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Evaluation of Bitter gourd (*Momordica charantia* L.) F1 hybrids for various commercial traits

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Abstract

The present study was conducted during the *Kharif*-2023 season to evaluate newly developed F_1 hybrids of bitter gourd (*Momordica charantia* L.). A full diallel mating design (10 × 10) involving 10 parental lines was employed, resulting in 90 F_1 hybrids. Of these, 40 selected F_1 hybrids were evaluated for qualitative and quantitative traits under field conditions in a Randomized Block Design (RBD). Significant variability was observed among the hybrids for all studied traits. Among vegetative parameters, the maximum vine length was recorded in BG111 (5.81 m), followed by BG14 (5.54 m). Shortest internodal length, indicative of compact growth, was observed in BG710 (6.18 cm) and BG103 (6.56 cm). Earliness in flowering was exhibited by BG15 (36.66 days), followed by BG610 (37.12 days) and BG51 (37.28 days). With respect to fruit characteristics, BG15 recorded the highest fruit length (29.30 cm) and fruit weight (97.84 g) closely followed by BG21 (97.80 g), while the maximum fruit diameter (4.16 cm) was observed in BG42. The shortest fruit length (8.31 cm) was noted in BG43. The highest number of fruits per vine was recorded in BG36 (40.64), followed by BG53 (36.49). Qualitative traits such as fruit colour, shape, tubercles and ridges pattern also exhibited noticeable variation among hybrids, facilitating their distinction. Overall, the study revealed substantial genetic variability among the F_1 hybrids, indicating their potential for further exploitation in breeding programs, including combining ability analysis, heterosis studies, and selection for superior yield and disease resistance.

Keywords: Bitter Gourd; F_1 Hybrids; Variability; Quantitative Traits; Qualitative Traits

1. Introduction

Bitter gourd (*Momordica charantia* L., 2n = 2x = 22) is a vital vegetable crop cultivated widely across tropical and subtropical regions, highly valued for its unique bitter flavour and many health advantages. It is one of the most popular and prized fruit and vegetable crop in the cucurbitaceous family and is cultivated year-round in most countries. In India, Bitter gourd exhibits considerable genetic diversity for several morphological and agronomic traits, including sex expression, growth habit, maturity, and fruit characteristics such as shape, size, colour, and surface texture [2]. It is widely distributed and extensively grown in China, India, Indonesia, Malaysia, Singapore, Thailand, Japan, South-East Asia, Tropical Africa and South America [8]. India is one of the leading producers of bitter gourd, with major cultivation in states such as Madhya Pradesh, Tamil Nadu, Chhattisgarh, Odisha, and Uttar Pradesh [4], with a total production of 184.39 million tonnes from an area of 10.25 million hectares, with a productivity of 17.98 tonnes per hectare [9]. During 2024–25, bitter gourd total production was 1931 MT [4]. Despite its economic importance, there remains considerable scope to improve bitter gourd yields through the development and evaluation of superior hybrids. Both cultivated bitter gourd and its wild relative (*M. charantia* var. *muricata*) are grown across tropical regions, where consumer preferences vary widely in fruit colour, length, diameter, shape, size, and tuberculation [7]. In this context, the exploitation of heterosis offers a promising approach for enhancing yield and improving desirable quality traits in bitter gourd, thereby enabling the development of region-specific, high-performing hybrids. The use of diverse parental lines in diallel mating

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designs facilitates the generation of a wide range of variability, enabling the identification of superior recombinants. The objectives of this study were to investigate the amount of morphological variation present in Bitter gourd hybrids. Evaluation of F_1 hybrids for both qualitative and quantitative traits is essential to assess their performance, distinctness, and breeding potential. In the present investigation, 90 F_1 hybrids were developed using a full diallel mating design. Out of these, 40 selected hybrids were evaluated under field conditions for important quantitative traits such as fruit length, weight, diameter, and number of fruits per vine, along with qualitative traits including fruit colour, shape, tubercles and ridges pattern. The study aimed to assess the extent of variability among the hybrids and to identify promising entries with consumer preferences for commercial exploitation and advanced evaluation.

2. Material and Methods

2.1. Experimental Site

The field experiment was conducted during *Kharif*-2023 (June-September), at the Research field of Ellora Natural Seeds Pvt. Ltd., Chhatrapati Sambhajinagar, Maharashtra and Department of Botany, Dr. Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.

2.2. Experimental Design

The study evaluated a diverse 40 selected F1 hybrids of bitter gourd (*Momordica charantia* L.). The F1 seed was sown in a Randomized Block Design (RBD) with 2 replications at a spacing of 1.5m between rows and 1.0m between plants. Standard agronomic practices, including trellis support, weeding, and fertigation, were followed uniformly across all seasons.

2.3. Observations recorded

Data of each hybrid were recorded on ten randomly selected plants in each replication for both quantitative (Vine length (m), Days to 1st & 50% flowering, Fruit length (cm), Fruit weight (g), Fruit diameter (cm), No. of fruit/vine, Average fruit weight (g)/vine) and qualitative (fruit colour, fruit shape, fruit tubercles) traits on the basis DUS key.

3. Result and Discussion

Evaluation of 40 selected F_1 hybrids of bitter gourd revealed significant variability in vegetative, reproductive, and yield-related traits, indicating a broad genetic base among the hybrids. The observed diversity reflects the differential genetic contributions inherited from the parental lines, which were effectively expressed in both qualitative and quantitative traits. The variability observed among the hybrids indicates substantial genetic control over these traits. High heritability associated with several characters indicates that the observed variation is predominantly governed by additive gene action with relatively low environmental influence [10], thereby facilitating effective selection for desirable traits in breeding programmes.

3.1. Quantitative traits

Significant variation in vine length was observed among the hybrids as illustrated in Figure 1, in which BG111 exhibited the longest vine at 5.81 m, followed by BG14 (5.54 m), and BG13 (5.30 m), highlighting their vigorous growth potential. Conversely, shorter vines were seen in BG612 (3.66 m) and BG31 (3.67 m), indicating a more compact growth habit. Internodal length is a key trait affecting plant architecture (Figure 3), ranging from 6.18 cm to over 10 cm. The shortest internodal length was noted in BG710 at 6.18 cm, with BG103 close behind at 6.56 cm. This variation in vine and internodal length reflects the genetic diversity among bitter gourd parental lines. Significant variation was observed among the F_1 hybrids in days to first flowering and 50% flowering, indicating genetic diversity in earliness traits, as shown in Figure 2. Earliness is an important agronomic attribute, as it facilitates early harvesting and provides a market advantage. The earliest flowering was recorded in BG15 (36.66 days), followed by BG610 (37.12 days) and BG51 (37.28 days), indicating their potential for early maturity. In contrast, delayed 50% flowering was observed in BG16 (44.82 days), followed by BG106 (43.92 days) and BG93 (43.88 days), reflecting their relatively late flowering behaviour. Substantial variability was observed among the F_1 hybrids for fruit-related traits. As illustrated in Figure 3, fruit length exhibited a wide range, with the maximum recorded in BG15 (29.30 cm), indicating its superiority for the elongated fruit type, while the shortest fruit length was observed in BG43 (8.31 cm). This variation in fruit length can be attributed to parental effects, as genetically diverse lines were utilized in the hybridization programme. Fruit length has a significant contribution to the enhancement of the yield of bitter gourd [5]. Fruit diameter also showed significant variation among the hybrids (Figure 3). The maximum fruit diameter was recorded in BG42 (4.16 cm), suggesting its suitability for thicker fruit types preferred in certain markets, whereas the minimum diameter was observed in BG75

(2.99 cm). Fruit weight, a key yield-contributing trait, ranged from 35.40 g to 97.84 g as shown in Figure 4. The highest fruit weight was recorded in BG15 (97.84 g), followed by BG21 (97.80 g), BG58 (93.56 g), and BG54 (92.65 g). In contrast, lower fruit weights were observed in BG13 (35.40 g) and BG93 (38.50 g). The wide range observed in fruit length, diameter, and weight clearly indicates the presence of diverse fruit types among the hybrids. The yield attributing character, i.e., number of fruits per vine exhibited considerable variation among the evaluated F_1 hybrids. As shown in Figure 5, the highest number of fruits per vine was recorded in BG36 (40.64), followed by BG53 (36.49), BG15 (34.24), BG35 (33.90), and BG46 (33.88). In contrast, a lower number of fruits per vine was observed in BG101 (19.20), BG536 (20.08), BG106 (20.26), BG21 (20.40), and BG510 (20.67). The observed variability in fruit number and size among hybrids can be attributed to the use of genetically diverse parental lines in the diallel mating design, resulting in short, medium, and long fruited F_1 hybrids.

3.2. Qualitative traits

The qualitative characterization of 40 F_1 hybrids of bitter gourd, as presented in Table 1, revealed substantial variation in flower colour, fruit colour, shape, tubercles and ridges pattern, indicating the presence of wide genetic diversity among the hybrids. Flower colour ranged from light yellow to deep yellow. Most hybrids exhibited yellow or light-yellow flowers, while a few, such as BG32, BG23, BG111, BG21, BG105, and BG101, had deep yellow flowers. This variation reflects genetic differences among parental lines and can serve as a distinguishing morphological marker. Fruit colour is an important quality attribute influencing consumer preference and marketability in bitter gourd. Uniform green peel colour is generally desirable; however, market preferences vary across regions. Long, dark green to glossy green fruits are preferred in northern India, white fruits in southern India, and small, dark green fruits in eastern regions [1]. In the present study, Fruit colour showed considerable diversity, including light green, green, dark green, and glossy green types. Most hybrids had green or dark green fruits, which are typically favoured in the market. Hybrids like BG42, BG64, BG14, BG41, BG46, BG54, BG85, BG84, and BG75 displayed glossy green fruits, reflecting a shiny green hue inherited from one parent. Three distinct fruit shapes were observed among the hybrids, namely short spindle, medium spindle, and long spindle. Short spindle-shaped fruits were predominant in early entries (BG32 to BG103), whereas medium spindle types were observed in hybrids ranging from BG83 to BG106. Long spindle-shaped fruits were recorded in hybrids including BG710, BG85, BG84, BG15, BG51, BG57, BG536, BG115, BG75, and BG101. This variation in fruit shape is primarily governed by genetic factors and is an important criterion for market preference and varietal identification. Fruit texture is an important attribute for genetic analysis and cultivar improvement in bitter gourd [3]. The presence of tubercles and the pattern of ridges (continuous vs. discontinuous) are economically significant traits that influence consumer preference and market price in India [6]. In the present study, considerable variation in fruit tubercles was observed among the F_1 hybrids, ranging from absent to few, medium, and many. Hybrids such as BG32, BG36, BG63, BG93, BG23, BG26, BG53, BG83, and BG610 exhibited dense and sharp tubercles, while BG42, BG111, and BG84 showed comparatively fewer tubercles. Absence of tubercles and ridges was observed in BG14, BG41, and BG101, whereas the rest of the hybrids showed a medium appearance of tubercles. The degree of tubercles is an important quality trait influencing consumer preference and distinctness for the selection of hybrids with desirable fruit texture suited to specific market need.

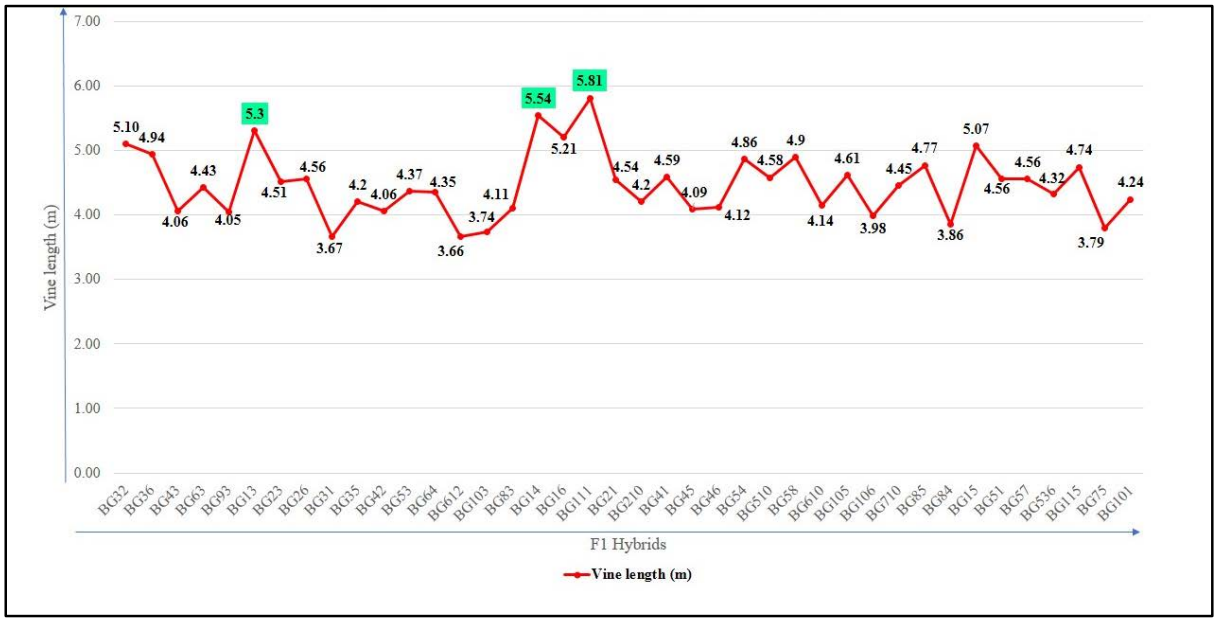

Figure 1 Vine length (m) of F1 hybrids

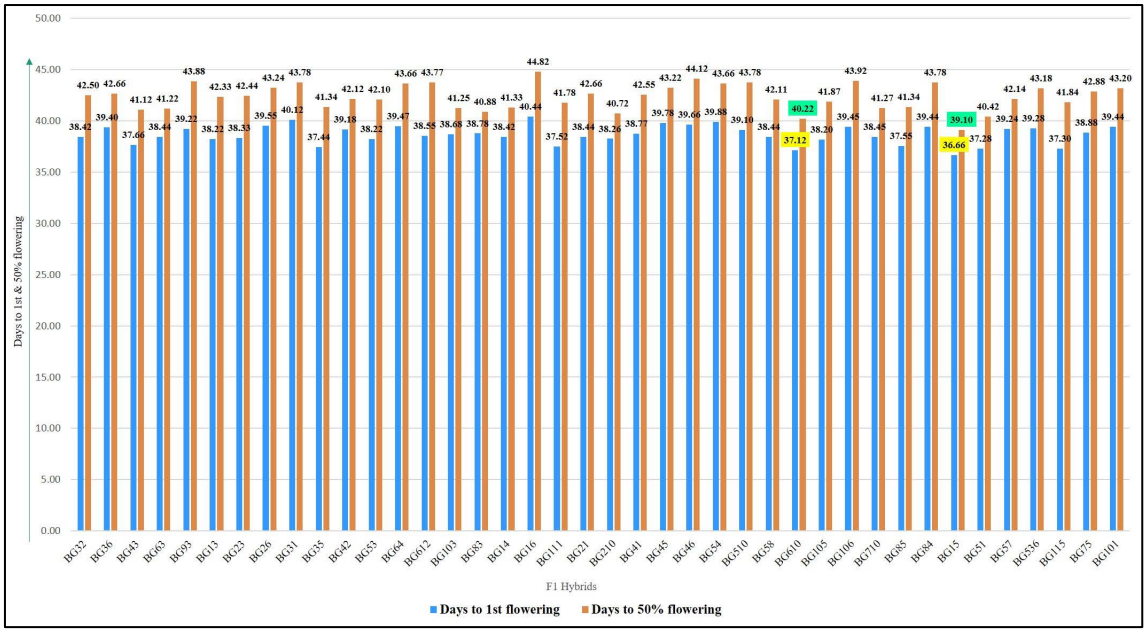

Figure 2 Days to 1st and 50% flowering

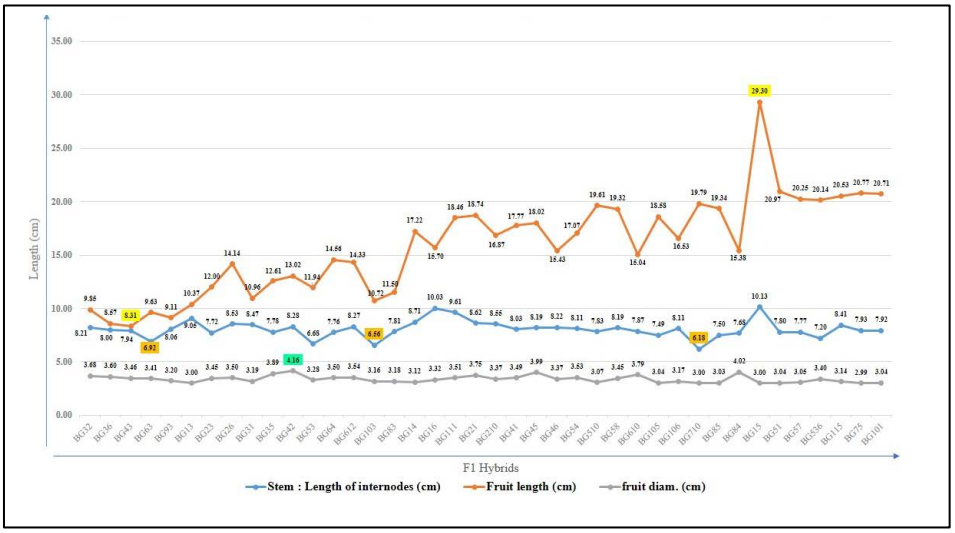

Figure 3 Internodal length, Fruit length and diameter of F1 hybrids

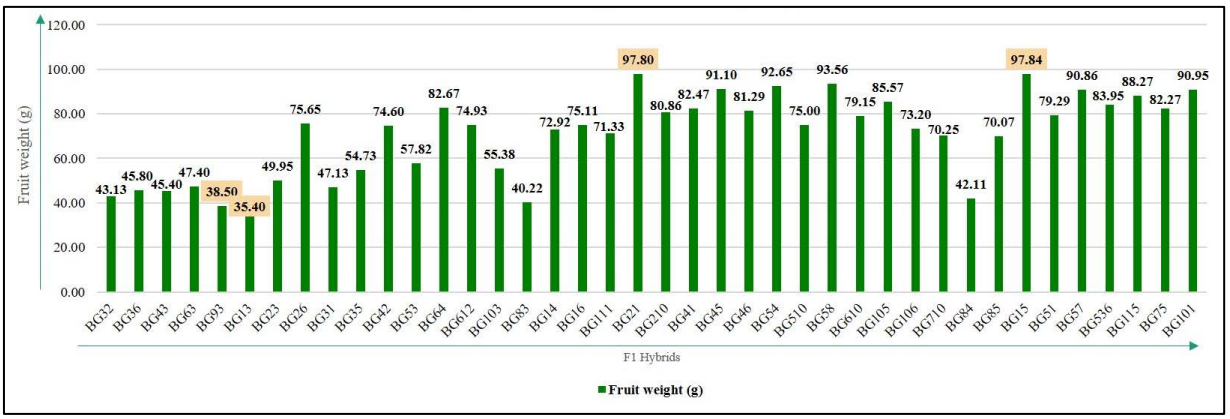

Figure 4 Average fruit weight (g)

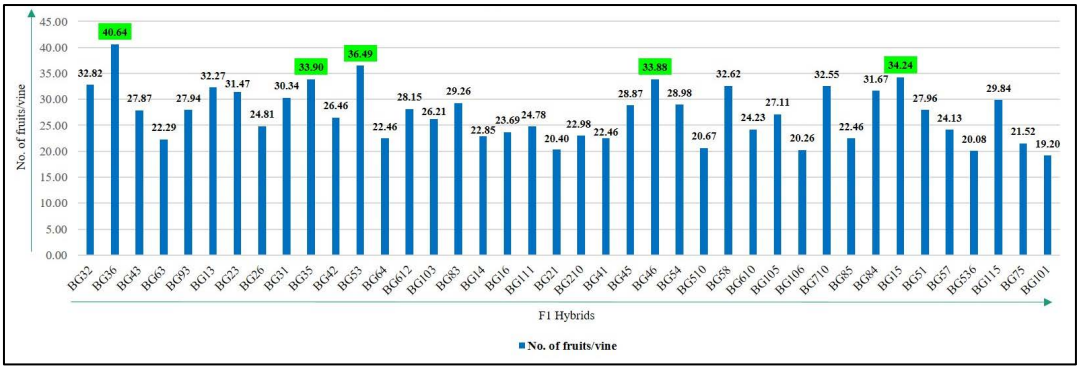

Figure 5 Maximum no. of fruit/vine

Table 1 Qualitative trait of bitter gourd F1 hybrid

Sr. No.	F1 Hybrids	Flower colour	Fruit colour	Fruit shape	Fruit tubercles	Patterns of ridges
1	BG32	Deep Yellow	Green	Short spindle	Many	Discontinuous
2	BG36	Yellow	Green	Short spindle	Many	Discontinuous
3	BG43	Light yellow	Dark Green	Short spindle	Medium	Discontinuous
4	BG63	Yellow	Green	Short spindle	Many	Discontinuous
5	BG93	Yellow	Dark green	Short spindle	Many	Discontinuous
6	BG13	Light yellow	Dark green	Short spindle	Medium	Discontinuous
7	BG23	Deep Yellow	Green	Short spindle	Many	Discontinuous
8	BG26	Yellow	Green	Short spindle	Many	Discontinuous
9	BG31	Light yellow	Green	Short spindle	Medium	Discontinuous
10	BG35	Light yellow	Dark green	Short spindle	Medium	Discontinuous
11	BG42	Light yellow	Glossy green	Short spindle	Few	Discontinuous
12	BG53	Light yellow	Green	Short spindle	Many	Discontinuous
13	BG64	Yellow	Glossy Green	Short spindle	Medium	Discontinuous
14	BG612	Light yellow	Dark green	Short spindle	Medium	Discontinuous
15	BG103	Light yellow	Green	Short spindle	Medium	Discontinuous
16	BG83	Yellow	Dark green	Medium spindle	Many	Discontinuous
17	BG14	Yellow	Glossy Green	Medium spindle	Absent	Continuous
18	BG16	Yellow	Green	Medium spindle	Medium	Discontinuous
19	BG111	Deep Yellow	Light Green	Medium spindle	Few	Discontinuous
20	BG21	Deep Yellow	Green	Medium spindle	Medium	Discontinuous
21	BG210	Light yellow	Green	Medium spindle	Medium	Discontinuous
22	BG41	Yellow	Glossy green	Medium spindle	Absent	Continuous
23	BG45	Yellow	Green	Medium spindle	Medium	Discontinuous
24	BG46	Yellow	Glossy green	Medium spindle	Medium	Discontinuous
25	BG54	Yellow	Glossy green	Medium spindle	Medium	Discontinuous
26	BG510	Yellow	Green	Medium spindle	Medium	Discontinuous

27	BG58	Light yellow	Green	Medium spindle	Medium	Discontinuous
28	BG610	Yellow	Dark green	Medium spindle	Many	Discontinuous
29	BG105	Deep Yellow	Green	Medium spindle	Medium	Discontinuous
30	BG106	Yellow	Green	Medium spindle	Medium	Discontinuous
31	BG710	Yellow	Green	Long spindle	Medium	Discontinuous
32	BG85	Yellow	Glossy green	Long spindle	Medium	Discontinuous
33	BG84	Light yellow	Glossy green	Long spindle	Few	Continuous
34	BG15	Yellow	Dark Green	Long spindle	Medium	Discontinuous
35	BG51	Yellow	Dark green	Long spindle	Medium	Discontinuous
36	BG57	Light yellow	Green	Long spindle	Medium	Discontinuous
37	BG536	Yellow	Light green	Long spindle	Medium	Discontinuous
38	BG115	Yellow	Light green	Long spindle	Medium	Discontinuous
39	BG75	Yellow	Glossy green	Long spindle	Medium	Discontinuous
40	BG101	Deep Yellow	Green	Long spindle	Absent	Continuous

4. Conclusion

The present investigation of 40 selected F_1 hybrids of bitter gourd revealed substantial genetic variability for quantitative and qualitative traits, indicating a broad genetic base among the hybrids. The observed variation was largely governed by additive gene action, as evidenced by high heritability, enabling effective selection for desirable traits. Among the hybrids, BG111 and BG14 demonstrated superior vine growth, while BG15 and BG610 were identified as early flowering types. In terms of fruit traits, BG15 exhibited the highest fruit length and weight, whereas BG43 recorded the shortest fruit length. BG42 recorded the largest fruit diameter, indicating its suitability for a broader range of fruit types. Higher yield potential, in terms of the number of fruits per vine, was observed in BG36 and BG53. However, due to variation in fruit size ranging from short to medium and long types, overall yield was not solely dependent on the number of fruits per vine but also on individual fruit length and weight, indicating the presence of different yield strategies among hybrids. Significant diversity was also observed for qualitative traits such as fruit colour, shape, tubercles and ridge pattern, which are important for market preference and varietal distinctness. This variability is attributed to the use of genetically diverse parental lines in the diallel mating design. Overall, the identified superior hybrids can be utilized for further evaluation, heterosis exploitation, and breeding programmes aimed at developing high-yielding, quality, and region-specific bitter gourd hybrids.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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