8.84**	7.43**	1.00
2	JMSA ₅ 20175	-0.32*	0.25*	-0.15*	0.90*	0.90	-4.52*	11.57**	-0.42	-0.39	-3.12	-4.33**	-1.16
3	JMSA ₁ 20181	-1.18**	-0.83**	0.14	-1.07*	-1.07*	-9.83**	-22.50**	-2.34**	-0.71**	-13.02**	-7.40	0.21
4	ICMA ₁ 15666	0.93**	-0.55**	0.19**	-0.16	-0.16	5.02*	-2.13	2.21**	0.73**	7.30**	4.30	0.37
	S.E. ±	0.13	0.11	0.05	0.32	0.05	1.75	1.74	0.22	0.19	1.92	1.07	0.74
Males													
1	J-2584	-0.72*	-0.49*	-0.08	0.13	-0.18	-5.40	-1.81	0.91*	0.42	-9.98*	-9.17**	-2.18
2	J-2591	3.03**	0.29	-0.02	0.29	-0.22*	-8.29*	12.41**	3.99**	-1.01**	-4.82	-11.61**	-5.18**
3	J-2598	2.63**	0.92**	0.15	2.00**	0.12	10.18*	20.34**	2.82**	0.40	9.87*	8.55**	1.36
4	J-2605	1.19**	0.02	-0.01	0.29	0.19	2.91	8.77*	0.74	0.18	3.28	5.17*	2.05
5	52-SB-18	-3.31**	0.32	-0.01	-1.55*	0.29*	-3.84	-11.63**	-4.34**	-0.11	-3.08	3.19	3.55*
6	72-SB-18	-1.39**	-0.26	-0.08	1.77	0.01	3.43	-8.33*	-1.76**	0.40	0.92	4.35*	2.27
7	88-SB-18	0.97**	-0.09	-0.12	-2.54**	-0.27*	-12.26**	-8.44*	-0.68	-0.65	8.50**	-9.56**	-2.53
8	92-SB-18	-0.22	0.67**	0.17	-0.45	0.21*	6.11	9.26**	-1.01*	0.40	7.67**	5.06*	0.61
9	120-SB-18	0.03	-0.76**	-0.01	0.05	-0.15	7.16*	-20.57**	0.68*	0.03	6.48*	4.02	0.07
	S.E. ±	0.20	0.16	0.08	0.48	0.08	2.63	2.61	0.33	0.28	2.89	1.61	1.11

*, ** Significant at 5% and 1% levels, respectively

Table.4 Top three crosses recorded sca effects for different characters

Characters	Crosses	Characters	Crosses	Characters	Crosses	Characters	Crosses
Days to 50% flowering	ICMA ₁ -15666 x 88-SB-18, JMSA ₄ -20172 x 52-SB-18, JMSA ₇ -20181 x J-2591	Ear head length (cm)	-	Plant height (cm)	JMSA5-20175 x 120-SB-18 ICMA1-15666 x 72-SB-18 JMSA5-20175 x J-2584	Dry fodder yield per plant (g)	JMSA ₁ -2181 x J-2605
Number of nodes on main stem	JMSA5-20175 x 120-SB-18 JMSA5-20175 x 92-SB-18	Ear head girth (cm)	JMSA1-20181 x J-2584 JMSA1-20181 x 120-SB-18 ICMA1-15666 x 88-SB-18	Days to maturity	JMSA4-20172 x J-2584 JMSA1-20181 x J-2591 JMSA1-20181 x J-2598	Grain yield per plant (g)	JMSA4-20172 x J-2591 JMSA1-20181 x J-2584 JMSA5-20175 x J-2598
Number of effective tillers/plant	JMSA5-20175 x J-2598 ICMA1-15666 x 92-SB-18 ICMA1-15666 x J-2605	Ear head weight (g)	JMSA1-20181 x J-2584 JMSA5-20175 x 88-SB-18 JMSA4-20172 x J-2591	1000-grain weight (g)	JMSA5-20175 x J-2598 JMSA4-20172 x J-2591 ICMA1-15666 x J-2605	Harvest index (%)	JMSA ₁ -20181 x J-2584

Table.5 The best five specific cross combination with their resulting sca effects for grain yield and other component characters including gca effects of their parents for grain yield per plant

Crosses	Grain yield per plant (g)	sca effect for grain yield per plant	gca effect for grain yield per plant		Heterosis (%) over Standard check (GHB-732)	Significant desirable sca effects for component traits
			Female	Male		
JMSA5-20175 x J-2598	74.17	11.03*	-4.33**	8.55**	27.43**	3, 9
ICMA ₁ -15666 x 92-SB-18	73.93	5.65	4.30*	5.06*	27.03**	3
ICMA ₁ -15666 x J-2605	72.67	4.27	4.30*	5.17*	24.86**	3,8,9
JMSA ₄ -20172 x J-2591	72.20	17.45**	7.43**	-11.61**	24.05**	3,6,9
JMSA ₄ -20172 x 52-SB-18	72.00	2.45	7.43**	3.19	23.71**	-

Where, *, ** significant at 5 % and 1 % levels, respectively
Where,

1	=	Days to 50% flowering	2	=	Number of nodes on main stem	3	=	Number of effective tillers/ plant	4	=	Ear head length (cm)
5	=	Ear head girth (cm)	6	=	Ear head weight (g)	7	=	Plant height (cm)	8	=	Days to maturity
9	=	1000-grain weight (g)	10	=	Dry fodder yield/plant (g)	11	=	Harvest index (%)			

These results are supported by Acharya (2017), Katba (2017), Solanki *et al.*, (2017), Kanfany *et al.*, (2018) and Kumawat *et al.*, (2019).

From the present inheritance studied traits, we can conclude that both additive and non-additive gene actions recorded equal importance as half of the traits governed by non-additive gene action and other half by additive gene action. From ongoing discussion, it was suggested that best two promising crosses namely JMSA₅-20175 x J-2598 and JMSA₄-20172 x J-2591 exhibited high *per se* performance, high magnitude of heterobeltiosis as well as standard heterosis, significant and positive sca effects in desired direction for grain yield per plant and some other component traits. Therefore, these two crosses could be further evaluated over years and locations to exploit for commercial cultivation or utilized in future breeding programme to obtain desirable transgressive segregants for the development of superior genotypes or inbreeds.

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