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Research Article

HETEROSIS FOR GRAIN YIELD COMPONENTS IN PEARL MILLET *(PENNISETUM GLAUCUM* (L.) R. BR.)

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ABSTRACT

Objectives: To studies the extent and magnitude of heterotic effects of the hybrids over better parents and check hybrids for middle Gujarat.

Methods: The experimental material was comprised six male sterile lines, 10 restorer pollinators and two standard check hybrids. These lines and testers were crossed in line × tester factorial mating system. Thus, 16 parents, 60 crosses, and two standard checks formed the experimental material for the present study. The inflorescences to be used as a female or male were covered with the glassine paper bag before visibility of any stigma. When all stigmas have emerged, the panicle could be considered ready for cross pollination as female line, whereas for to use as male parents, inflorescence were covered with glassine paper bags prior to 2-3 days before dehiscencing pollens from anthers. Hybridization was performed in the morning from 8.00 A.M. to 10.00 A.M. by hand pollination. Fresh pollen from dehiscencing anthers, visible as yellow powder in the transparent selfing bags were collected by tapping the bagged inflorescences. The pollination was carried out by quickly removing the bag from the inflorescences of female (seed) parents, and collected pollen grains were dusted on inflorescences of seed parent plants.

Results: For grain yield highest significant positive heterobeltiosis and standard heterosis were observed in the hybrid ICMA 98444 × J 2526 and ICMA 96222 × AIB-2 respectively**.** The majority of yield and yield contributing characters had a more numbers of hybrids founds significant positive heterobeltiosis and standard heterosis under study.

Conclusion: Considering the real need of farmers, the hybrids developed in the present investigation were evaluated and selected on their standard heterosis values. The hybrids Gujarat Hybrid Bajra (GHB) 558 and GHB 538 were used as a standard hybrid. The hybrid, namely, ICMA 96222 × AIB-2 expressed high standard heterotic value for six traits of 14 traits studied including grain yield per plant.

Keywords: Heterobeltiosis, Standard heterosis, *Pennisetum glaucum*, Male sterile line.

INTRODUCTION

Pearl millet (*Pennisetum glaucum* [L.] R. Br.) is world's sixth imperative and widely grown prospective staple food cereal crop. In India, it ranks fourth in acreage next to rice, wheat and sorghum. However, in USA, Australia, and South Africa it is primarily grown as a forage crop. The pearl millet is an annual tillering diploid (2n=14) belongs to family *Poaceae* and subfamily *Paniceidae,* and alleged to be originated and domesticated in west and central Africa. It is a highly cross-pollinated crop with protogynous flowering and wind-borne pollination mechanism, which fulfills one of the essential biological requirements for the development of hybrids.

In India, it is commonly known as bajra or bajri, and is mainly grown in Rajasthan, Maharashtra, Gujarat, Haryana, Uttar Pradesh, Karnataka, and Tamil Nadu. Pearl millet occupies an area of 8.69 million ha with a production in the tune of 10.05 million metric tons and productivity of 1156 kg/ha in the country. While, in Gujarat it is grown on 1.07 million ha with a production of 1.23 million metric tons and productivity of 1250 kg/ha [1].

In arid and semi-arid regions of India and Africa, pearl millet has become the staple grain food crop due to its better adaptability and nutritive value of grains as it is a major source of calories and protein of human diet. The better nutritive value of grains appears from its protein (9-15%), fat (5%), and minerals (2-7%) content. It is also rich in vitamin A, vitamin B, thiamin, and riboflavin, and imparts substantial energy to the body with easy digestibility. Apart from grain, it also supplies good quality of dry matter in large bulk, the forage and stover at harvest are an important secondary product in low-resource agriculture for farm animals.

Pearl millet plant is highly heterozygous because of its cross-pollinating nature. The floral biology of pearl millet consent many breeding techniques to be used ranging from various types of population improvement to strict pedigree selection. The wild relatives like five stemmed grassy species *Panicum violaceum* and *Panicum miliaceum* have the greatest abrupt value to the pearl millet breeder as they have equal chromosome numbers (2n=14) as pearl millet, both are annual, intermates freely and exchange genes easily.

The breeding methods of pearl millet are fundamentally those which are largely adapted for cross-pollinated crops. Its genetic improvement has been carried out through conventional breeding procedures. For developing composites, synthetics and hybrids methods of breeding like hybridization followed by selection are important. The use of cytoplasmic genetic male sterility (CGMS) and techniques of population improvement along with modern biotechnological techniques have provided a great scope for the genetic upgrading of this crop.

The breeding and improvement work in pearl millet was under accentuated as it was believed to be a crop of low value of marginal land. Although the improvement in this crop in India was initiated as early as in 1920, the real breakthrough was made when the first, and the most widely used cytoplasmic genetic male sterile line, Tifton 23A was released which permitted the commencement of hybrid development programs in India. With the production and extensive testing of single crosses with $23A_1$, Indian breeders were able to announce the release of "HB-1" hybrid in 1965 subsequently, availability of several CGMS sources have facilitated production and release of a number of hybrids with increased drought tolerance, increased resistance to biotic stress and higher yield with greater efficiency in growth factors use [2,3].

The phenomenon of heterosis has proved to be the outstanding genetic tool in enhancing the yield of cross-pollinated species in general and pearl millet in particular. With the ease of use of CGMS system in pearl millet, exploitation of hybrid vigor on a commercial scale has become realistic and economical. In India, a factual breakthrough in pearl millet production has come with development and release of hybrids for commercial cultivation. In heterosis breeding program, it is essential to study and evaluate available useful promising diverse potential lines in their hybrid combinations for yield and yield components. Recognition of a potential hybrid combination through the magnitude and direction of heterotic behavior is of paramount importance.

In Gujarat, pearl millet is grown as a summer as well *kharif* crop, in low fertility soils of north Gujarat as rainfed crop and also in high fertility regimes of middle Gujarat under assured irrigation. By stimulating environmental conditions existing in different pearl millet growing regions of Gujarat, and evaluating different hybrid combinations in these environments, it is possible to draw plausible conclusions regarding the performance of hybrids, which will be suitable under varied environmental conditions. An extensive survey of pearl millet literature showed 35% average better parent heterosis for grain yield. Therefore, this investigation was conducted to study the extent of hybrid vigor in F_1 for grain yield and its components.

METHODS

The present study involving six male sterile lines and 10 restorer pollinators and two standard check hybrids of pearl millet were chosen for the study. These lines and testers were crossed in line × tester factorial mating system. The CGMS lines were received from Main Bajra Research Station, Junagadh Agricultural University, Jamnagar. Whereas, pollen parents were used for restorers supplied by Jamnagar Station and also from the lines maintained at Regional Research Station, Anand Agricultural University, Anand. The experimental material, consisting of 78 test entries representing 16 parents, their 60 crosses and two standard check hybrids (GHB-558 and GHB-538) was grown in randomized complete block design, replicated thrice in July, 2011 at Regional Research Station, Anand Agricultural University, Anand. The genotypes were randomized separately among the parents as well as hybrids in each replication. Each experimental unit was represented by a single row of 3.5 m length with 60 cm × 15 cm inter- and intra-row spacing. Nonexperimental extra two rows were also planted on both sides of experimental blocks to eliminate border effects. The recommended package of agronomical practices obligatory to raise good crop were followed. The observations were recorded on five randomly selected competitive plants from each replication for the traits *viz.,* plant height (cm), total number of tillers, total productive tillers, earhead length (cm), earhead girth (cm), test weight of 1000 grains (g), dry earhead weight per plant (g), grain yield per plant (g), total biomass per plant (g), stover yield per plant (g), panicle harvest index, total protein content (%) and days to 50% flowering and days to maturity on population basis. The expression of heterosis in 60 hybrids involving six lines and 10 testers was measured regarding heterobeltiosis about better parent and standard heterosis in comparison with GHB-558 and GHB-538, the hybrid as the standard.

Table 1: Mean value of grain yield and grain yield component characters of pearl millet among parent (line and testers) and their hybrids

Characters	Line	Testers	Hybrids	CD at 5 (%)
Days to 50% flowering	49.1	48.2	42.5	2.54
Days to maturity	81.9	81.4	78.6	2.48
Plant height (cm)	132.3	195.6	202.9	27.10
Total number of tillers per plant	2.3	2.5	2.6	0.60
Total productive tillers	2.2	2.5	2.6	0.55
Ear head length (cm)	15.1	19.8	19.9	2.21
Ear head girth (cm)	8.4	9.5	9.6	1.10
Dry earhead weight (g)	42.7	63.9	66.9	8.50
Grain yield per plant (g)	14.7	30.9	36.5	7.15
Test weight of 1000 grain (g)	7.506	8.799	9.256	0.52
Total biomass per plant (g)	76.5	168.4	163.6	20.46
Stover yield per plant (g)	33.7	104.5	96.9	19.30
Panicle harvest index	35.0	48.0	54.8	11.28
Total protein content (%)	10.25	10.35	10.27	0.71

RESULTS AND DISCUSSION

The analysis of variance for yield and its components traits in randomized block design revealed that the parents and their hybrids involved in this study differed significantly for all the characters. The mean values of grain yield and yield component characters of parent (lines and testers) and their hybrids are presented in Table 1. The range of heterobeltiosis and standard heterosis, as well as, number of hybrids showing significant heterosis in desirable direction is presented in Table 2.

For days to 50% flowering, 53 hybrids for heterobeltiosis recorded significant negative heterosis. Highest and significant negative heterobeltiosis and standard heterosis was observed in the cross ICMA 96222 × J 2423. None of the hybrids had observed significant and negative standard heterosis for early flowering and plant height. The results confirmed the findings Hapase *et al.* [4], Vetriventhan *et al.* [5], Aher *et al.* [6], Joshi *et al.* [7] and Karale *et al.* [8]. The hybrid combination ICMA 97111 × J 2526 (43.33%) showed the higher magnitude of significant and positive heterbeltiosis for total number of tillers. None of the hybrids had observed significant positive standard heterosis for total number of tillers. For total productive tillers per plant, 9 hybrids for heterobeltiosis and one hybrid for standard heterosis

Table 2: Range of heterosis and number of crosses showing significant heterosis in desirable direction in pearl millet

Characters	Heterosis (%) over better parent		Heterosis (%) over standard check	
	Range	Number of crosses	Range	Number of crosses
Days to 50% flowering	−19.33 to 0.68	53	−4.73 to 15.84	-
Days to maturity	−7.53 to 0.41	-	−5.42 to 3.03	-
Plant height	−5.14 to 146.72	-	−13.59 to14.25	-
Total number of tillers per plant	−34.00 to 43.33	7	−38.70 to 16.10	-
Total productive tillers	−31.67 to 36.67	9	−36.70 to 20.0	1
Ear head length	−22.62 to 28.52	8	−18.65 to 25.91	8
Ear head girth	−18.26 to 29.07	9	−17.65 to 10.78	-
Dry earhead weight	−35.75 to 46.96	19	−42.14 to 13.86	3
Grain yield per plant	−47.71 to 143.28	30	−52.49 to 39.90	11
Test weight of 1000 grain	−35.75 to 46.96	25	−42.14 to 13.86	7
Total biomass per plant	−49.80 to 68.15	12	−39.18 to 53.61	8
Stover yield per plant	−59.53 to 77.38	14	−46.97 to 64.49	10
Panicle harvest index	−32.39 to 88.57	19	−28.30 to 37.92	3
Total protein content	−11.11 to 11.07	3	−11.12 to 7.41	2

was recorded significant and positive heterosis. Highest and significant positive heterobeltiosis and standard heterosis was observed in the cross JMSA 20041 × J 2340. Total 8 hybrids showed significant positive heterobeltiosis and standard heterosis for earhead length. The highest magnitude of heterobeltiosis and standard heterosis was recorded in the hybrid ICMA 04999 × J 2490 (28.52%) and ICMA 04999 × J 2433, respectively for the trait ear head length. For earhead girth, 9 hybrids for heterobeltiosis recorded significant positive heterosis. Highest and significant positive heterobeltiosis were observed in the hybrid ICMA 04999 × J 2526. None of the hybrids had observed significant and positive standard heterosis for earhead girth. Total 19 and 3 hybrids recorded significant positive heterobeltiosis and standard heterosis for dry earhead weight, respectively. Highest significant positive heterobeltiosis and standard heterosis was observed in the cross ICMA 96222 × J 2526 (70.22%) and ICMA 97111 × J-2340 (30.88%), respectively.

Among the hybrids, 30 exhibited a significant positive heterobeltiosis and 11 for standard heterosis for the trait grain yield per plant. Highest significant positive heterobeltiosis was observed in the hybrid ICMA 98444 × J 2526 (143.28%). The hybrid ICMA 96222 × AIB-2 (39.90%) showed highest significant positive standard heterosis. Similar findings were also reported by Patil *et al.* [9], Ramamoorthi and Govindasaru [10] and Vetriventhan *et al*. [5] observed high magnitude of heterosis for grain yield. Total 25 and 7 hybrids recorded significant positive heterobeltiosis and standard heterosis for 1000 grain weight, respectively. Highest significant positive heterobeltiosis and standard heterosis was observed in the cross ICMA 96222 × J 2526 (46.96%) and ICMA 98444 × AIB 11 (13.86%), respectively. Presterl and Weltzien [11] reported the same results. For total biomass per plant and stover yield per plant highest and significant positive heterobeltiosis and standard heterosis was observed in the cross JMSA-20041 × J-2526 and ICMA-97111 × J-2340. Among the hybrids, 19 exhibited a significant positive heterobeltiosis and 11 for standard heterosis for the trait panicle harvest index. Highest significant positive heterobeltiosis was observed in the hybrid ICMA 04999 × J 2340 (88.57%). The hybrid ICMA 97111 × 236 SB (37.92%) showed highest significant positive standard heterosis.

Total 3 and 2 hybrids recorded significant positive heterobeltiosis and standard heterosis for total protein content, respectively. Highest significant positive heterobeltiosis and standard heterosis was observed in the cross JMSA-9904 × J 2340 (11.07%) and JMSA-20041 × J 2507 (7.41%) respectively.

CONCLUSION

The general expectation of the pearl millet farmers is mainly focused on newly developed high yielding hybrids than the local standard hybrids, which is grown widely. Hence, there is a compulsion need for the breeder to evaluate the newly developed hybrids with such standard hybrids for yield or any other desirable characters. So considering the real need of farmers, the hybrids developed in the present investigation were evaluated and selected on their standard heterosis values. The hybrids GHB 558 and GHB 538 was used as standard hybrid. The hybrid namely ICMA 96222 × AIB-2 expressed high standard heterotic value for six traits of 14 traits studied including grain yield per plant. The two hybrids namely ICMA 96222 × AIB-20 and ICMA 97111 × AIB-23 both expressed significantly high standard heterosis for three characters each (grain yields per plant, total productive tillers, and ear head length). The cross combination ICMA 97111 × AIB-11 was good for two important characters; earhead length and 1000 grain weight. Among 60 hybrids studied, five hybrids namely ICMA 96222 × AIB-2, ICMA 96222 × AIB-20, ICMA 97111 × AIB-23, JMSA 20041 × J 2526 and ICMA 97111 × AIB-11 were selected as best hybrids since they expressed high-standard heterosis over best standard hybrid (GHB-558) for many of the traits studied for high-grain yield.

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