International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 8, Issue 54, 2016, pp.-2829-2835.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

ESTIMATION OF HETEROSIS FOR YIELD AND ITS RELEVANT TRAITS IN FORAGE PEARL MILLET [*Pennisetum glaucum* L. R. Br.]

KAPADIA V.N.[1*], SAIYAD M.R.[2], RAIYANI A.M.[1] AND BHALALA K.C.[1]

[1]Department of Genetics and Plant Breeding, B. A. College of Agriculture, Hadgood, Anand, 388110, Gujarat
[2]Main forage research station, Anand Agricultural University, Anand, 388110 Gujarat, India
*Corresponding Author: Email-kapadiavn77@gmail.com

Received: September 30, 2016; Revised: October 17, 2016; Accepted: October 18, 2016; Published: November 06, 2016

Abstract- The objective of this research was to investigate heterotic effects between the crosses of selected lines. The pearl millet crosses were produced by crossing ten parents in L X T mating design. The female parents JMSA-101 exhibited the highest mean green fodder yield per plant followed by ICMA-01777 and ICMA-05888. The male parent AFB-4 exhibited the highest mean green fodder yield per plant followed by MJC-2 and MJC-8. The hybrids exhibited significant and positive heterosis over check (RBC-2) for green fodder yield and the hybrid ICMA-01777 X J-2500 exhibited maximum standard heterosis for green fodder yield per plant followed by ICMA-01777 X J-2290 and ICMA-01777 X MJC-2 and large number of crosses registered heterotic effects in negative direction. Most of the crosses had different ranking in *per se* performance for different characters, which suggested that crosses exhibiting high sca effects need not necessarily register either higher mean values or high heterotic effects and *vice versa*. Therefore, while favouring a cross for further advancement, one has to consider all the above aspects independently. The hybrids ICMA-05888 X J-2500, ICMA-01777 X J-2290 and ICMA-01777 X MJC-2 recorded highest *per se* performance.

Keywords- Breeding, Standard Heterosis and *per se* performance.

Citation: Kapadia V.N., et al., (2016) Estimation of Heterosis for Yield and Its Relevant Traits in Forage Pearl Millet [*Pennisetum glaucum* L. R. Br.]. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 8, Issue 54, pp.-2829-2835.

Academic Editor / Reviewer: Dr N Sasidharan

Introduction

Pearl millet is the sixth important cereal food crop in the world and in India ranking fourth in acreage for the vast majority of poor people, mainly farmers and also an important fodder crop for livestock population in arid and semi-arid regions of the country. Pearl millet is one of the most important cereals, which is amazingly tolerant to adverse environmental conditions. It is a short day, cross pollinated, C_4 crop, warm weather plant with extra ordinary qualities of drought resistance and salt tolerance with an added advantage of very high nutritive value. Pearl millet is palatable to livestock but its nutritive value depends on variety, growing conditions, and stand management and preservation methods. Several varieties have been developed in order to enhance forage yield, palatability and digestibility. Green fodder is the cheapest source of feed for milch, beef and draft animals. Therefore, development of fodder resources of the country becomes a high priority in national programme. India inhabits 15% of the world livestock on 2% geographical area with 5.23% cultivates fodder area. Feeding accounts 60-70% of total cost of milk production. Feeding based on green fodder is cost effective, so, green fodder production must be encouraged. Only 8.4 m ha which is static since last two-three decades, so, option is vertical increase, only. The fodder production in the country is not sufficient to meet the requirements also the forages offered are mostly of poor quality. Present availability of green fodder is 462 m.t. and dry fodder is 394 m.t. contribution of crop residue, cultivated fodder and grasslands is 54,28 and 18%, respectively. At present, the country faces a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients. Pearl millet is an embodiment of unique features like allogamy, protogyny, male sterility, huge genetic variability and remarkable geographic diversity but the breeding improvement work in earlier days was neglected because it was considered to be crop of low value. The assessment of magnitude and direction of heterotic behavior also assume a great significance.

Material and Methods

The experimental material consisted of 18 parents (3 female lines *viz*., JMSA-101, ICMA-01777 and ICMA-05888 and 15 testers *viz*., MJC-2, MJC-8, BAIF BAJRA, BAJRA BAWAL, GIANT BAJRA, GFB-1, AFB-3, AFB-4, AFB-5, AFB-13, GAB-44, GAB-51, J-2290, J-2500 and SB-221 and their 45 hybrids derived by crossing in line x tester fashion at Main forage research station, Anand Agricultural University, Anand (Gujarat), during summer season of 2014. Each experimental plot consisted of two row of 3 m length each. The inter-row and intra-row spacing were 30 and 10 cm respectively. The experiment was evaluated in a randomized block design with three replications. The recommended agronomic practices were followed for raising a normal crop.

For recording observations five competitive plant were randomly selected from each replication and average value per plant was computed for 17 characters *viz.* days to 50 per cent flowering, plant height, number of tillers per plant, number of leaves per plant, leaf length, leaf width, leaf: stem ratio, stem diameter, internode length, green fodder yield per plant, dry matter content, dry matter yield per plant, crude protein content, Fe content, Mn content, Zn content and Cu content. The collected data were subjected to statistical analysis for estimates of heterotic effects and gene effects. The standard heterosis was computed as per procedure suggested [26]. In heterosis breeding programme, it is of paramount importance to evaluate available, useful and promising diverse parental lines and their cross combinations for grain yield and its attributes as well as quality characters [2, 25]. Hence, the only strategy to meet fodder requirement is to exploit crop productivity

through better high yielding varieties and efficient agronomic management.

Results

Analysis of variance for experimental design

The mean square values due to genotypes were significant for all the characters indicating existence of considerable amount of variability among genotypes. The variance due to parents and hybrids differed significantly for all the characters except leaf : stem ratio, stem diameter, dry matter content (DM %) and dry matter yield per plant for the parents and internode length for the hybrids. The variance due to parents revealed that mean squares due to females and males were significant for most of the characters, which revealed existence of sufficient variability among females as well as males [Table-1].

Table-1 *Analysis of variance (mean squares) for parents and hybrids for various traits studied*

Source	d. f.	DAF	PH	NT	NL	LL	LW	LS	SD	IL
Replications	2	0.672	44.25	5.15**	0.44	3737.50**	0.04	0.22**	2.83**	25.14
Genotypes (G)	63	72.90**	196.64**	2.47**	80.97**	60.05**	0.17**	0.15**	0.05**	16.96**
Parents (P)	17	37.06**	152.92**	2.01*	33.82**	55.28**	0.11**	0.03	0.01	36.85**
-Females (F)	2	80.33**	82.92	0.74	19.06*	16.06	0.01	0.09*	0.46**	10.14
-Males (M)	14	31.70**	165.30**	2.31**	36.18**	60.48**	0.11**	0.03	0.01	42.60**
F *vs* M	1	25.51**	119.43	0.23	30.27*	60.87	0.01	0.01	0.38**	9.69
Hybrids (H)	44	76.67**	168.74**	2.52**	100.41**	63.24**	0.18**	0.17**	0.03*	9.82
Parents *vs* Hybrids	1	58.88**	603.75**	9.85**	88.92**	2.33	0.85**	0.89**	0.01	9.11
Check *vs* Hybrids	1	1.45	1592.75**	1.55	13.17	59.78	0.11*	0.22**	0.11*	0.32
Error	126	2.11	46.78	0.95	5.22	17.99	0.02	0.02	0.02	9.19

Source	d. f.	GFY	DMC	DMY	CPC	Fe C	Mn C	Zn C	Cu C
Replications	2	33928.00**	4.29	887.00**	0.36	9592.00*	153.75*	0.06	0.05
Genotypes (G)	63	8005.33**	7.39**	366.12**	3.14**	454374.40**	1648.58**	17.24**	6.39**
Parents (P)	17	4189.56**	4.66	182.43	3.03**	440388.80**	1014.58**	11.99*	7.45**
-Females (F)	2	3673.41	4.91	220.64	1.00	21318.00**	2495.44**	16.93**	4.13**
-Males (M)	14	4562.57**	4.79	187.61	3.46**	523026.20**	805.60**	11.85*	7.85**
F *vs* M	1	0.55	2.32	33.52	0.96	121603.00**	978.53**	4.08**	8.56**
Hybrids (H)	44	9620.00**	8.13**	453.16**	2.98**	471371.40**	1857.12**	19.30**	6.09**
Parents *vs* Hybrids	1	9860.00*	27.92**	3.90	14.33**	281412.00**	2405.06**	25.327**	1.42**
Check *vs* Hybrids	1	175.85	0.27	19.80	0.97	146778.82**	2109.04**	9.93**	5.83**
Error	126	1533.85	3.99	124.03	0.33	2065.27	43.74	0.09	0.06

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

DAF= Days to 50 per cent flowering, PH= Plant height, NT= Number of tillers per plant, NL=Number of leaves per plant, LL= Leaf length, LW= Leaf width, LS= Leaf: stem ratio, SD= Stem diameter, IL= Internode length, GFY= Green fodder yield per plant, DMC= Dry matter Content, DMY= Dry matter yield per Plant, CPC= Crude protein content, Fe C= Iron Content, Mn C= Manganese Content, Zn C= Zink Content and Cu C=Copper Content.

Per se performance of parents and hybrids

The mean values of genotypes for different characters revealed that both parents and hybrids varied for all the characters, which suggested possibility of heterotic effects. Among female parents, JMSA-101 exhibited the highest mean green fodder yield per plant followed by ICMA-01777 and ICMA-05888. The female parent JMSA-101 was superior with respect to days to 50 per cent flowering, leaf width, Internode length, green fodder yield, dry matter yield per plant and Zink (Zn) content. While female lines, ICMA-01777 was found superior for plant height, number of leaves per plant, leaf length, leaf stem ratio, stem diameter, dry matter content, Iron (Fe) content, manganese (Mn) content and copper (Cu) content. ICMA-05888 had highest crude protein content [Table-2].

The mean values of males for different characters varied significantly. Among male parents AFB-4 exhibited the highest mean green fodder yield per plant and yield contributing characters followed by MJC-2 and MJC-8. The different hybrids exhibited highest mean values for different characters *viz.*, SB-221 (days to 50 % flowering, stem diameter and copper content), MJC-2 (plant height and number of tiller per plant), GFB-51 (number of leaves per plant), MJC-8 (leaf length), AFB-13 (Leaf width), AFB-3 (leaf : stem ratio, internode length), AFB-4 (Green forage yield per plant and dry matter yield per plant), GFB-1(dry matter content), AFB-5 (crude protein content), BAJRA BAWAL (iron content and zinc content) and J-2290 (manganese content).

Regarding hybrids to the also exhibited highest mean values for different characters. Among the hybrids ICMA-05888 X J-2005 exhibited maximum values for green fodder yield per plant followed by ICMA-01777 X J-2290 and ICMA-01777 X MJC-2, while the hybrid JMSA-101 X BAIF BAJRA (days to 50 percent flowering), ICMA-01777 X GIANT BAJRA (plant height and leaf width), ICMA-01777 X MJC-8 (number of tillers per plant), JMSA-101 X GIANT BAJRA (number of leaves per plant), JMSA-101 X GAB-51 (leaf length), JMSA-101 X BAJRA BAWAL (leaf : stem ratio), ICMA-01777 X J-2290 (stem diameter and iron (Fe) content), ICMA-01777 X AFB-4 (internode length), ICMA-05888 X J-2005 (green forage yield per plant), ICMA-05888 X BAJRA BAWAL (dry matter content), JMSA-101 X SB-101 (dry matter yield per plant), ICMA-05888 X AFB-5 (crude protein content), JMSA-101 X MJC-2 (manganese content), ICMA-01777 X GFB-5 (Zink content) and ICMA-01777 X BAJRA BAWAL (copper content) were found superior as per their mean performances [Table-2].

Magnitude of Standard Heterosis

Days to 50 per cent flowering: The minimum and maximum estimates of standard heterosis were -18.95 and 17.65 per cent, respectively. The cross ICMA 01777 X AFB-5 (-18.95%) had the least negative estimate of standard heterosis followed by ICMA-01777 X GAB-51 (-17.66%) and ICMA-05888 X J-2500(-16.99%), whereas, the hybrid JMSA-101 X BAIF BAJRA (17.65%) had the maximum positive standard heterosis. The results are in accordance with the result obtained [2, 7, 8, 13, 20-22,27-29] in pearl millet [Table-3].

Plant height: The estimates of standard heterosis ranged from -3.42 to 25.59 per cent. The hybrid ICMA-01777 X GIANT BAJRA (25.59%) had maximum positive estimate followed by ICMA-05888 X GFB-1 (24.10%) and ICMA-01777 X GFB-1 (23.11%), the minimum heterotic effect for standard heterosis was observed with hybrid JMSA-101 X MJC-2 (3.42%). The results are in conformity with the

estimates of which were moderate to low as reported [1-3, 7, 10, 11, 13, 15, 17-19, 23, 24, 28, 29] [Table-3].

Number of tillers per plant: The range of standard heterosis varied from -11.02 to 42.70 per cent. Hybrids ICMA-01777 X MJC-8 (42.70%), ICMA-01777 X AFB-3 (36.82%) and JMSA-101 X J-2500 (33.98%) showed maximum significant positive heterosis in desirable direction. Whereas, the cross combination ICMA-05888 X MJC-2 (-11.02%) had least estimates of standard heterosis. The results are in accordance with findings [9, 11, 13-17, 19-22, 24 and 29] in pearl millet [Table-3].

Table-2 *Top three lines, testers and hybrids with respect to their magnitude of pre se performances for various traits in forage pearl millet*

Traits	Rank	Magnitude of *per se* performances					
		Lines		Testers		Hybrids	
DAF	1st	**ICMA-05888**	**47.67**	**BAJRA BAWAL**	**48.67**	**ICMA-01777 X AFB-5**	**41.33**
	2nd	ICMA-01777	52.33	MJC—2	50.33	ICMA-01777 X AFB-5	42.00
	3rd	JMSA-101	58.00	AFB-13	51.33	ICMA-05888 X J-2500	42.33
PH	1st	**ICMA-05777**	**183.80**	**MJC-2**	**187.27**	**ICMA-01777 X GIANT BAJRA**	**185.87**
	2nd	JMSA-101	178.67	AFB-13	186.27	ICMA-05888 X GFB-1	183.67
	3rd	IVMA-05888	173.27	GFB-51	182.73	ICMA-01777 X GFB-1	182.20
NT	1st	**ICMA-10777**	**8.19**	**MJC-2**	**8.99**	**ICMA-01777 X MJC-8**	**10.36**
	2nd	JMSA-101	7.43	GFB-1	8.69	ICMA-01777 X AFB-3	9.93
	3rd	ICMA-05888	7.26	GFB-51	8.43	JMSA-101 X J-2500	9.73
NL	1st	**ICMA-01777**	**46.27**	**GFB-51**	**48.13**	**JMSA-101 X GIANT BAJRA**	**54.97**
	2nd	ICMA-05888	42.50	MJC-2	44.33	JMSA-101 X BAJRA BAWAL	54.53
	3rd	JMSA-101	41.47	AFB-4	44.07	ICMA-05888 X BAJRA BAWAL	51.80
LL	1st	**ICMA-01777**	**64.73**	**MJC-8**	**75.27**	**JMSA-101 X GAB-51**	**79.20**
	2nd	ICMA-05888	61.07	BAJRA BAAWAL	72.33	ICMA-05888 X GIANT BAJRA	71.40
	3rd	JMSA-101	60.47	GAB-44	68.47	ICMA-05888 X J-2500	71.13
LW	1st	**JMSA-101**	**2.59**	**AFB-13**	**2.92**	**ICMA-01777 X GIANT BAJRA**	**3.35**
	2nd	ICMA-05888	2.49	GFB-1	2.88	JMSA-101 X AFB-13	3.25
	3rd	ICMA-01777	2.31	GIANT BAJRA	2.76	JMSA-101 X GIANT BAJRA	3.19
LS	1st	**ICMA-01777**	**1.12**	**AFB-3**	**1.08**	**JMSA-101 X BAJRA BAWAL**	**1.98**
	2nd	JMSA-101	0.85	BIAF BAJRA	1.00	JMSA-101 X GAB-44	1.51
	3rd	ICMA-05888	0.81	MJC-2	0.99	JMSA-101 X AFB-1	1.37
SD	1st	**ICMA-05888**	**0.72**	**AFB-3**	**0.67**	**ICMA-05888 X GFB-1**	**0.67**
	2nd	JMSA-101	0.87	AFB-4	0.73	ICMA-01777 X GAB-44	0.69
	3rd	ICMA-01777	1.46	BAIF BAJRA	0.75	ICMA-05888 X GIANT BAJRA	0.72
IL	1st	**ICMA-01777**	**16.90**	**BAJRA BAWAL**	**15.83**	**ICMA-05888 X BAIF BAJRA**	**15.64**
	2nd	ICMA-05888	19.02	BAIF BAJRA	17.41	JMSA-101 X MJC-8	15.66
	3rd	JMSA-101	20.56	J-2290	17.66	ICMA-01777 X BAJRA BAWAL	15.72
GFY	1st	**JMSA-101**	**436.00**	**AFB-4**	**484.67**	**ICMA-05888 X J-2500**	**522.33**
	2nd	ICMA-01777	379.00	MJC-2	443.33	ICMA-01777 X J-2290	502.69
	3rd	ICMA-05888	372.33	MJC-8	423.67	ICMA-01777 X MJC-2	505.00
DMC	1st	**ICMA-01777**	**20.99**	**GFB-1**	**21.48**	**ICMA-05888 X BAJRA BAWAL**	**20.77**
	2nd	JMSA-101	19.31	AFB-5	20.98	JMSA-101 X SB-221	20.77
	3rd	ICMA-05888	18.47	BAIF BAJRA	20.50	ICMA-01777 X GAB-44	20.59
DMY	1st	**JMSA-101**	**84.26**	**AFB-4**	**91.40**	**JMSA-101 X SB-221**	**101.12**
	2nd	ICMA-01777	79.72	AFB5-5	84.45	ICMA-01777 X GAB-44	99.32
	3rd	ICMA-05888	67.66	MJC-2	82.29	ICMA-01777 X MJC-2	95.95
CPC	1st	**ICMA-05888**	**12.53**	**AFB-5**	**14.60**	**ICMA-05888 X AFB-5**	**15.63**
	2nd	JMSA-101	12.37	AFB-13	13.92	ICMA-01777 X GFB-1	14.47
	3rd	ICMA-01777	11.45	AFB-4	13.91	ICMA-05888 X GFB-1	14.44
Fe C	1st	**ICMA-01777**	**802.67**	**BAJRA BAWAL**	**1968.33**	**ICMA-01777 X J-2290**	**2255.00**
	2nd	ICMA-05888	743.33	AFB-3	1461.67	ICMA-01777 X BAJRA BAWAL	1832.67
	3rd	JMSA-101	636.33	GAB-51	1369.00	JMSA-101 X GAB-44	1813.33
Mn C	1st	**ICMA-01777**	**158.67**	**J-2290**	**197.67**	**JMSA-101 X MJC-2**	**209.67**
	2nd	ICMA-05888	128.67	BAJRA BAWAL	164.33	ICMA-01777 X MJC-2	196.67
	3rd	JMSA-101	101.00	GFB-1	162.00	ICMA-01777 X BAJRA BAWAL	192.33
Zn C	1st	**JMSA-101**	**9.13**	**BAJRA BAWAL**	**10.20**	**ICMA-01777 X GFB-1**	**12.13**
	2nd	ICMA-01777	8.10	AFB-3	10.00	ICMA-01777 X J-2290	11.93
	3rd	ICMA-05888	4.60	J-2500	7.43	IJMSA-101 XAFB-3	11.13
Cu C	1st	**ICMA-01777**	**6.60**	**SB-221**	**7.87**	**ICMA-01777 X BAJRA BAWAL**	**9.50**
	2nd	ICMA-05888	6.60	BAJRA BAWAL	7.40	ICMA-01777 X J-2290	7.67
	3rd	JMSA-101	4.56	GFB-1	5.77	ICMA-05888 X J-2290	7.23

Numbers of leaves per plant: The range of standard heterosis varied from -25.46 to 44.27 per cent. The hybrids JMSA-101 X GIANT BAJRA (44.27%), JMSA-101 X BAJRA BAWAL (43.13%) and ICMA-05888 X BAJRA BAWAL (35.96%) showed significant positive heterosis in desirable direction. The cross combination ICMA-05888 X SB-221 (-25.46%) noted highest negative standard heterosis. The present findings are in fidelity with reports [1, 7, 15-17] in pearl

millet [Table-3].

Leaf length: The standard heterosis for leaf length varied from -3.75 to 36.95 per cent. The hybrids were JMSA-101 X GAB-51 (36.95%), ICMA-05888 X J-2500 (23.00%) and JMSA-101 X GAB 44 (22.54%) which exhibited heights significant positive heterosis. Whereas, ICMA-01777 X AFB-5 (-3.75%) recorded highest negative standard heterosis. These results are in agreement with those reported [13-15, 17] in pearl millet [Table-3].

Leaf width: The standard heterosis varied from -14.19 to 33.42 per cent. The top three hybrids were ICMA-01777 X GIANT BAJRA (33.42%) followed by JMSA-101 X AFB-13 (29.44%), JMSA-101 X GIANT BAJRA (26.92 exhibited significant positive heterosis. Whereas, ICMA-01777 X GAB-44 (-14.19%) recorded highest negative standard heterosis. The present results are in accordance with findings [13-15, 17] in pearl millet [Table-3].

Table-3 *The hybrids with respect to their magnitude of Standard Heterosis for various traits in forage pearl millet*

Sr. No.	Hybrids	DAF	PH	NT	LP	LP	LW	LSR	SD	IL
1	**JMSA-101 x MJC-2**	5.88*	3.42	-0.46	-5.86**	2.02**	1.59**	54.29**	25.93**	-1.76**
2	**JMSA-101 x MJC-8**	16.99**	19.59**	-2.75	13.21**	8.24**	10.48**	20.81**	29.21**	-17.37**
3	**JMSA-101 x BAIF BAJRA**	17.65**	6.13	8.26	10.41**	6.86**	16.71**	61.22**	24.87**	-1.69**
4	**JMSA-101 x BAJRA BAWAL**	15.69	15.00**	9.18	43.13**	17.46**	10.08**	154.28**	45.19**	12.80**
5	**JMSA-101 x GIANT BAJRA**	0.00	15.90**	3.21	44.27**	12.62**	26.92**	72.59**	26.03**	7.37**
6	**JMSA-101-1 x GFB-1**	13.73**	21.73**	10.56	11.37**	11.70**	13.93**	76.44**	23.81**	14.74**
7	**JMSA-101 x AFB-3**	-15.03**	13.51**	3.67	-2.45**	13.78**	12.07**	40.03**	53.02**	13.56**
8	**JMSA-101 x AFB-4**	-6.54**	8.33	-0.92	14.17**	3.75**	-1.72**	72.14**	28.68**	1.46**
9	**JMSA-101 x AFB-5**	15.69**	17.25**	-3.21	18.72**	10.78**	-1.72**	75.30**	45.19**	-11.54**
10	**JMSA-101 x AFB-13**	-5.88*	20.59**	16.99	11.37**	4.78**	29.44**	43.51**	25.93**	-2.62**
11	**JMSA-101 x GAB-44**	-3.27	19.28**	7.35	-12.77**	22.54**	2.12**	93.74**	18.62**	13.79**
12	**JMSA-101 x GAB-51**	-5.88*	17.03**	25.71*	-1.49**	36.95**	6.76**	17.42**	24.34**	14.75**
13	**JMSA-101 x J-2290**	-6.54**	16.64**	10.56	-11.20**	14.93**	-11.80**	61.47**	20.11**	-10.13**
14	**JMSA-101 x J-2500**	-13.73**	16.85**	33.98**	12.34**	6.97**	-4.64**	20.19**	29.84**	-3.90**
15	**JMSA-101 x SB-221**	1.96	10.27**	23.88*	13.82**	10.26**	16.58**	-1.84**	38.84**	-2.15**
16	**ICMA-01777 x MJC-2**	-15.69**	20.50**	24.33*	-2.89**	17.00**	13.40**	9.03**	29.95**	-12.54**
17	**ICMA-01777 x MJC-8**	0.00	11.76**	42.70**	20.30**	0.17**	12.20**	6.96**	55.03**	7.37**
18	**ICMA-01777 x BAIF BAJRA**	-1.31	21.26**	14.69	3.06**	0.40**	11.14**	46.88**	15.77**	-3.25**
19	**ICMA-01777 x BAJRA BAWAL**	-7.19**	8.24	10.56	-20.91**	13.89**	-6.50**	37.67**	25.50**	-17.06**
20	**ICMA-01777 x GIANT BAJRA**	1.31	25.59**	12.86	6.30**	-0.81**	33.42**	21.63**	48.57**	-1.32**
21	**ICMA-01777 x GFB-1**	-11.76**	23.11**	6.89	-11.81**	8.88**	8.62**	5.83**	27.94**	-0.76**
22	**ICMA-01777 x AFB-3**	11.76**	10.50**	36.82**	6.56**	19.19**	7.96**	51.18**	20.11**	4.40**
23	**ICMA-01777 x AFB-4**	-7.84**	18.29**	12.40	14.09**	17.93**	11.94**	14.13**	15.98**	19.68**
24	**ICMA-01777 x AFB-5**	-18.95**	13.42**	2.75	-6.82**	-3.75**	10.48**	39.66**	35.77**	17.36**
25	**ICMA-01777 x AFB-13**	1.96	14.59**	18.37	4.99**	2.13**	16.58**	3.54**	32.38**	17.97**
26	**ICMA-01777 x GAB-44**	-3.27	14.50**	-5.05	0.09**	7.09**	-14.19**	18.20**	9.74**	18.09**
27	**ICMA-01777 x GAB-51**	-17.65**	18.02**	14.69	0.96**	16.89**	8.49**	31.60**	19.26**	5.47**
28	**ICMA-01777 x J-2290**	-11.76**	17.52**	21.12	-9.45**	9.74**	-6.37**	60.80**	104.23**	-0.23**
29	**ICMA-01777 x J-2500**	4.58*	21.58**	11.02	4.11**	14.58**	10.08**	40.47**	30.05**	-1.00**
30	**ICMA-01777 x SB-221**	-5.88*	18.24**	22.96**	7.17**	8.36**	-3.45**	48.31**	32.91**	3.87**
31	**ICMA-05888 x MJC-2**	7.84**	9.91**	-11.02	14.96**	10.78**	-1.59**	-8.55**	55.66**	0.58**
32	**ICMA-05888 x MJC-8**	-5.23*	11.71**	10.10	-0.96**	9.97**	13.40**	53.78**	29.21**	-1.83**
33	**ICMA-05888 x BAIF BAJRA**	6.54**	15.36**	4.59	-12.25**	11.47**	9.81**	21.20**	39.47**	-17.48**
34	**ICMA-05888 x BAJRA BAWAL**	0.65	15.14**	25.71*	35.96**	20.69**	7.16**	29.62**	21.27**	-6.61**
35	**ICMA-05888 x GIANT BAJRA**	3.27	18.29**	10.10	21.35**	23.46**	2.12**	34.61**	14.07**	-5.54**
36	**ICMA-05888 x GFB-1**	-6.54**	24.10**	10.10	-0.76**	10.43**	8.09**	9.95**	6.46**	1.28**
37	**ICMA-05888 x AFB-3**	2.61	17.48**	-11.02	-16.89**	-1.33**	16.84**	27.69**	57.88**	2.60**
38	**ICMA-05888 x AFB-4**	-3.27	14.59**	10.56	14.35**	19.77**	4.77**	55.11**	20.63**	2.02**
39	**ICMA-05888 x AFB-5**	12.42**	3.65	-9.64	-6.04**	8.70**	7.03**	1.84**	29.42**	9.90**
40	**ICMA-05888 x AFB-13**	-14.38**	14.46**	-5.05	15.66**	4.09**	20.69**	20.94**	52.17**	8.46**
41	**ICMA-05888 x GAB-44**	6.54**	15.77**	23.88*	12.69**	9.86**	8.62**	9.39**	27.51**	-2.15**
42	**ICMA-05888 x GAB-51**	3.27	19.37**	11.02	21.78**	18.16**	7.16**	21.55**	25.19**	-1.34**
43	**ICMA-05888 x J-2290**	1.31	13.1**	-9.18	11.72**	3.86**	-1.19**	1.87**	28.99**	1.65**
44	**ICMA-05888 x J-2500**	-16.99**	15.00**	0.00	-10.67**	23.00**	-0.27**	-2.85**	27.83**	-4.15**
45	**ICMA-05888 x SB-221**	-9.15**	21.71**	-2.30	-25.46**	8.70**	7.69**	24.07**	25.08**	6.14**
	S. E. (Sij) ±	1.19	5.61	0.79	1.86	3.42	0.12	0.12	0.10	2.49

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

DAF= Days to 50 per cent flowering, PH= Plant height, NT= Number of tillers per plant, NL=Number of leaves per plant, LL= Leaf length, LW= Leaf width, LS= Leaf: stem ratio, SD= Stem diameter, IL= Internode length

Leaf: stem ratio: The estimates of standard heterosis were ranged from -8.55 to 154.28 per cent. The top three crosses *viz*., JMSA-101 X BAJRA BAWAL (154.28%) followed by the crosses JMSA-101 X GAB-44 (93.74%) and JMSA-101 X GFB-1 (76.44%) depicted positive significant estimates, whereas ICMA-05888 X MJC-2 (-8.55%) recorded highest negative standard heterosis. The present results are in accordance with findings [15, 17] in forage pearl millet [Table-3].

Stem diameter: The minimum and maximum estimates of standard heterosis were 6.46 and 104.23 per cent, respectively. The crosses ICMA-05888 X GFB-1 (6.46%) had the least estimates of standard heterosis. Whereas, ICMA-01777 X J-2290 (104.23%) recorded highest positive standard heterosis. The results are in conformation with the findings of [13] in pearl millet observed only significant positive estimates of heterosis [15, 17] [Table-3].

Internode length: The estimates of standard heterosis ranged from-17.48 to 19.68 per cent. The crosses ICMA-05888 X BAJRA BAWAL (-17.48%) exhibited highest significant negative heterosis followed by JMSA-101 X MJC-2 (17.37%) and ICMA-01777 X BAIF BAJRA (17.06%). Whereas, ICMA-01777 X AFB-4 (19.68%) recorded highest positive standard heterosis. The result are partially in agreement with those reported [13, 15, 17, 28] in forage pearl [Table-3].

Green fodder yield per plant: Regarding heterosis over standard check, the values ranged between -32.04 to 29.40 per cent. The hybrid ICMA-05888 X J-2500 (29.40%) exhibited maximum significant estimate, followed by ICMA-01777 X J-2290 (25.10%) and ICMA-01777 X MJC-2 (24.53%) Whereas, JMSA-101 X J-2290 (-32.04%) had highest negative estimate. The results of this investigation were in agreement with those reported [3, 5, 15-17, 27] [Table-4].

Table-4 *The hybrids with respect to their magnitude of Standard Heterosis for various traits in forage pearl millet*

Sr. No.	Hybrids	GFY	DMC	DMY	CPC	Fe C	Mn C	Zn C	Cu C
1	JMSA-101 x MJC-2	1.98**	4.92**	5.45**	12.42**	28.86**	20.73**	73.37**	-24.62**
2	JMSA-101 x MJC-8	-12.30**	3.51**	-10.92**	14.94**	-8.25**	-7.29**	17.16**	0.00**
3	JMSA-101 x BAIF BAJRA	-18.00**	1.73**	-18.49**	12.64**	-30.87**	-28.02**	62.72**	-56.78**
4	JMSA-101 x BAJRA BAWAL	-28.24**	-2.58**	-31.67**	1.85**	-22.67**	-38.77**	64.50**	-59.30**
5	JMSA-101 x GIANT BAJRA	1.57**	-5.36**	-6.02**	13.25**	109.40**	-3.45**	84.62**	-41.71**
6	JMSA-101-1 x GFB-1	8.01**	-1.60**	4.20**	3.61**	-24.40**	-19.19**	97.63**	-15.08**
7	JMSA-101 x AFB-3	3.22**	-4.71**	-2.96**	4.93**	-5.47**	-3.65**	-7.69**	-26.13**
8	JMSA-101 x AFB-4	-21.30**	0.96**	-23.40**	-2.68**	-1.97**	-32.63**	82.25**	-14.07**
9	JMSA-101 x AFB-5	0.33**	0.54**	-1.23**	4.85**	24.21**	-12.09**	3.55**	-30.15**
10	JMSA-101 x AFB-13	10.98**	3.84**	12.37**	-1.61**	5.51**	-30.33**	20.12**	-13.07**
11	JMSA-101 x GAB-44	9.83**	5.18**	14.79**	11.41**	160.79**	4.41**	84.62**	-18.09**
12	JMSA-101 x GAB-51	0.33**	8.81**	7.08**	10.25**	20.90**	-17.08**	-24.85**	-15.08**
13	JMSA-101 x J-2290	-32.04**	0.67**	-33.43**	-4.39**	53.69**	-20.73**	79.88**	3.02**
14	JMSA-101 x J-2500	12.55**	-8.22**	0.91**	8.43**	44.58**	3.07**	19.53**	-7.54**
15	JMSA-101 x SB-221	20.97**	15.56**	36.62**	5.62**	34.23**	-33.40**	-55.03**	-43.72**
16	ICMA-01777 x MJC-2	24.53**	6.34**	29.63**	5.84**	99.57**	13.24**	1.18**	2.51**
17	ICMA-01777 x MJC-8	23.04**	9.74**	32.06**	-13.90**	-9.88**	-12.09**	19.53**	-26.13**
18	ICMA-01777 x BAIF BAJRA	-9.66**	2.21**	-9.36**	-2.41**	45.83**	-13.24**	2.37**	6.53**
19	ICMA-01777 x BAJRA BAWAL	-7.68**	2.32**	-7.97**	5.11**	163.57**	10.75**	79.29**	43.22**
20	ICMA-01777 x GIANT BAJRA	6.11**	6.81**	12.32**	5.27**	11.98**	-13.44**	34.32**	-42.71**
21	ICMA-01777 x GFB-1	14.20**	6.94**	19.75**	16.20**	5.94**	-19.19**	115.38**	-41.71**
22	ICMA-01777 x AFB-3	-7.18**	9.13**	-0.80**	-0.03**	2.54**	-29.56**	-35.50**	4.02**
23	ICMA-01777 x AFB-4	-4.13**	3.62**	-2.65**	3.96**	-10.88**	-15.55**	22.49**	-45.23**
24	ICMA-01777 x AFB-5	9.41**	14.34**	22.67**	7.95**	11.60**	-22.84**	-53.85**	-40.70**
25	ICMA-01777 x AFB-13	-14.62**	14.26**	-3.83**	10.63**	-4.94**	-8.83**	42.01**	-42.71**
26	ICMA-01777 x GAB-44	19.32**	14.60**	34.19**	0.24**	8.87**	-22.84**	72.19**	-11.06**
27	ICMA-01777 x GAB-51	-5.45**	1.63**	-4.95**	5.78**	136.15**	-14.20**	5.92**	-15.08**
28	ICMA-01777 x J-2290	25.10**	-8.70**	11.62**	-14.43**	224.30**	-4.22**	111.83**	15.58**
29	ICMA-01777 x J-2500	0.83**	1.93**	0.67**	-2.36**	17.79**	-21.50**	97.63**	-47.24**
30	ICMA-01777 x SB-221	1.73**	8.51**	8.22**	8.38**	10.16**	-15.74**	44.97**	-13.57**
31	ICMA-05888 x MJC-2	17.75**	-2.32**	13.16**	1.79**	3.60**	-27.83**	-17.75**	-34.17**
32	ICMA-05888 x MJC-8	0.99**	-33.98**	-35.65**	12.85**	64.19**	-26.49**	1.78**	2.51**
33	ICMA-05888 x BAIF BAJRA	2.73**	-17.51**	-16.88**	2.17**	82.26**	-9.79**	47.34**	-14.07**
34	ICMA-05888 x BAJRA BAWAL	-7.93**	15.56**	4.20**	8.81**	10.79**	-26.10**	-15.38**	-30.65**
35	ICMA-05888 x GIANT BAJRA	-20.48**	-1.35**	-23.68**	-3.94**	102.92**	-12.48**	97.04**	-28.64**
36	ICMA-05888 x GFB-1	9.99**	-0.50**	6.78**	15.98**	11.60**	-9.21**	33.73**	-46.23**
37	ICMA-05888 x AFB-3	-10.49**	8.14**	-4.96**	-8.59**	-8.39**	-28.02**	33.14**	-32.66**
38	ICMA-05888 x AFB-4	-7.76**	9.29**	-0.83**	-6.16**	-39.60**	-25.14**	12.43**	-43.72**
39	ICMA-05888 x AFB-5	4.46**	2.76**	5.24**	25.52**	30.63**	3.45**	28.40**	-29.15**
40	ICMA-05888 x AFB-13	11.73**	2.50**	12.29**	8.49**	1.10**	-32.44**	-15.38**	-30.15**
41	ICMA-05888 x GAB-44	7.68**	3.04	8.66**	7.76**	-31.02**	-31.29**	16.57**	-43.22**
42	ICMA-05888 x GAB-51	2.31**	0.30**	0.11**	-0.70**	8.96**	-33.59**	40.83**	-4.02**
43	ICMA-05888 x J-2290	4.79**	-6.62**	-3.82**	-2.65**	9.64**	-4.99**	-34.32**	9.05**
44	ICMA-05888 x J-2500	29.40**	-14.90**	8.29**	2.73**	85.43**	-32.63**	0.00**	-11.06**
45	ICMA-05888 x SB-221	7.68**	-4.99**	0.07**	12.29**	14.05**	9.60**	79.29**	-3.52**
S. E. (Sij) ±		32.11	1.64	9.15	0.47	36.90	5.20	0.25	0.19

*, ** indicate level of significance at 5 % and 1 %, respectively

GFY= Green fodder yield per plant, DMC= Dry matter Content, DMY= Dry matter yield per Plant, CPC= Crude protein content, FeC= Iron Content, MnC= Manganese Content, Zn C= Zink Content and CuC=Copper Content.

Dry matter content (DM %): The heterotic effect over check varied from -33.98 to 15.56 per cent. The highest value was observed for the cross ICMA-05888 X

BAJRA BAWAL (15.56%) followed by ICMA-01777 X AFB-5 (14.34%), ICMA-01777 X AFB-13 (14.26%), whereas, ICMA-05888 X MJC-2(-33.98%) recorded highest negative standard heterosis [15] [Table-4].

Dry matter yield per plant: The heterotic effect over check varied from -35.65 to 36.62 per cent. The highest value was observed for the cross JMSA-101 X SB-221 (36.62%) followed by ICMA-01777 X GAB-44 (34.19%) and ICMA-01777 X MJC-8 (32.06%). Whereas, ICMA-05888 X MJC-8 (-35.65%) recorded highest negative standard heterosis. The results of this investigation were in agreement with those reported [2, 4, 16] in pearl millet [Table-4].

Crude protein percent (CP %): The estimates of standard heterosis ranged from -14.43 to 25.52 per cent. The three hybrids were ICMA-05888 X AFB-5 (25.52%) followed by ICMA-01777 X GFB-1 (16.20%) and ICMA-05888 X GFB-1 (15.98%). Whereas, hybrid ICMA-01777 X J-2290 (-14.43%) manifested the least standard heterosis for this trait. The results of this investigation were in agreement with those reported [15] in pearl millet [Table-4].

Iron content (Fe): The heterotic effect over check varied from -39.60 to 224.30 per cent. The highest value was observed for the cross ICMA-01777 X J-2290 (224.30%) followed by ICMA-01777 X BAJRA BAWAL (163.57%) and JMSA-101 X GAB-44 (160.79%). Whereas, ICMA-05888 X AFB-3 (-39.60%) recorded highest negative standard heterosis [15] [Table-4].

Manganese (Mn) content: The estimates of standard heterosis ranged from - 38.77 to 20.73 per cent. The hybrid JMSA-101 X MJC-2 (20.73%) exhibited the highest estimate, followed by the crosses ICMA-01777 X MJC-2 (13.24%) and ICMA-01777 X BAJRA BAWAL (10.75%). Whereas, the hybrid JMSA-101 X BAJRA BAWAL (-38.77%) manifested least standard heterosis for this trait [15] [Table-4].

Zinc (Zn) content: The estimates of standard heterosis ranged from -55.03 to 115.58 per cent. The hybrid ICMA-01777 X GFB-1 (115.38%) exhibited the highest estimate of standard heterosis, followed by the crosses ICMA-01777 X J-2290 (111.83%) and ICMA-01777 X J2500 (97.63%). Whereas, hybrid JMSA-101 X SB-221 (-55.03%) manifested the least standard heterosis for this trait [15] [Table-4].

Copper (Cu) content: The estimates of standard heterosis ranged from -59.30 to 43.22 per cent. The hybrid ICMA-01777 X BAJRA BAWAL (43.22%) exhibited the highest estimate, followed by ICMA-01777 X J-2290 (15.58%) and ICMA-015888 X J-2290 (9.05%). Whereas, hybrid JMSA-101 X BAJRA BAWAL (-59.30%) manifested the least standard heterosis for this trait [15] [Table-4].

Discussion

The mean values of female parents JMSA-101 exhibited the highest mean green fodder yield per plant followed by ICMA-01777 and ICMA-05888. The mean values of male parents AFB-4 exhibited the highest mean green fodder yield per plant followed by MJC-2 and MJC-8. The different hybrids exhibited highest mean values for different characters *viz.,* the males SB-221 (days to 50 % flowering, stem diameter and copper content), MJC-2 (plant height and number of tiller per plant), GFB-51 (number of leaves per plant), MJC-8 (leaf length), AFB-13 (Leaf width), AFB-3 (leaf : stem ratio, internode length), AFB-4 (Green forage yield per plant and dry matter yield per plant), GFB-1(dry matter content, AFB-5 (crude protein content), BAJRA BAWAL (iron content and zinc content) and J-2290 (manganese content). The magnitude of standard heterosis varied from cross to cross and character to character. Total 30 hybrids exhibited significant and positive heterosis over check (RBC-2) for green fodder yield and the hybrid ICMA-01777 X J-2500 exhibited maximum standard heterosis for green fodder yield per plant followed by ICMA-01777 X J-2290 and ICMA-01777 X MJC-2 and large number of crosses registered heterotic effects in negative direction [Table-5].

Table-5 *Top three hybrids with respect to their magnitude of heterosis for various traits in forage pearl millet.*

Traits	Rank	Standard Heterosis		Traits	Rank	Standard Heterosis	
DAF	1st	**ICMA-01777 X -5**	**-18.95****	GFY	1st	**ICMA-05888 X J-2500**	**29.40****
	2nd	ICMA-01777 X GAB-51	-17.66**		2nd	ICMA-01777 X J-2290	25.10**
	3rd	ICMA-05888 X J-2500	-16.99**		3rd	ICMA-01777 X MJC-2	24.53
PH	1st	**ICMA-01777 X GIANT BAJRA**	**25.59****	DMC	1st	**ICMA-05888 X BAJRA BAWAL**	**15.56**
	2nd	ICMA-05888 X GFB-1	24.10**		2nd	ICMA-01777 X AFB-5	14.34
	3rd	ICMA-01777 X GFB-1	23.11**		3rd	ICMA-0588 X AFB-13	14.26
NT	1st	**ICMA-01777 X MJC-8**	**42.70****	DMY	1st	**JMSA-101 X SB-221**	**36.62****
	2nd	ICMA-01777 X AFB-3	36.82**		2nd	ICMA-01777 XGAB-44	34.19**
	3rd	JMSA-101 X J-2500	33.98**		3rd	ICMA-01777 X MJC-8	32.06**
NL	1st	**JMSA-101 X GIANT BAJRA**	**44.27****	CPC	1st	**ICMA-05888 X AFB-5**	**25.52****
	2nd	JMSA-101 X BAJRA BAWAL	43.13**		2nd	ICMA-01777 X GFB-1	16.20**
	3rd	ICMA-05888 X BAJRA BAWAL	35.96**		3rd	ICMA-05888 X GFB-1	15.98**
LL	1st	**JMSA-101 X GAB-51**	**36.95****	Fe C	1st	**ICMA-01777 X J-2290**	**224.30****
	2nd	ICMA-05888 X J-2500	23.00**		2nd	ICMA-01777 X BAJRA BAWAL	163.57**
	3rd	JMSA-101 X GFB-44	22.54**		3rd	JMSA-101 X GFB-44	160.79**
LW	1st	**ICMA-01777 X GIANT BAJRA**	**32.42****	Mn C	1st	**JMSA-101 X MJC-2**	**20.73****
	2nd	JMSA-101 X AFB-13	29.44**		2nd	ICMA-01777 X MJC-2	13.24**
	3rd	JMSA-101 X GIANT BAJRA	26.92**		3rd	ICMA-01777 X BAJRA BAWAL	10.75**
LS	1st	**JMSA-101 X BAJRA BAWAL**	**154.28****	Zn C	1st	**ICMA-01777 X GFB-1**	**115.38****
	2nd	JMSA-101 X GFB-44	93.74**		2nd	ICMA-01777 X J-2290	111.83**
	3rd	JMSA-101 X GFB-1	76.44**		3rd	ICMA-01777 X J-2500	97.63**
SD	1st	**ICMA-01777 X J-2290**	**104.23****	Cu C	1st	**ICMA-01777 X BAJRA BAWAL**	**43.22****
	2nd	ICMA-05888 X AFB-3	57.88**		2nd	ICMA-01777 X J-2290	15.58**
	3rd	ICMA-05888 X MJC-2	55.66**		3rd	ICMA-05888 X J-2290	9.05**
IL	1st	**ICMA-05888 X BAIF BAJRA**	**-17.48****				
	2nd	JMSA-101 X MJC-8	-17.37**				
	3rd	ICMA-01777 X BAJRA BAWAL	-17.06**				

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

DAF= Days to 50 per cent flowering, PH= Plant height, NT= Number of tillers per plant, NL=Number of leaves per plant, LL= Leaf length, LW= Leaf width, LS= Leaf: stem ratio, SD= Stem diameter, IL= Internode length, GFY= Green fodder yield per plant, DMC= Dry matter Content, DMY= Dry matter yield per Plant, CPC= Crude protein content, Fe C= Iron Content, Mn C= Manganese Content, Zn C= Zink Content and Cu C=Copper Content.

Conclusions

The assessment of magnitude and direction of heterotic behavior also assume a great significance.The mean values of genotypes for different characters revealed that both parents and hybrids varied for all the characters, which suggested possibility of heterotic effects. The mean values of female parent JMSA-101 and the female parent AFB-4 exhibited the highest mean green fodder yield per plant. The magnitude of standard heterosis varied from cross to cross and character to character. The hybrids exhibited significant and positive heterosis over check (RBC-2) for green fodder yield and the hybrid ICMA-01777 X J-2500 exhibited maximum standard heterosis for green fodder yield per plant and large number of crosses registered heterotic effects in negative direction. Most of the crosses had different ranking in *per se* performance for different characters, which suggested that crosses exhibiting high sca effects need not necessarily register either higher mean values or high heterotic effects and *vice versa.* Therefore, while favouring a cross for further advancement, one has to consider all the above aspects independently. The hybrids ICMA-05888 X J-2500, ICMA-01777 X J-2290 and ICMA-01777 X MJC-2 recorded highest *per se* performance. Green fodder yield per plant was influenced by non-additive gene effect and improvement could be achieved either through heterosis breeding or through recurrent selection, by way of intermating the most desirable segregants followed by selection or with the use of multiple crosses or bi-parental mating. Therefore, these parents are of immense value for simultaneous improvement of lines and testers for desirable agronomical /morphological traits in addition to heterosis breeding.

Conflict of Interest: None declared

References

[1] Borle U. M., Patil F. B. and Ugale S. D. (1992) *Journal of Maharashtra Agriculture University,* 17(1), 38-39.

[2] Chauhan G. P., Chovatiya V. P., Savaliya J. J., Mehta D. R. and Pansurya A. G. (2010) *Crop Research,* 39(1, 2 & 3), 98-102.

[3] Dangaria C. J., Chotalia J. M., Savaliya Davda B. K. and Pansuria A. G. (2009 a) *Agricultural Science Digest*, 29(4), 275-278.

[4] Devanand P. S. and Das L. D. V. (1996 a) *Agricultural Science Digest,* 16(4), 205-208.

[5] Dutt Y. and Bainiwal C. R. (2002) *Agricultural Science Digest,* 22(1), 27-29.

[6] Fonesca S. and Patterson F. L. (1968) *Crop Sc*ience, 8, 85-88.

[7] Harer P.N., Navale P.A. and Harinarayan G. (1990) *Journal of Maharashtra Agriculture University,* 15(1), 52-54.

[8] Ingale P. W., Navale P. A., Krishnakishore V. and Gandhi S. D. (1997) *Journal of Maharashtra Agriculture University*, 22(3), 352-354.

[9] Jethva A. S., Lata Raval, Madariya R. B., Mehta D. R. and Mandavia C. (2012) *Electronic Journal of Plant Breeding,* 3(3), 848-852.

[10] Joshi V. J., Ugale S. D. and Desale S. C. (2000) *Crop Research,* 19(2), 260-265.

[11] Karale M. V., Ugale S. D., Suryanvanshi and Patil B. D. (1997) *Indian Journal Agriculture Research,* 31(1), 39-42.

[12] Kempthorne O. (1957) An introduction to Genetic Statistic. John Willey and Sons. Inc., New York.

[13] Kushwah V. S. and Singh M. (1992) *Indian Journal Genetics and plant breeding,* 52 (2), 107-110.

[14] Lal S. and Singh D. (1968) *Indian Journal Genetics and plant breeding,* 28(2), 190-195.

[15] Maitry G. (2011) Heterosis and combining ability in forage pearl millet [*P. glaucum* (L). R. Br.] Submitted M. Sc. thesis to Anand Agricultural University, Anand

[16] Patel K. Y. (2005) Heteroisis and combining ability studies in Bajara [*P. glaucum* (L) R.Br.]. Published Ph. D. thesis by Anand Agricultural University, Anand.

[17] Patel K. Y., Kulkarni G. U. and Patel D. R. (2008) *Journal of Maharashtra Agriculture University*, 33 (1), 009-012.

[18] Patel V. G., Sigh A. and Kukadia M. V. (1987) *Indian Journal Agriculture Research,* 21(2), 93-100.

[19] Patil C. M., Aher R. P., Anarase S. A. and Suryawanshi N. V. (2008) *Journal of Maharashtra Agriculture University*, 33 (1), 004-006.

[20] Patil Harshal E. (2006) *Journal of Maharashtra Agriculture University*, 33 (1), 007-009.

[21] Patil P. A., Mehetre S.S. and Mahajan C. R. (1994) *Annals Agriculture Research,* 15 (1), 50-53.

[22] Pethani K. V., Atara S. D. and Monpara B. A. (2004) *Natural Journal Plant Improvement,* 6(2), 115-118.

[23] Raveendram T. S. and Appadurai R. (1984) *Indian Journal of Agriculture Science,* 54(10), 888-93.

[24] Subramaniam R. and Rathinam M. (1980a) *Madras Agricultural Journal*, 67 (9), 561-566.

[25] Turner J. H. (1953) *Agronomy Journal,* 45, 487-490.

[26] Meredith and bridge (1972) *Agronomy Journal*, 45, 487-490.

[27] Vagadiya K. J., Dhedhi K. K., Joshi H. J., Bhadelia A. S. and Vekariya H. B. (2010) *Agricultural Science Digest*, 30(3), 197-201.

[28] Vaghasiya V.D., Dangaria C.J. and Dhedhi K.K. (2009) *Agricultural Science Digest*, 29(2), 84-88.

[29] Vetriventhan M., Nirmalakumari A. and Ganapathy S. (2008) *World Journal of Agricultural Science,* 4(5), 657-660.

[30] Rakesh Kumar (2016) Fodder Production: Status, constraints, strategies *(http://www.biotecharticles.com/Agriculture-Article/Fodder-Production-Status-constraints-strategies-3563.htm.l*