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RESEARCH ARTICLE

Potential of Gynoecious Line in Generating Superior Heterotic Hybrids in Bitter Gourd (*Momordica charantia* L.)

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An experiment was designed to find out the extent of heterosis in bitter gourd using gynoecious line, KAU-MCGy-101 and three monoecious lines *viz*., Preethi, Priyanka, and MC133. Hybrids were generated by both direct and reciprocal crosses. All the hybrids exhibited earliness in terms of days to first female flower opening, node bearing first female flower, and days to first harvest. The hybrid KAU-MCGy-101 × Priyanka exhibited significantly higher heterosis with regard to heterobeltiosis (-16.03 %) and standard heterosis (-18.63 %) for days to first female flower opening. All the six hybrids manifested significant standard heterosis for sex ratio in the desirable negative direction, ranged from 44.25 to -55.52 %. The highest yield was recorded in the hybrid KAU-MCGy-101 × Priyanka (22.88 t/ha) and was followed by KAU-MCGy-101 × Preethi (20.42 t/ha) and KAU-MCGy-101 × MC 133 (20.05 t/ha). Heterobeltiosis for yield (t/ha) varied from 14.72 to 57.85 % and the standard heterosis ranged between 37.59 to 89.31 %.The best performing hybrids were KAU-MCGy-101 × Preethi, KAU-MCGy-101 × Priyanka, and KAU-MCGy-101 × MC 133 with respect toearliness, number of fruits per plant, and yield. Thus, the superiority of hybrids having gynoecious line as a maternal parent is prominent in the present study.

Key Words: Gynoecious hybrids, Heterobeltiosis, *Momordica charantia*, Standard heterosis, Yield

Introduction

Bitter gourd (*Momordica charantia* L., 2n=22) is an economically important cucurbitaceous vegetable known for its immense medicinal properties. This vegetable with a bitter taste is popular and grown extensively in India, China, Japan, South East Asia, Tropical Africa and South America. Bitter gourd shows variation in fruit size, color, surface texture, and edible maturity throughout the cultivated area (Robinson and Decker-Walters, 1999). A region-specific variation in consumer preference is observed for fruit color, shape, and size (Dey *et al*., 2008).

Bitter gourd is predominantly a monoecious crop with cross-pollination as a rule. Hence heterosis is well exploited for early harvest, higher yield and other agronomic traits (Alhariri *et al.*, 2018). The development of hybrids in the bitter gourd is labor-intensive because of hand pollination. But the reports on gynoecious bitter gourd lines give scope for less expensive hybrid seed production (Behera, 2004; Dey *et al.*, 2010). Gynoecy is a condition where all the flowering nodes produce only female flowers (Airina *et al*., 2013). Hence open pollinated seeds in the gynoecious parent will be F_1 hybrids and hybrid seed production becomes more economical by reducing the cost of male flower pinching and hand pollination (Behera *et al*., 2009). Inheritance of gynoecy has been well documented in cucumber and is commercially employed for hybrid seed production (Kumar and Singh, 2004). In bitter gourd, gynoecism is under the control of a single recessive gene (Ram *et al*., 2006). Though the utilization of gynoecious lines for crop improvement programs is limited in bitter gourd, it is having immense potential (Ram *et al*., 2002). The succeeding generations using gynoecious line as a maternal parent exhibited a very high percentage of pistillate flowers with high yield potential both in cucumber as well as bitter gourd. (Dey *et al*., 2010; Shukla *et al*., 2014; Kumari *et al*., 2021). A highly stable

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bitter gourd gynoecious line, KAU-MCGy-101 was identified from Kerala Agricultural University (Minnu Ann, 2019) which can be efficiently utilized for crop improvement programs. Scientific literature pertaining to the use of gynoecious lines for heterosis breeding in bitter gourd are very scarce (Behera *et al*., 2009; Dey*et al*., 2012; Alhariri *et al*., 2018). Hence, the present experiment was formulated to investigate the scope of heterosis breeding exploiting gynoecious line in bitter gourd.

Materials and Methods

Development of F_1 hybrids

The work was undertaken in the experimental field of the Department of Vegetable Science, College of Agriculture (COA), Vellanikkara, Kerala Agricultural University (KAU), Thrissur, during the period of 2019-2020. Gynoecious line KAU-MCGy-101, identified from the Department of Vegetable Science, COA, KAU, and three monoecious lines *viz*., Preethi, Priyanka, and MC 133 were used for the hybridization. Preethi and Priyanka are the two promising varieties with high yield and light green fruits, which were released from KAU. MC 133 is a high yielding inbred line with white fruits. Ten plants per genotype were maintained in the crossing block, following recommended cultivation practices (KAU, 2016). Six hybrids were developed by crossing KAU-MCGy-101 with Preethi, Priyanka, and MC 133. KAU-MCGy-101 was used as both male and female parents. Hermaphrodite flowers induced in KAU-MCGy-101 by spraying 200 ppm silver thiosulphate solution after the first female flower emergence (Minnu Ann, 2019), which were used as a pollen source in the crosses involving KAU-MCGy-101 as a male parent.

Evaluation of parents and F_1 hybrids

The six hybrids along with the four parents were evaluated in Randomized Block Design with three replications. Preethi was considered as the standard variety. Observations such as days to first female flower opening, node bearing first female flower, sex ratio, number of seeds, number of harvests, fruit length (cm), fruit girth (cm), fruit weight (g), days to the first harvest, number of fruits per plant and yield (t/ha) were taken from five randomly selected plants from each replication. Analysis of variance was done for all characters using GRAPES **(**Gopinath *et al*., 2020). Genetic parameters *viz*., heterobeltiosis (HB%) and standard heterosis (SH%) were calculated as the deviation of the mean performance of hybrids from their better parent and standard variety as proposed by Briggle (1963) and Hayes *et al*. (1965).

Results and Discussion

Mean performance

Significant differences were observed among the parental lines and their hybrids for all the characters interpreted. The range of mean values of different traits observed in the parents and hybrids are depicted in Table 1.Considerable variations were observed among the parents and hybrids for the traits determining the earliness of a variety/hybrid. Comparing with the monoecious parents, the gynoecious parent, KAU-MCGy-101 exhibited earliness in terms of minimum days to first female flower opening (32.28), lowest node number bearing first female flower (13.89) and minimum days to first harvest (52.61). Among the monoecious parents, Priyanka was found superior for the traits attributing earliness such as, minimum days to first female flower opening (34.67), lowest node number bearing first female flower (19.67) while, the minimum days to first harvest was observed in Preethi (61.44). the earliness of the gynoecious bitter gourd lines in comparison to the monoecious lines was also reported by Behera *et al*. (2009) and Dey *et al*. (2010). Among the hybrid combinations KAU-MCGy-101 × Priyanka was found to be earlier than both the gynoecious and monoecious parents, followed by KAU-MCGy-101 × MC 133 and KAU-MCGy-101 × Preethi. Yield (parents=14.49 to 12.08 t/ha and hybrids=22.88 to 16.63 t/ha) and yield attributing traits like sex ratio (parents=0.00 to 21.56 and hybrids=8.18 to 10.25), fruit weight (parents= 105.40 to 163.33 g and hybrids=118.07 to 172.47 g), fruit length (parents=16.65 to 22.01cm and hybrids=15.82 to 21.84 cm), fruit girth (parents=14.99 to 18.59 cm and hybrids= 15.94 to 17.27 cm), number of harvests (parents= 6.17 to 9.83 and hybrids= 9.00 to 12.00) and number of fruits per plant (parents= 40.17 to 57.33 and hybrids= 44.67 to 69.67) also showed ample variations among the parents and their hybrids. Among the parents used for hybridization, the lowest sex ratio was found in the gynoecious line KAU-MCGy-101 (0.00) whereas; the highest was in Priyanka (21.56). As regard to sex ratio (male:female), the crosses MC 133 × KAU-MCGy-101 and Priyanka × KAU-MCGy-101 registered the lowest (8.18) and highest (10.25) values, respectively. Among the hybrids, minimum days to the first harvest were registered in the hybrid KAU-MCGy-

Table 1. Mean performance of parents and hybrids for earliness and yield characters

	Days to first female flower opening	Node bearing first female flower	Sex ratio (Male: Female)	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Number of seeds	Days to first harvest	Number of harvests	Number of fruits per plant	Yield (t/ ha)
Preethi	35.78	20.56	18.39	133.67	18.01	17.33	22.20	61.44	6.17	40.17	12.08
Priyanka	34.67	19.67	21.56	163.33	22.01	18.59	29.07	65.33	7.50	42.50	12.93
MC 133	35.67	19.78	13.13	153.40	20.43	15.45	33.87	61.67	8.67	44.50	13.10
KAU-MCGy-101	32.28	13.89	0.00	105.40	16.65	14.99	19.13	52.61	9.83	57.33	14.49
Preethi × KAU-MCGy-101	31.78	14.44	8.62	118.07	15.82	17.27	15.73	58.44	11.33	62.17	17.64
Priyanka × KAU-MCGy-101	32.67	14.95	10.25	137.00	17.01	16.11	16.67	59.67	9.33	46.17	16.63
MC 133 × KAU-MCGy-101	31.33	15.56	8.18	163.07	19.26	16.68	33.53	57.67	9.00	44.67	18.13
KAU-MCGy-101 × Preethi	31.89	16.89	9.57	165.13	21.84	16.25	21.80	57.89	12.00	61.17	20.42
KAU-MCGy-101 × Priyanka	29.11	12.89	8.94	172.47	20.93	17.15	32.87	56.44	11.33	69.67	22.88
KAU-MCGy-101 × MC 133	31.78	15.89	9.94	153.20	19.19	15.94	34.47	57.44	10.33	63.33	20.05
CD (0.05 %)	3.45	3.04	3.345	22.74	2.71	0.98	3.78	5.44	3.06	13.05	2.478
CV (%)	6.15	10.78	17.96	9.05	8.25	3.45	8.50	5.39	18.67	14.31	8.58
SEd	1.64	1.45	1.592	10.82	1.29	0.47	1.80	2.59	1.46	6.21	1.179

101 × Priyanka (56.44) followed by KAU-MCGy-101 × MC 133 (57.44). This is comparatively very early than monoecious parents which require a period of 61.44 to 65.33 days for the first harvest. The general approach of selecting parental lines based on mean performance does not give a valid result (Kumar *et al*., 2017). Therefore, we have determined the heterotic potential for all the traits under study.

Heterosis

The extent of the heterotic response of the F_1 hybrids largely depends on the breeding value and genetic diversity of the parents included in the cross (Geleta and Labuschagne, 2004). From the mean performance, it is clear that a wide variation exists for the earliness and yield attributing traits of gynoecious and monoecious parents. For most of these traits, the hybrids registered markedly significant heterosis. The characters like days to first female flower opening and node bearing first female flower are considered as good indices of earliness. All the hybrids manifested heterosis for these characters in the desirable negative direction (Table 2). The cross KAU-MCGy-101 × Priyanka exhibited highly significant heterosis of -16.03 and -18.63 percentage in terms of heterobeltiosis and standard heterosis for days to first female flower opening. Crosses *viz*., Preethi × KAU-MCGy-101, MC 133 × KAU-MCGy-101, KAU-MCGy-101 × Preethi and KAU-MCGy-101 × MC 133 also registered significant negative heterosis for days to first female flower opening over better parent and standard variety. Among the six hybrids, the lowest node number (12.89) bearing the first female flower appeared in the cross KAU-MCGy-101 × Priyanka, which showed statistically superior heterosis of -34.46 per cent over its better parent and -37.30 per cent over the standard variety. Significant negative heterosis was observed in all other hybrids for the same trait. There are reports of hybrids involving gynoecious line in bitter gourd and cucumber exhibiting heterosis in a negative direction for days to first female flower opening and node bearing first female flower (Dey *et al*., 2012; Airina *et al*., 2013; Jat *et al*., 2015; Alhariri *et al*., 2018).

Similar to other cucurbits, the ratio between male and female flowers is the crucial determining factor for high yield in bitter gourd. A lower sex ratio is always desirable for high yield and productivity (Thangamani and Pugalendhi, 2013; Alhariri *et al*., 2018). Hence, heterosis in the negative direction is desirable for this trait. All

the crosses registered significant heterosis over standard variety (Table 2), which was mainly due to the high mean value of the standard variety for sex ratio (18.39). With respect to heterobeltiosis, the superior hybrid was KAU-MCGy-101 × Priyanka (-58.56 %) followed by Preethi × KAU-MCGy-101 (-53.13 %). It is important to note that these hybrids having a gynoecious parent are exhibiting earliness along with a lower sex ratio (male:female). The results of the present investigations are in accordance with the findings of Dey *et al*. (2012). Khan and Behera (2011) also reported a lower sex ratio (male:female) in gynoecious × monoecious hybrids, compared to the monoecious × monoecious hybrids of bitter gourd. Heterosis in the desirable negative direction in terms of heterobeltiosis and standard heterosis was found in all the hybrids for days to first harvest (Fig. 1). A highly significant heterobeltiosis of -13.61 per cent was observed in the hybrid KAU-MCGy-101 × Priyanka. Days to the first harvest is a critical observation as it directly contributes towards the earliness.

In the case of fruit weight, the highest significant heterobeltiosis of 23.54 per cent was expressed by the hybrid KAU-MCGy-101 × Preethi, while the hybrid KAU-MCGy-101 × Priyanka showed 29.03 per cent in terms of standard heterosis (Fig. 1). KAU-MCGy-101 × Preethi and KAU-MCGy-101 × Priyanka were the best performing hybrids with respect to fruit length (Table 2). Meanwhile, most of the hybrids showed negative heterosis for the fruit girth. In this case it is discernable that, most of the combinations with gynoecious line as one parent yielded long and slender fruits compared to the monoecious parents. Generally, long slender fruits in bitter gourd are more preferred in the market. Hence these hybrids are in accordance with the consumer predilection. On contrary, Dey *et al*. (2010) reported significant positive heterosis for fruit girth in gynoecious × monoecious hybrids of bitter gourd. The deviation could be on account of the variation in genotypes used in hybrid combinations. Regarding the number of seeds, significant heterosis was observed for the hybrids KAU-MCGy-101 × Priyanka and KAU-MCGy-101 × MC 133 (Table 2). The hybrid KAU-MCGy-101 × Priyanka manifested 13.07 per cent heterosis over better parent and 48.05 per cent heterosis over the standard variety. Comparatively a higher heterosis of 55.26 per cent over standard variety was obtained in the hybrid KAU-MCGy-101 × MC 133. For all the hybrids standard heterosis was found to be significant for the number of harvests ranging from 45.95 to 94.59 per cent.

The number of fruits per plant is one of the most important traits, which directly contributes towards yield (Alhariri *et al*., 2018). The magnitude of heterosis for

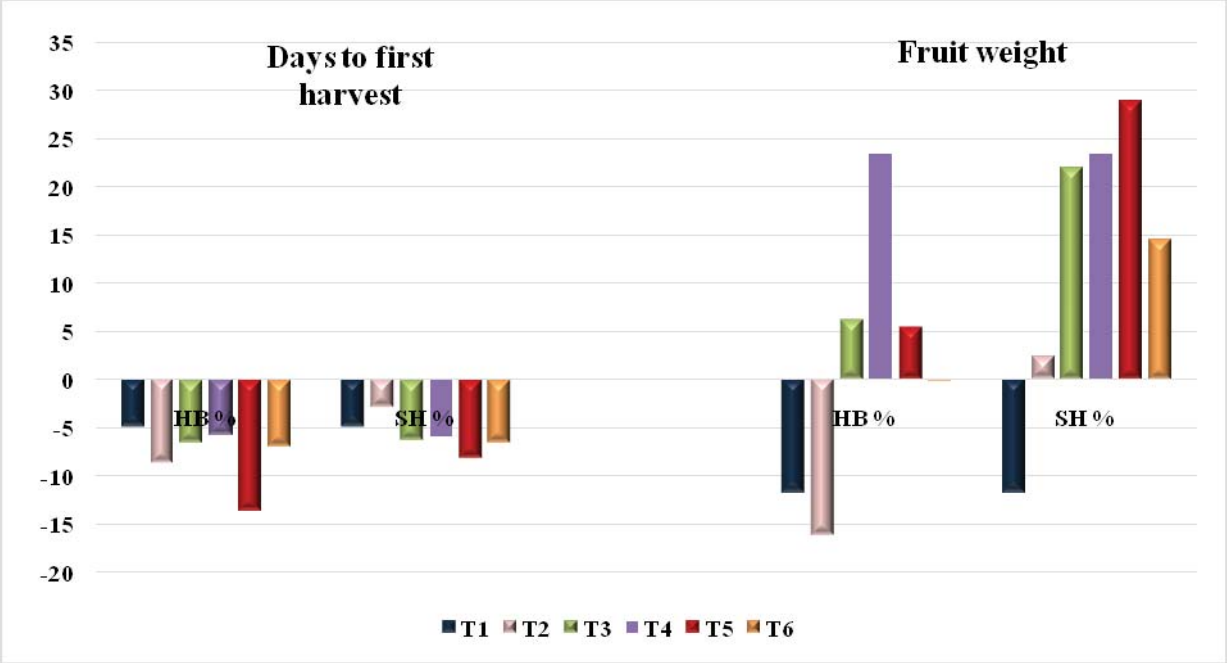

Fig. 1. Heterobeltiosis (HB %) and standard heterosis (SH %) percentage for days to first harvest and fruit weight

(T1- Preethi × KAU-MCGy-101, T2- Priyanka × KAU-MCGy-101, T3- MC 133 × KAU-MCGy-101, T4- KAU-MCGy-101 × Preethi, T5- KAU-MCGy-101 × Priyanka, T6-KAU-MCGy-101 × MC 133)

Table 2. Heterosis for different characters in F_1 hybrids of bitter gourd

	Days to first female flower opening		Node bearing first female flower		Sex ratio (Male:Female)		Number of seeds		Number of harvests		Fruit length (cm)		Fruit girth (cm)	
	HB %	SH %	HB %	SH %	HB%	SH %	HB %	SH %	HB %	SH %	HB %	SH %	HB%	SH %
Preethi × KAU-MCGy-101	-11.18**	-11.18**	-29.73**	-29.73**	-53.13**	-53.13**	-29.13**	-29.13**	15.25	83.78**	-12.16	-12.16	-0.31	-0.31
Priyanka × KAU-MCGy-101	-5.77	-8.70	-23.98**	-27.27**	-52.47**	-44.25**	-42.66**	-24.92**	-5.08	51.35**	-22.72**	-5.53	-13.37**	-7.04**
MC 133 × KAU-MCGy-101	-12.15**	-12.42**	-21.35**	-24.32**	-37.69**	-55.52**	-0.98	51.05**	-8.47	45.95**	-5.73	6.96	7.94**	-3.73
KAU-MCGy-101 × Preethi	-10.87**	-10.87**	-17.84**	-17.84**	-47.95**	-47.95**	-1.80	-1.80	22.03**	94.59**	21.27**	21.29**	-6.19**	-6.19**
KAU-MCGy-101 × Priyanka	-16.03**	-18.63**	-34.46**	-37.30**	-58.56**	-51.40**	13.07**	48.05**	15.25	83.78**	-4.91	16.23**	-7.74**	-1.00
KAU-MCGy-101 × MC 133	-10.90**	-11.18**	-19.66**	-22.70**	-24.27	-45.94**	1.77	55.26**	5.08	67.57**	-6.07	6.57	3.15	-8.00**

**Significant at 5% level, Fisher's t test.

the number of fruits per plant varied from11.20 to 73.44 per cent over standard variety (Fig. 2). Considering the number of fruits per plant, the most promising hybrids were KAU-MCGy-101 × Preethi, KAU-MCGy-101 × Priyanka, and KAU-MCGy-101 × MC 133. The present study observed highly significant heterosis for yield for all the hybrids. The highest (22.88 t/ha) and lowest yield (16.63 t/ha) were recorded in the hybrid KAU-MCGy-101 × Priyanka and Priyanka × KAU-MCGy-101, respectively. Heterobeltiosis for yield was ranged from 14.72 to 57.85 per cent and the standard heterosis ranged from 37.59 to 89.31 per cent (Fig. 2). Significant heterosis for yield is the result of the interaction of simultaneous increase in the expression of heterosis for yield attributing traits (Grafius, 1959). Three cross combinations *viz*., KAU-MCGy-101 × Preethi, KAU-MCGy-101 × Priyanka, and KAU-MCGy-101 × MC 133 with very high heterosis for yield over better parent as well as over standard variety may be considered outstanding for exploitation through heterosis breeding (Fig. 3). The mean values of earliness and yield attributing traits of these hybrids were desirably higher than those of the parents (Fig. 4).

Utilization of gynoecious lines as female parent ensures better success in heterosis breeding of bitter gourd. It is conspicuous that hybrids developed with gynoecious parent were characterized with high heterosis for earliness attributing traits like days to first female flower opening, node bearing first female flower, and days to first harvest over the monoecious parents and standard variety. The traits such as lower sex ratio and a greater number of fruits per plant contributed to the realization of higher yield in these hybrids.The

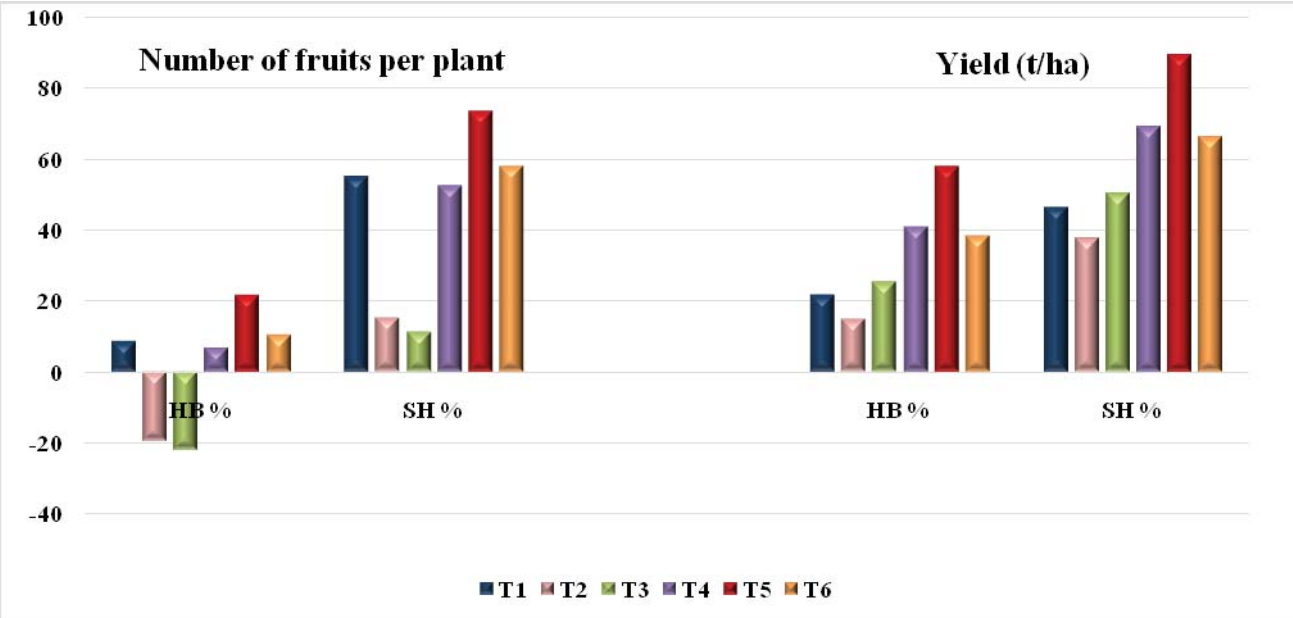

Fig. 2. Heterobeltiosis (HB %) and standard heterosis (SH %) percentage for number of fruits per plant and yield (t/ha) (T1- Preethi × KAU-MCGy-101, T2- Priyanka × KAU-MCGy-101, T3- MC 133 × KAU-MCGy-101, T4- KAU-MCGy-101 × Preethi, T5- KAU-MCGy-101 × Priyanka, T6-KAU-MCGy-101 × MC 133)

Fig. 3. High yielding hybrids KAU-MCGy-101 X Preethi (A), KAU-MCGy-101 × Priyanka (B) and KAU-MCGy-101 × MC 133 (C)

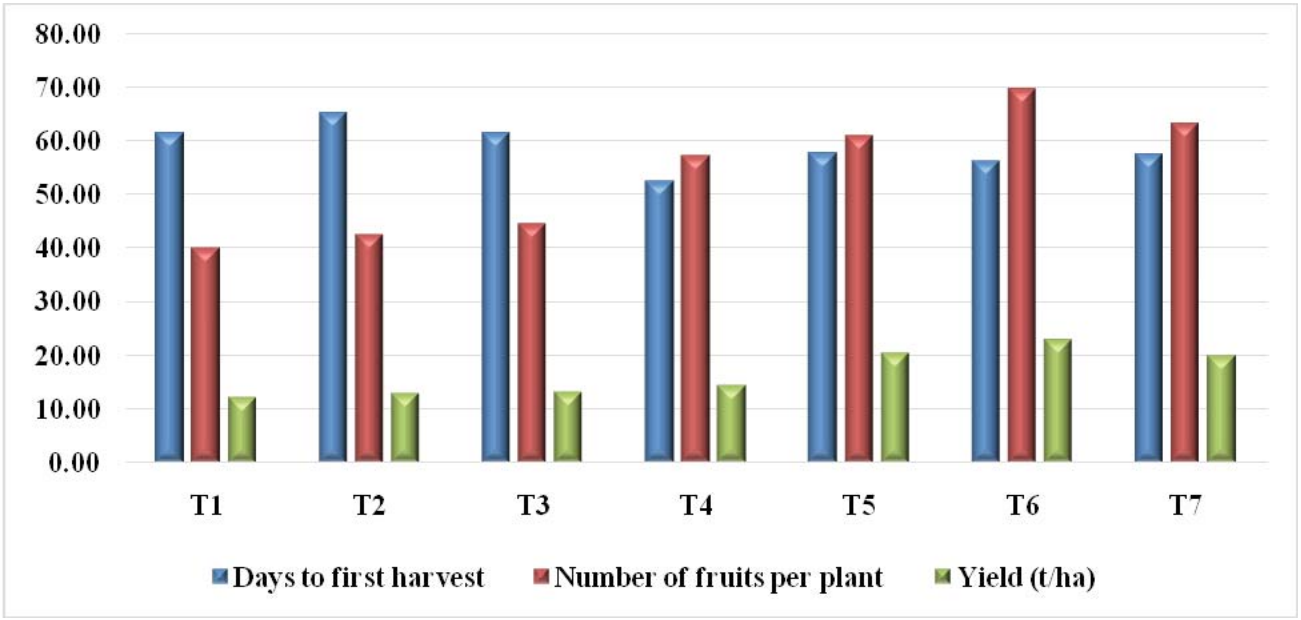

Fig. 4. Comparison between earliness and yield contributing traits in parents and superior hybrids.
T1-Preethi, T2-Priyanka, T3-MC133, T4- KAU-MCGy-101 (Parents), T5- KAU-MCGy-101 × Preethi, T6- KAU-MCGy-101 × Priyanka, T7- KAU-MCGy-101 × MC 133 (Superior hybrids)

superiority of hybrids having gynoecious line as a maternal parent is prominent in the present study. A similar trend was inferred from earlier authors, when a different gynoecious line was employed in the heterosis breeding program (Behera *et al*., 2009; Dey *et al*., 2012; Alhariri *et al*., 2018). Hence the gynoecious line, KAU-MCGy-101 used in this study is proven as a promising parent in hybridization to develop early and high yielding hybrids in bitter gourd.

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