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ESTIMATION OF HETEROSIS FOR YIELD AND YIELD RELATED COMPONENTS USING DIVERSE TESTERS IN PEARL MILLET [PENNISETUM GLAUCUM (L.) R. BR.]

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ABSTRACT Experiment comprised of twenty six female type parents and seven restorer parents of pearl millet and their 182 hybrids was conducted at two locations viz., ICRISAT, Patancheru (Latitude 17.52° N; Longitude 78.26° E and Altitude 522 m) and research farm of Super seeds Pvt Ltd., Hisar (Latitude 29.15° N; Longitude 75.72° E and Altitude 215 m) during rainy 2018, for studying the extent of hybrid vigour in F1 for grain yield and its components. For days to 50% flowering, top cross hybrid MBL-5 X MOPT-31 (-13.37**) showed highest significant and positive heterosis over check 86M86. The top cross hybrid MBL-17 X MOPT-33 (45.21**) highest, significant standard heterosis in positive direction over check 86M86 for panicle length (cm). The single cross hybrid MBL-3 X MIT-29 (14.12*) exhibited significant and positive standard heterosis over 86M86 for panicle girth (cm). for productive tillers, single cross hybrid MBL-8 X MIT-28 (98.34**) showed highest significant positive standard heterosis over check 86M86 and the single cross hybrid MBL-24 X MIT-28 (18.42) showed positive standard heterosis over check 86M86.

KEYWORDS : Heterosis, Standard heterosis, testers, grain yield

INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is an important cereal crop for arid and semi-arid regions of India and several African countries. Being a C4 crop with climate-resilient attributes allows pearl millet to grow not only in the harshest conditions including soils with low moisture, high pH, high salinity, low fertility and high Al^{3+} saturation, but also in regions prone to frequent drought with low rainfall (annual average rainfall <250 mm) and high temperature, where other cereals fail to survive and produce grain.[1] Pearl millet is the most widely grown drought tolerant warm season coarse grain cereal grown on 26 million ha in some of the harshest semi-arid tropical environments of south Asia and sub-Sahara Africa (AICPMIP site). It occupies an area of 6.93 million ha with an average production of 8.61 million tones and productivity of 1243 kg/ha during 2018-19 (Directorate of Millets Development, 2020; Project Coordinator Review, 2020). As a highly cross-pollinating crop, heterosis was exploited by the development of a commercially viable cytoplasmic male-sterility (CMS) system involving a three-lines breeding system (A-, B- and R-lines). In cereals, particularly in pearl millet, heterosis has been exploited very well, with the development of many single-cross hybrids that revolutionized the yield and productivity enhancements. Effective deployment of hybrids in India led to the remarkable improvement in pearl millet productivity from 305 kg ha^{-1} in the 1950s to the present production of 1132 kg ha^{-1}.[2] The utility of other CMS sources in hybrid production has been very poor, due to the unavailability of suitable restorer lines. Several studies have reported that, among the various existing CMS sources, A_4 and A_5 have been found to be highly stable, along with the A_1 source. However, suitable restorers are very poorly available in these sources.[3] Hence, for the development of suitable restorer lines, three different CMS A_1, A_4 and A_5 sources have been used. In one study, moderate to incomplete fertility restoration in both A_4 and A_5 CMS sources was clearly observed. A_4 cytoplasm had higher (16% to 52%) fertility restoration than the A_5 (20%) cytoplasm.[4]

Considering the importance of the crop and above facts, the present investigation was conducted to study the extent of hybrid vigour in F_1 for grain yield and its components using different type of testers.

MATERIAL AND METHODS

Material in the present study involves twenty six pearl millet parents used as females and seven restorer parents used as Males, among these three were inbred restorers and four were open pollinated varieties. The materials were obtained from the ICRISAT, Patancheru, India. The twenty six female parents were designated as MBL-1 to MBL-26 (MBL-Millet B Line) and Males were designated as MIT-27 to MIT-29 (MIT - Millet inbred testers) and MOPT-30 to MOPT-33 (MOPT-Millet Open Pollinated Tester).

The parents (33), F_1 hybrids (182) generated in line x tester design and the standard checks 9444, 86M86 (Private popular hybrids), HHB 67 Imp, ICMH 1301 and ICMH 356 (ICRISAT popular hybrids) were evaluated in Alpha lattice design during *Kharif* 2018 at two locations one is at ICRISAT, Patancheru and second at research farm of Super seeds Pvt Ltd., Hisar, to get the heterosis of the hybrids for yield and yield components. Each entry accommodated in two rows and two replications, with 15 cm plant to plant spacing, whereas, 75 cm and 60 cm row to row spacing at ICRISAT (Latitude 17.52° N; Longitude 78.26° E and Altitude 522 m) and Hisar (Latitude 29.15° N; Longitude 75.72° E and Altitude 215 m), respectively.

The observations were recorded on five random plants for each replication for five traits viz., days to 50% flowering, panicle length (cm), panicle girth (cm) and productive tillers, grain yield (kg/ha). The expressions of heterosis in 182 hybrids were measured in terms of standard heterosis in comparison with 86M86 because this is commercial popular hybrid of private organization. But we were planted other popular hybrids as well for comparison.

RESULTS

Analyses of variances for all the studied traits, i.e., days to 50% flowering, panicle length, panicle girth, number of productive tillers and grain yield are presented in table 1. Results revealed that variance due to locations were highly significant for all the studied traits except for number of productive tillers. Variances due to hybrids were highly significant for all the studied traits, indicating the wide diversity between the parental materials used in the present study and the hybrids were sufficiently different from each other for the studied traits. Variance due to lines, testers and interaction effects of lines and testers were significant for all studied traits. The significant variance of line x tester interaction indicated the importance of specific combing ability. The mean squares due to testers were of a larger magnitude than those of lines and line x tester interaction for all the characters indicating greater diversity among the testers than the lines. Mean squares due to line x tester interactions were significant for all studied traits suggested that inbred lines may have different combining ability patterns and performed differently in crosses depending on type of tester used. The interactions between hybrids and locations was significant for all studied traits except for panicle girth indicating that test crosses presented differential performance in the testing locations. The location x line interactions were significant for day to 50% bloom, panicle length and grain yield. location x tester interactions were significant for days to 50% bloom and panicle girth indicated that inbred lines performed differently as reflected in their respective test crosses from one location to another. The interactions for location x line x tester were significant only for number of productive tillers. These findings indicated that there are different ranks of interaction of inbred lines (parental) in their crosses from one location to another that appeared in number of productive tillers (Table 1). The range of standard heterosis as well as number hybrids showing significant heterosis in desirable direction is presented in Table 2.

For days to 50% flowering, heterosis percent ranges from -13.37 to 26.97. Sixty six hybrids recorded negative heterosis. Whereas, 12 hybrids recorded significant negative heterosis over check 86M86. While two hybrids, top cross hybrid MBL-5 X MOPT-31 (-13.37**) and single cross hybrid MBL-19 X MIT-27 (-9.6*) showed highest significant heterosis towards negative direction over the check 86M86 (Table 2). These results are in agreement with earlier findings.[5,6,and7]

For panicle length (cm), 81 hybrids recorded heterosis over check, among these 12 top cross hybrids and two single cross hybrids showed significant heterosis in positive direction. Whereas, top cross hybrid MBL-17 X MOPT-33 (45.21**) and single cross hybrid MBL-17 X MIT-29 (16.71*) showed highest significant and positive heterosis for this trait over commercial check 86M86. This indicates that heterosis for this trait commercially can be exploited. Also, 6 hybrids among 12 significant positive hybrids, had MBL-17 common parent from female side and MOPT-33 from Male side, this indicates these two parents are very good donors for this trait and can be exploited for further line development program. They can also be improved for combining ability and used as base parental populations to derive superior inbreds for hybrid breeding, following reciprocal recurrent selection.[8] Range of heterosis for this trait ranges from -28.09 to 45.21 (Table 2). They can also be improved for combining ability and used as base parental populations to derive superior inbreds for hybrid breeding, following reciprocal recurrent selection.

For panicle girth (cm), 42 hybrids showed positive heterosis, while 140 hybrids showed negative heterosis. Only one hybrid MBL-3 X MIT-29 (14.12*) showed significant heterosis in positive direction over commercial check 86M86. The range of heterosis ranges from -24.84 to 14.12 (Table 2). Many earlier researchers have also obtained the similar results.[9and10]

For productive tillers, range of heterosis varies from -35.39 to 98.34. Sixty nine hybrids were recorded positive heterosis. Whereas, 113 hybrids were recorded negative heterosis. However, eight hybrids were recorded significant heterosis in positive direction. Among these, single cross hybrid MBL-8 X MIT-28 (98.34**) recorded highest significant and positive heterosis over check 86M86 (Table 2). In all 8 hybrids, Male parent MIT-28 found common this means that, this parent is donor for this trait. So, we can exploit MIT-28 Male in our further restorer development program as well as for development of high tillering hybrids.

For grain yield (kg/ha), heterosis ranges from -36.67 to 18.42. Four hybrids were recorded positive heterosis and 178 hybrids showed negative heterosis over check 86M86. None of the hybrid found significantly positive for grain yield over commercial check 86M86 (Table 2). We can use these 4 single hybrids for further improvement. None of the top cross hybrid showed positive heterosis for grain yield, this reveals that inbreds are best parents for exploitation of heterosis for grain yield.

DISCUSSION

The general expectation of the pearl millet researchers and farmers is mainly focused on level of superiority of newly released hybrids than the local standard hybrids, which is grown widely. So 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. Also, breeder need the effective tester which will identify good number of inbred lines as well as specific combination to directly promote that combination for commercial release. With this point of views the hybrids generated in the present investigation were evaluated and selected on their standard heterosis values over popular commercial check 86M86. Top ten hybrids were ranked for pooled mean grain yield over comer check 86M86 are presented in table 3. Hybrid MBL-24 X MIT-28 exhibited 28 percent more yield than the commercial check 86M86. This reveals that we can directly use this hybrid for commercial release. Among top ten hybrids 9 were single crosses while only one top cross hybrid MBL-4 X MOPT-31 ranked fifth over commercial check. This result showed that more number of single cross hybrids out yielded over commercial check 86M86 (Table 3). So, this may be the reason that breeder mostly prefer inbred tester than the open pollinated variety as a tester. More number of top cross hybrids exhibited significant positive heterosis for days to 50% flowering and panicle length reveals that we can use open pollinated varieties as tester for improvement of these traits. At the end among 150 hybrids studied, four hybrids namely MBL-24 X MIT-28 (18.42), MBL-9 X MIT-28 (4.48), MBL-14 X MIT-28 (2.41) and MBL-26 X MIT-28 (1.46) were selected as best crosses since they expressed high standard heterosis over standard hybrid (86M86) for number of productive tillers and high grain yield.

CONCLUSION

Present study concluded that single crosses were exhibited high heterosis than top crosses for grain yield. Ultimately means that inbred testers are better for development of commercial hybrids and open pollinated varieties for improvement of yield related traits and identification of good combiners.

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Author Contributions

MB planned the experiments, interpreted the results, made the write up, SWB guided for research, and SWB approved the research and MB made illustrations.

* and ** indicate insignificant, significant at 0.05 and 0.01 probability levels, respectively.

Table 1. Analysis of variance for combining ability effects of different traits in pearl millet

Sources	DF	Days to 50% flowering	Panicle length (cm)	Panicle girth (cm)	Number of productive tillers	Grain yield (kg/ha)
Loc	1	1972.79**	125.5**	40.86**	1.14	53.4**
Rep(LOC)	2	30.54**	26.27**	1.12	28.78**	18.96**
TRT	186	9.54**	8.1**	6.5**	4.22**	3.05**
Hybrids	181	8.39**	7.91**	5.95**	3.74**	2.7**
Checks	4	23.4**	7.81**	28.54**	18.95**	19.26**
Hybrids vs Checks	1	161.04**	44.56**	21.1**	32.63**	0.51
Hybrid-Line	25	18.43**	13.68**	6.11**	2.61**	3.62**
Hybrid-Testers	6	21.4**	39.77**	43.68**	49.14**	7.95**
Hybrid-Line*Tester	150	2.05**	1.96**	1.89**	1.32*	1.66**
Loc*TRT	186	2.23**	1.48**	1.17	1.32*	1.95**
Loc*Hybrids	181	2.26**	1.42**	1.17	1.36**	1.83**
Loc*Checks	4	1.43	0.21NS	0.71	0.07	3.3*
Loc*(Hybrids vs Checks)	1	0.04	17.67**	2.44	0	15.55**
Hybrid-Loc*Line	25	8.18**	1.84*	0.99	1.44	4.39**
Hybrid-Loc*Tester	6	8.96**	2NS	5.93**	1.09	1.76
Hybrid-Loc*Line*Tester	150	1.01	1.23NS	1	1.27*	1.23
GCA variance		2.81	3.42	0.04	0.01	51471.47
SCA variance		1.25	1.07	0.01	0.00	70595.00

Table 2: Topmost crosses showing significant level of heterosis with respective direction and their ranges for 5 different traits in pearl millet

Traits	Crosses with desired heterosis	Positive (Nos)	Negative (Nos)	Heterosis range %
Days to 50% flowering	MBL-5 X MOPT-31 (-13.37**) MBL-12 X MOPT-32 (-12.1**) MBL-15 X MOPT-30 (-11.59*) MBL-19 X MOPT-30 (-10.85*) MBL-1 X MOPT-31 (-10.07*) MBL-4 X MOPT-33 (9.99*) MBL-15 X MOPT-32 (-9.9*) MBL-13 X MOPT-32 (-9.85*) MBL-19 X MIT-27 (-9.6*) MBL-15 X MOPT-33 (-9.22*) MBL-21 X MOPT-30 (-9.17*) MBL-25 X MOPT-31 (-9.1*)	116	66	-13.37 to 26.97
Panicle length (cm)	MBL-17 X MOPT-33 (45.21**) MBL-17 X MOPT-32 (31.07**) MBL-17 X MOPT-31 (30.75**) MBL-5 X MOPT-33 (28.65**) MBL-10 X MOPT-33 (23.42**) MBL-7 X MOPT-33 (22.22**) MBL-4 X MOPT-32 (21.78**) MBL-22 X MOPT-33 (21.67**) MBL-24 X MOPT-32 (19.57*) MBL-18 X MOPT-33 (18.81*) MBL-8 X MOPT-32 (18.17*) MBL-17 X MIT-29 (16.71*) MBL-17 X MIT-27 (16.7*) MBL-17 X MOPT-30 (16.44*)	81	101	-28.09 to 45.21
Panicle girth (cm)	MBL-3 X MIT-29 (14.12*)	42	140	-24.84 to 14.12
Productive tillers	MBL-8 X MIT-28 (98.34**) MBL-9 X MIT-28 (94.31**) MBL-5 X MIT-28 (59.31*) MBL-21 X MIT-28 (55*) MBL-15 X MIT-28 (54.05*) MBL-14 X MIT-28 (53.5*) MBL-26 X MIT-28 (52.59*) MBL-3 X MIT-28 (51.29*)	69	113	-35.39 to 98.34
Grain yield (kg/ha)	MBL-24 X MIT-28 (18.42) MBL-9 X MIT-28 (4.48) MBL-14 X MIT-28 (2.41) MBL-26 X MIT-28 (1.46)	4	178	-39.67 to 18.42

Table 3: Ranks And Commonality Of Top Ten Hybrids Across The Locations For Grain Yield During Rainy 2018

Top 10 hybrids	Rank	Pooled GY(kg/ha)	%Over 86M86
MBL-24 X MIT-28	1	7434.2	29
MBL-9 X MIT-28	2	6429.2	18
MBL-14 X MIT-28	3	6254.3	15
MBL-26 X MIT-28	4	6243.2	15
MBL-4 X MOPT-31	5	6064.8	13
MBL-4 X MIT-27	6	6053.0	13
MBL-10 X MIT-28	7	5993.8	12
MBL-11 X MIT-28	8	5845.9	9
MBL-16 X MIT-28	9	5836.5	9
MBL-4 X MIT-28	10	5836.4	9
Check-86M86	31	5295.0	

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