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Evaluation of various monoecious and gynoecious genotypes of bitter gourd (*Momordica charantia*L.) for yield and attributing traits

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Abstract

Bitter gourd is one of the significant cucurbitaceous crops with high economic importance. Exploitation of novel traits like gynoecism in particular and yield in general can substantially contribute to the future crop improvement programmes in bitter gourd. In the present investigation, 38 monoecious lines and 6 gynoecious lines were evaluated pertaining to 9 important quantitative morphological traits at the experimental farm of ICAR-Indian Institute of Vegetable Research, Varanasi across two seasons of spring-summer and *kharif*. From the mean performance analysis of all the accessions under study, VRBTG-5 was found to be the best performer among the monoecious lines, whereas, Gy-323 was the best peforming gynoecious line concerning the yield per plant (g). Moreover, for all other major yield-contributing traits, both of these lines have exhibited superior performance over all other accessions across the seasons and can be exploited further in crop improvement programmes.

Key words: Bitter gourd, gynoecism, monoecism, yield

Introduction

Bitter gourd (*Momordica charantia* L., 2n = 2x = 22), variously known as bitter melon, bitter cucumber, balsam pear, and African cucumber, holds a prime position among vegetable crops thanks to its high culinary, nutritional, and medicinal properties. The fruits, enriched with vitamin C, beta-carotene, iron, phosphorus, magnesium, potassium, and carbohydrates, are considered the most nutritional among the cucurbits (Raj et al.1993, Desai and Musmade 1998, Dhillon et al. 2017). This cucurbitis cultivated widely in India, Japan, Malaysia, China, and different parts of South America and Africa (Singh 1990, Raj et al. 1993, Van Wyk 2005). This dicot vine species belongs to the subtribe Thalidianthinae, tribe Joliffieae, subfamily Cucurbitoideae, and family Cucurbitaceae (De Wilde and Duyfjes 2002). Contrasting to other cucurbits, the bitter flavour of bitter gourd is consciously preferred for consumption which is the reason behind the selection of bitter flavour during the domestication of the crop (Marr et al.2004). Unripe or physiologically immature bitter gourd fruits with fresh bright appearance are highly preferred by the consumers although the preference criteria vary according to fruit size, shape, colour, skin pattern, etc. The sex form of bitter gourd is predominantly monoecious in nature, i.e., staminate and pistillate flowers appear separately on the same plant. However, gynoecious (only pistillate flowers on a plant) sex form has been reported in India, China, and Japan by various researchers (Ram et al. 2002, Behera et al. 2006, Iwamoto and Ishida 2006). Subsequently, several gynoecious inbreds (Gy263B, DBGy-201, DBGy-202, OHB61-5, IIHRBTGy-491, IIHRBTGy-492, etc.) with high combining ability

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that enhanced fruit yield and early maturity in bitter gourd hybrids have been developed (Ram et al. 2006, Behera et al. 2006, Iwamoto et al. 2009, Varalakshmi et al. 2014).

In bitter gourd, hybrid seed production is a cumbersome approach due to the high involvement of cost as well as labour in the tedious processes like pinching of staminate flowers, hand pollination, and manual bagging (Behera et al. 2009). Moreover, very few numbers of seeds are obtained per fruits. Hence, gynoecious bitter gourd plants can be utilized and exploited to overcome these hurdles and make the bitter gourd seed production program a more economical venture. Furthermore, with the use of gynoecious parental lines, yield potential, seed purity, genetic purity of the hybrids, and earliness can also be improved (Behera et al. 2006, Gaikwad et al. 2008, Dey et al. 2010, Alhariri et al. 2018, Pandey et al. 2019, Sunny et al. 2022). Keeping these in mind, an investigation was undertaken comprising of different bitter gourd genotypes of monoecious and gynoecious sex form and their performance evaluation was conducted pertaining to yield and other important quantitative traits.

Materials and Methods

The research was conducted in the experimental farm of the Indian Council of Agricultural Research-Indian Institute of Vegetable Research (ICAR-IIVR), Varanasi, Uttar Pradesh, India, in two consecutive seasons of spring-summer (season I) and *kharif* (season II) of 2017. Varanasi is situated in the Indo-Gangetic plains and the climate is humid with a temperature range between 22 to 46 ºC in summers. For the experimentation, a randomized complete block design (RCBD) with three replications was followed. The experimental material consisted of 44 bitter gourd accessions including 38 monoecious and 6 gynoecious lines collected and maintained at ICAR-IIVR (Table 1, Figures 1 and 2).

Table 1: List of bitter gourd accessions studied along with their sources

Sl. No.	Accession name	Source institution
Monoecious lines		
1.	ArkaHarit	ICAR-IIHR
2.	BBGS-09-1	ICAR-IIVR
3.	DVBTG-4	ICAR-IIVR
4.	IC-212504	ICAR-IIVR
5.	IC-44428	ICAR-IIVR
6.	KalyanpurBaramasi	CSAUAT
7.	Pusa Do Mausami	ICAR-IARI
8.	VRBTG-10	ICAR-IIVR
9.	VRBTG-15	ICAR-IIVR
10.	VRBTG-4	ICAR-IIVR
11.	VRBTG-46	ICAR-IIVR
12.	VRBTG-47	ICAR-IIVR
13.	VRBTG-47-2	ICAR-IIVR
14.	VRBTG-5	ICAR-IIVR
15.	VRBTG-7	ICAR-IIVR
16.	VRBTG-8	ICAR-IIVR
17.	VRBTG-29	ICAR-IIVR
18.	VRBTG-23	ICAR-IIVR
19.	VRBTG-21	ICAR-IIVR
20.	VRBTG-35	ICAR-IIVR
21.	VRBTG-20	ICAR-IIVR
22.	VRBTG-12	ICAR-IIVR
23.	VRBTG-28	ICAR-IIVR
24.	VRBTG-31	ICAR-IIVR
25.	VRBTG-33	ICAR-IIVR
26.	VRBTG-41	ICAR-IIVR
27.	VRBTG-3	ICAR-IIVR
28.	VRBTG-27	ICAR-IIVR
29.	VRBTG-39	ICAR-IIVR
30.	VRBTG-6	ICAR-IIVR
31.	VRBTG-1	ICAR-IIVR
32.	VRBTG-2	ICAR-IIVR
33.	VRBTG-62	ICAR-IIVR
34.	VRBTG-11	ICAR-IIVR
35.	VRBTG-37	ICAR-IIVR
36.	IC-44438	ICAR-IIVR
37.	VRBTG-30	ICAR-IIVR
38.	DVBTG-3	ICAR-IIVR
Gynoecious lines		
1.	Gy-144	ICAR-IIVR
2.	Gy-2116	ICAR-IIVR
3.	Gy-2135	ICAR-IIVR
4.	Gy-318	ICAR-IIVR
5.	Gy-323	ICAR-IIVR
6.	Gy-333	ICAR-IIVR

The seeds were sown in the pro trays and the four-week-old seedlings were transplanted in the main field on both sides of the channel with a spacing of 3.0 m in between channels and 0.5 m between hills in spring-summer and 2.0 m in between channels and 0.75 m between hills in *kharif* (Figure 3). Each treatment consisted of ten hills and one plant was kept per hill. The width of the irrigation channel was 0.5 m. All the recommended cultural practices including need-based chemical applications for disease and insect pest management were followed to maintain a good crop stand. The random sampling method was adopted for recording the observations. Five random plants, excluding the border ones, were selected to record nine important agro-economical traits, viz., days to first germination, days to 50% flowering, node bearing first pistillate flower, vine length (cm), fruit length (cm), fruit circumference (cm), fruit weight (g), number of fruits per plant, and yield per plant (g).

Results and Discussion

The performance of 38 monoecious and 6 gynoecious lines based on nine important agro-economical traits was recorded and significant differences were noticed among the accessions. The mean performance of 44 accessions of bitter gourd pertaining to yield and yield-attributing traits across both the seasons was illustrated in Table 2 and Table 3.

Selection of superior monoecious lines: For days to first germination in season I, the desired minimum value was observed in VRBTG-7 (9.80 ± 0.3 days) which was statistically at par with VRBTG-10 (9.93 ± 0.6 days) followed by VRBTG-62 (10.07 ± 0.4 days).In season II, the lowest value was obtained in VRBTG-10 (9.00 ± 0.4 days) which was statistically at par with VRBTG-1 (9.07 ± 0.1 days), VRBTG-62 (9.13 ± 0.1 days), and VRBTG-11 (9.13 ± 0.3 days).Similarly, pertaining to the days to 50% flowering in season I, accessions IC-212504 and Arka Harit take the minimum number of days, i.e., 33.00 ± 1.2 days and 33.00 ± 0.8 days , respectively to attain the 50% flowering which were statistically at par with DVBTG-4 (33.33 ± 1.7 days), VRBTG-12 (33.33 ± 0.3 days), VRBTG-33 (33.33 ± 0.7 days), IC-44438 (33.33 ± 0.7 days), Kalyanpur Baramasi (34.00 ± 1.4 days), and VRBTG-30 (34.00 ± 0.9 days).Likewise, in season II, accessions DVBTG-4 and IC-212504 had shown the lowest values of 35.00 ± 2.1 days and 35.00 ± 1.3, respectively which was statistically at par with VRBTG-47 (35.33 ± 1.1 days) and VRBTG-47-2 (35.33 ± 1.4 days.

In season I, the accessions VRBTG-6 (10.47 ± 0.7 node) and VRBTG-10 (10.47 ± 0.9 node) were the quickest with respect to the trait node bearing first pistillate flower followed by VRBTG-47-2 (11.00 ± 0.8 node). In season II, the desired lowest value was detected in VRBTG-10 (10.47 ± 0.9 node) followed by IC-44438 (11.40 ± 0.6 node) and VRBTG-47-2 (11.53 ± 0.6 node).With respect to vine length, Kalyanpur Baramasi was found to be the longest one in both seasons (193.27 ± 2.1 cm in season Iand 201.77 ± 1.7 cm in season II) which was statistically at par with VRBTG-62 with values of 190.00 ± 5.2 cm and 195.60 ± 3.5 cm in season I and season II, respectively. In seasons I and II, these two genotypes have been followed by VRBTG-28 (182.30 ± 3.5 cm) and VRBTG-1 (195.60 ± 3.5 cm), respectively.

For fruit length, the highest value was observed in VRBTG-10 in both the seasons (21.92 ± 0.2 cm in season I and 22.01 ± 0.2 cm in season II). In season I, VRBTG-10 was followed by VRBTG-5 (16.85 ± 0.4 cm) and VRBTG-62 (15.68 ± 0.4 cm), whereas, in season II, it was followed by VRBTG-39 (16.97 ± 0.8 cm) and VRBTG-5 (16.94 ± 0.5 cm).Considering fruit circumference, accession VRBTG-4 had the highest value of 15.70 ± 0.5 cm which was statistically at par with DVBTG-3 (15.35 ± 0.7 cm) in season I and 16.37 ± 0.3 cm in season II. In season I, VRBTG-4 was followed by IC-212504 (15.03 ± 0.6 cm), whereas, in season II, it is followed by DVBTG-3 (15.68 ± 0.5 cm).Pertaining to the fruit weight in season I, the maximum value was obtained in case of VRBTG-5 (102.95 ± 1.7 g) followed by the accessions Kalyanpur Baramasi and VRBTG-10 with values of 100.33 ± 2.2 g and 97.04 ± 1.7 g, respectively. However, in season II, the highest value was observed in Kalyanpur Baramasi (110.25 ± 2.1 g) followed by the accessions VRBTG-5 and VRBTG-39 with values of 106.69 ± 0.6 g, 100.79 ± 0.8 g, respectively. In the case of number of fruits per plant, VRBTG-12 was found to be the best one in both the seasons. The values obtained were 20.13 ± 0.5 and 21.07 ± 0.5 for season and II, respectively. In both the seasons, it was followed by VRBTG-23 (18.40 ± 0.3 in season I and 18.93 ± 0.5 in season II) and VRBTG-15 (18.33 ± 0.4 in season I and18.87 ± 0.3 in season II).

Table 2: Performance of 44 accessions of bitter gourd pertaining to yield and yield-related traits in spring summer season

S. No.	Name of the accession	DFG	D50%F	NBFPF	VL (cm)	FL (cm)	FC (cm)	FW (g)	NF/P	Y/P (g)
1.	ArkaHarit	11.93 ± 1.1	33.00 ± 0.8	11.13 ± 0.4	165.60 ± 9.3	13.16 ± 0.1	9.27 ± 0.2	90.98 ± 0.9	13.93 ± 0.3	1268.44 ± 39.4
2.	BBGS-09-1	10.80 ± 0.5	35.67 ± 1.2	12.20 ± 1.4	140.90 ± 6.5	12.50 ± 0.5	11.52 ± 0.3	88.80 ± 1.3	16.00 ± 0.3	1420.91 ± 31.3
3.	DVBTG-4	12.33 ± 0.6	33.33 ± 1.7	13.40 ± 1.0	169.67 ± 8.2	13.03 ± 0.6	11.46 ± 0.5	88.62 ± 1.5	14.60 ± 0.3	1294.93 ± 43.2
4.	Gy-144	12.07 ± 0.9	35.67 ± 1.0	13.80 ± 0.8	141.30 ± 7.0	11.85 ± 0.2	13.44 ± 0.3	101.85 ± 1.5	20.40 ± 0.6	2075.24 ± 30.1
5.	Gy-2116	11.13 ± 1.0	40.00 ± 0.9	13.40 ± 1.0	172.53 ± 5.6	10.63 ± 0.3	11.78 ± 0.4	89.35 ± 4.9	21.87 ± 0.4	1949.45 ± 84.7
6.	Gy-2135	10.73 ± 0.5	37.33 ± 0.7	13.07 ± 0.6	157.00 ± 9.7	9.94 ± 0.1	11.65 ± 0.2	92.44 ± 0.6	20.47 ± 0.4	1891.46 ± 34.5
7.	Gy-318	10.93 ± 0.6	33.67 ± 1.5	10.47 ± 0.6	146.73 ± 10.8	11.49 ± 0.3	13.02 ± 0.5	102.22 ± 1.4	21.53 ± 0.5	2200.98 ± 53.8
8.	Gy-323	10.33 ± 0.5	35.33 ± 1.0	10.27 ± 0.4	149.20 ± 11.3	11.53 ± 0.4	13.29 ± 0.6	102.32 ± 0.5	21.87 ± 0.5	2237.26 ± 53.9
9.	Gy-333	12.40 ± 1.0	35.00 ± 1.2	13.53 ± 1.3	134.23 ± 9.8	11.10 ± 0.2	12.21 ± 0.2	94.48 ± 0.8	20.13 ± 0.3	1901.84 ± 29.6
10.	IC-212504	10.93 ± 0.5	33.00 ± 1.2	15.40 ± 0.2	146.67 ± 8.5	10.20 ± 0.2	15.03 ± 0.6	85.42 ± 2.2	18.33 ± 0.2	1564.55 ± 22.5
11.	IC-44428	10.93 ± 0.7	38.00 ± 0.8	12.67 ± 1.1	122.73 ± 9.8	11.82 ± 0.7	12.16 ± 0.5	90.78 ± 0.3	15.47 ± 0.5	1404.30 ± 50.7
12.	KalyanpurBaramasi	10.80 ± 0.3	34.00 ± 1.4	12.60 ± 0.7	193.27 ± 2.1	10.57 ± 0.3	12.99 ± 0.4	100.33 ± 2.2	14.73 ± 0.5	1481.34 ± 82.0
13.	Pusa Do Mausami	11.87 ± 0.9	38.33 ± 0.5	11.27 ± 0.4	162.67 ± 2.2	12.45 ± 0.4	10.29 ± 0.4	96.28 ± 0.3	14.13 ± 0.1	1360.69 ± 13.7
14.	VRBTG-10	9.93 ± 0.6	36.33 ± 1.4	10.47 ± 0.9	179.80 ± 10.3	21.92 ± 0.2	7.91 ± 0.4	97.04 ± 1.7	17.40 ± 0.3	1686.85 ± 14.5
15.	VRBTG-15	12.00 ± 0.5	35.33 ± 1.2	13.20 ± 0.4	152.20 ± 10.7	13.17 ± 0.6	11.13 ± 0.2	77.42 ± 4.2	18.33 ± 0.4	1424.63 ± 109.9
16.	VRBTG-4	11.40 ± 0.5	39.33 ± 1.5	14.27 ± 0.9	154.87 ± 11.7	10.86 ± 0.5	15.70 ± 0.5	96.77 ± 0.8	15.00 ± 0.3	1452.20 ± 36.5
17.	VRBTG-46	13.00 ± 0.59	41.33 ± 1.4	13.80 ± 0.5	147.03 ± 3.5	9.11 ± 0.1	11.58 ± 0.4	92.29 ± 0.5	16.27 ± 0.1	1502.22 ± 92.5
18.	VRBTG-47	11.40 ± 0.6	33.67 ± 0.5	12.33 ± 0.5	161.30 ± 10.5	11.85 ± 0.6	13.18 ± 0.1	95.07 ± 1.8	14.73 ± 0.2	1401.99 ± 49.2
19.	VRBTG-47-2	10.13 ± 0.4	34.33 ± 1.4	11.00 ± 0.8	139.70 ± 6.9	12.99 ± 0.2	12.23 ± 0.2	82.53 ± 0.4	15.80 ± 0.4	1304.16 ± 35.2
20.	VRBTG-5	11.33 ± 0.3	42.00 ± 1.2	14.80 ± 0.7	173.13 ± 7.1	16.85 ± 0.4	9.08 ± 0.5	102.95 ± 1.7	16.87 ± 0.1	1736.67 ± 36.32
21.	VRBTG-7	9.80 ± 0.3	38.00 ± 1.2	15.13 ± 0.6	134.70 ± 9.0	12.09 ± 0.1	11.74 ± 0.3	81.71 ± 2.1	15.27 ± 0.3	1248.26 ± 49.0
22.	VRBTG-8	12.73 ± 0.7	37.67 ± 1.0	14.13 ± 0.6	161.70 ± 11.3	13.66 ± 1.1	9.13 ± 0.4	81.22 ± 1.3	14.40 ± 0.6	1167.46 ± 28.0
23.	VRBTG-29	11.33 ± 0.5	44.00 ± 2.1	13.27 ± 0.4	147.57 ± 3.6	13.30 ± 0.5	13.40 ± 0.5	94.76 ± 1.0	15.40 ± 0.6	1457.59 ± 44.1
24.	VRBTG-23	11.53 ± 0.7	43.00 ± 0.8	14.93 ± 0.5	164.97 ± 12.0	13.34 ± 0.2	14.02 ± 1.2	82.50 ± 0.9	18.40 ± 0.3	1517.13 ± 14.4
25.	VRBTG-21	12.00 ± 0.3	38.67 ± 1.0	12.00 ± 1.2	161.60 ± 3.0	13.35 ± 0.3	11.22 ± 1.1	82.57 ± 0.6	14.33 ± 0.3	1183.07 ± 18.4
26.	VRBTG-35	10.13 ± 0.8	36.33 ± 1.0	13.13 ± 1.0	154.83 ± 12.4	12.75 ± 0.7	11.65 ± 1.2	87.22 ± 0.6	16.20 ± 0.2	1412.72 ± 8.5
27.	VRBTG-20	12.53 ± 0.6	37.33 ± 1.5	11.27 ± 0.1	137.67 ± 7.3	14.05 ± 0.1	9.85 ± 1.0	93.43 ± 0.9	15.00 ± 0.1	1401.66 ± 21.3
28.	VRBTG-12	11.27 ± 1.1	33.33 ± 0.3	12.60 ± 0.8	129.10 ± 6.8	12.90 ± 0.7	12.66 ± 0.2	77.53 ± 0.6	20.13 ± 0.5	1560.74 ± 32.4
29.	VRBTG-28	10.20 ± 0.7	41.67 ± 2.1	12.93 ± 1.0	182.30 ± 3.5	14.28 ± 0.9	12.94 ± 0.8	81.56 ± 0.6	14.93 ± 0.3	1218.37 ± 32.4
30.	VRBTG-31	11.53 ± 0.7	42.67 ± 0.3	14.53 ± 0.8	138.43 ± 11.7	13.87 ± 1.6	13.32 ± 0.9	78.46 ± 0.3	14.60 ± 0.3	1145.65 ± 23.5
31.	VRBTG-33	11.07 ± 0.7	33.33 ± 0.7	11.13 ± 0.6	162.17 ± 12.6	9.90 ± 0.11	14.46 ± 0.9	94.66 ± 1.8	14.13 ± 0.2	1337.45 ± 27.8
32.	VRBTG-41	11.07 ± 0.6	37.67 ± 0.7	13.00 ± 0.8	165.97 ± 13.7	15.45 ± 0.6	11.50 ± 0.8	91.52 ± 1.3	16.87 ± 0.7	1544.88 ± 74.7
33.	VRBTG-3	11.53 ± 1.1	38.67 ± 1.0	11.27 ± 0.8	151.43 ± 14.2	10.00 ± 0.1	13.48 ± 1.0	95.18 ± 1.2	14.87 ± 0.7	1416.44 ± 75.8
34.	VRBTG-27	11.80 ± 0.9	40.00 ± 0.8	12.60 ± 0.8	175.07 ± 9.5	15.29 ± 0.9	10.50 ± 0.6	84.93 ± 1.8	13.60 ± 0.4	1157.28 ± 60.6
35.	VRBTG-39	12.27 ± 0.8	40.00 ± 0.5	13.47 ± 0.9	155.53 ± 13.0	17.09 ± 0.4	12.98 ± 0.7	93.65 ± 2.9	15.07 ± 0.6	1415.28 ± 94.8
36.	VRBTG-6	11.13 ± 0.4	39.67 ± 1.0	10.47 ± 0.7	131.37 ± 6.7	13.30 ± 1.6	11.07 ± 1.5	82.67 ± 1.3	13.93 ± 0.3	1150.94 ± 14.3
37.	VRBTG-1a	10.10 ± 0.4	38.33 ± 1.1	13.13 ± 0.2	180.37 ± 6.6	13.29 ± 0.7	13.67 ± 1.2	94.71 ± 4.5	15.13 ± 0.3	1437.58 ± 97.1
38.	VRBTG-2	11.13 ± 0.2	41.00 ± 0.8	13.33 ± 1.4	140.73 ± 11.4	13.16 ± 0.1	11.65 ± 0.8	87.79 ± 2.4	15.73 ± 0.3	1380.18 ± 33.1
39.	VRBTG-62	10.07 ± 0.4	45.00 ± 0.5	11.40 ± 0.9	190.00 ± 5.2	15.68 ± 0.4	13.64 ± 0.7	92.03 ± 2.9	14.67 ± 0.6	1355.40 ± 104.0
40.	VRBTG-11	10.80 ± 1.0	42.67 ± 0.7	13.53 ± 1.5	151.10 ± 5.5	13.50 ± 1.0	10.94 ± 0.6	88.51 ± 0.5	15.47 ± 0.5	1368.91 ± 39.8
41.	VRBTG-37	12.80 ± 0.2	41.33 ± 1.0	12.20 ± 0.7	114.27 ± 5.3	13.94 ± 1.6	14.70 ± 0.6	84.83 ± 1.3	16.53 ± 0.2	1401.96 ± 14.4
42.	IC-44438	11.47 ± 0.7	33.33 ± 0.7	11.13 ± 0.6	153.17 ± 3.7	12.92 ± 0.7	12.44 ± 0.8	90.77 ± 1.2	16.20 ± 0.4	1469.37 ± 29.0
43.	VRBTG-30	10.47 ± 0.5	34.00 ± 0.9	12.80 ± 0.7	135.27 ± 4.1	13.97 ± 0.4	14.47 ± 0.7	89.92 ± 0.7	15.87 ± 0.5	1425.79 ± 29.2
44.	DVBTG-3	12.53 ± 0.4	39.67 ± 0.7	11.67 ± 1.0	135.97 ± 4.1	12.55 ± 0.7	15.35 ± 0.7	89.86 ± 3.5	15.47 ± 0.4	1386.98 ± 37.9
	Mean	11.31	37.77	12.68	153.77	12.97	12.27	90.23	16.37	1480.03
	CD at 5%	0.26	1.03	0.41	5.43	0.68	0.53	2.08	0.70	80.52
	CV (%)	7.45	8.97	10.66	11.61	17.31	14.23	7.58	14.16	17.89

DFG: Days to first germination, D50%F: Days to 50% flowering, NBFPF: Node bearing first pistillate flower, VL: Vine length (cm), FL: Fruit length (cm), FC: Fruit circumference (cm), FW: Fruit weight (g), NF/P: Number of fruits per plant, and Y/P: Yield per plant (g)

Table 3: Performance of 44 accessions of bitter gourd pertaining to yield and yield-related traits in kharif season

S. No.	Name of the accession	DFG	D50%F	NBFPF	VL (cm)	FL (cm)	FC (cm)	FW (g)	NF/P	Y/P (g)
1.	ArkaHarit	10.33 ± 0.9	36.33 ± 0.7	11.60 ± 0.4	175.77 ± 10.2	13.58 ± 0.2	11.87 ± 0.7	92.54 ± 0.7	14.67 ± 0.3	1357.56 ± 32.6
2.	BBGS-09-1	9.53 ± 0.4	37.33 ± 1.4	11.93 ± 1.2	158.80 ± 8.7	13.00 ± 0.6	12.38 ± 0.7	90.29 ± 1.3	17.93 ± 0.4	1619.78 ± 46.7
3.	DVBTG-4	10.93 ± 0.9	35.00 ± 2.1	13.87 ± 0.6	182.70 ± 5.0	13.52 ± 0.7	11.64 ± 0.7	89.74 ± 1.4	15.53 ± 0.3	1395.20 ± 48.5
4.	Gy-144	10.73 ± 0.8	37.33 ± 0.7	13.80 ± 0.8	159.20 ± 5.3	12.93 ± 0.1	15.26 ± 0.7	103.96 ± 1.0	21.67 ± 0.6	2251.40 ± 57.8
5.	Gy-2116	9.87 ± 0.5	41.00 ± 1.7	14.00 ± 0.7	182.83 ± 7.1	10.84 ± 0.4	13.26 ± 0.2	93.57 ± 0.7	23.13 ± 0.5	2164.16 ± 39.6
6.	Gy-2135	9.80 ± 0.1	39.33 ± 0.7	13.53 ± 0.6	171.37 ± 11.1	9.99 ± 0.1	13.22 ± 0.5	92.44 ± 0.6	21.73 ± 0.5	2008.70 ± 39.2
7.	Gy-318	10.93 ± 0.6	35.33 ± 1.4	14.33 ± 0.8	155.43 ± 9.3	11.60 ± 0.5	12.42 ± 0.5	105.91 ± 1.5	22.33 ± 0.6	2367.68 ± 90.1
8.	Gy-323	10.00 ± 0.5	37.67 ± 0.7	11.40 ± 0.5	176.03 ± 4.6	11.41 ± 0.3	13.00 ± 0.7	106.71 ± 1.1	23.40 ± 0.5	2495.92 ± 46.0
9.	Gy-333	11.53 ± 0.9	36.33 ± 1.2	14.47 ± 0.5	148.93 ± 9.6	11.10 ± 0.2	12.75 ± 0.4	96.64 ± 1.1	20.33 ± 0.4	1964.31 ± 36.7
10.	IC-212504	9.67 ± 0.3	35.00 ± 1.3	15.47 ± 0.5	155.87 ± 6.7	10.49 ± 0.3	14.49 ± 0.5	90.95 ± 0.7	18.87 ± 0.3	1715.71 ± 23.2
11.	IC-44428	9.73 ± 0.7	40.00 ± 0.8	13.87 ± 0.6	141.73 ± 1.1	12.17 ± 0.4	12.30 ± 0.2	91.83 ± 0.3	16.47 ± 0.5	1512.39 ± 51.6
12.	KalyanpurBaramasi	9.73 ± 0.2	36.67 ± 1.9	13.27 ± 0.7	201.77 ± 1.7	11.14 ± 0.2	11.76 ± 0.7	110.25 ± 2.1	15.47 ± 0.6	1704.93 ± 67.8
13.	Pusa Do Mausami	10.13 ± 0.5	39.67 ± 0.7	11.67 ± 0.8	183.67 ± 6.4	12.94 ± 0.5	12.73 ± 0.4	99.11 ± 0.1	14.60 ± 0.2	1447.02 ± 19.3
14.	VRBTG-10	9.00 ± 0.4	36.67 ± 0.7	10.47 ± 0.9	194.13 ± 2.3	22.01 ± 0.2	9.39 ± 0.4	98.55 ± 1.8	18.47 ± 0.1	1819.28 ± 22.6
15.	VRBTG-15	10.47 ± 0.5	36.00 ± 1.9	13.20 ± 0.4	168.30 ± 9.9	13.07 ± 0.5	12.17 0.2	87.47 ± 0.53	18.87 ± 0.3	1650.01 ± 19.7
16.	VRBTG-4	10.40 ± 0.2	41.33 ± 1.8	15.40 ± 0.6	166.83 ± 10.3	11.74 ± 0.7	16.37 ± 0.3	99.99 ± 0.6	15.47 ± 0.1	1546.57 ± 14.3
17.	VRBTG-46	11.13 ± 0.6	42.00 ± 1.7	14.87 ± 0.2	177.80 ± 5.1	10.13 ± 0.1	11.64 ± 0.6	96.14 ± 1.3	16.87 ± 0.8	1622.04 ± 78.5
18.	VRBTG-47	9.93 ± 0.1	35.33 ± 1.1	12.87 ± 0.3	182.70 ± 4.0	11.93 ± 0.4	13.25 ± 0.4	98.56 ± 0.6	15.53 ± 0.1	1530.77 ± 11.9
19.	VRBTG-47-2	9.27 ± 0.5	35.33 ± 1.4	11.53 ± 0.6	164.70 ± 4.2	13.88 ± 0.1	12.58 ± 0.4	86.26 ± 0.9	16.93 ± 0.6	1461.24 ± 56.5
20.	VRBTG-5	10.33 ± 0.2	43.00 ± 1.3	15.80 ± 0.3	189.77 ± 5.1	16.94 ± 0.5	11.86 ± 0.2	106.69 ± 0.6	18.13 ± 0.9	1934.44 ± 90.6
21.	VRBTG-7	9.20 ± 0.3	37.33 ± 1.0	15.60 ± 0.5	158.00 ± 7.1	14.26 ± 0.3	12.79 ± 0.6	83.56 ± 2.1	16.27 ± 0.3	1360.29 ± 51.6
22.	VRBTG-8	10.47 ± 0.3	38.67 ± 0.3	15.33 ± 0.4	161.70 ± 11.2	14.69 ± 1.3	10.23 ± 0.2	82.95 ± 1.5	15.20 ± 0.4	1259.06 ± 8.2
23.	VRBTG-29	10.53 ± 0.3	46.67 ± 1.0	13.27 ± 0.5	165.47 ± 1.4	14.04 ± 0.5	13.07 ± 1.0	95.91 ± 0.7	16.20 ± 0.6	1552.61 ± 46.2
24.	VRBTG-23	9.80 ± 0.3	43.67 ± 1.2	15.27 ± 0.6	164.97 ± 12.0	13.76 ± 0.2	14.17 ± 1.3	84.94 ± 0.9	18.93 ± 0.5	1609.40 ± 59.2
25.	VRBTG-21	12.00 ± 0.3	40.67 ± 0.8	12.53 ± 0.8	181.20 ± 7.4	13.20 ± 0.3	10.57 ± 0.8	84.84 ± 0.8	15.20 ± 0.2	1289.65 ± 21.6
26.	VRBTG-35	9.73 ± 0.6	37.00 ± 1.3	13.93 ± 0.8	191.70 ± 3.1	13.16 ± 0.2	12.37 ± 0.4	88.81 ± 0.6	17.13 ± 0.1	1521.73 ± 18.4
27.	VRBTG-20	12.00 ± 0.4	39.67 ± 1.7	12.67 ± 0.2	164.30 ± 3.1	14.80 ± 0.3	10.70 ± 0.2	95.69 ± 0.6	16.87 ± 0.3	1613.55 ± 20.0
28.	VRBTG-12	10.27 ± 0.8	36.67 ± 0.7	13.60 ± 0.6	145.47 ± 5.4	13.12 ± 0.7	13.52 ± 0.3	80.16 ± 0.9	21.07 ± 0.5	1687.46 ± 18.1
29.	VRBTG-28	9.40 ± 0.1	41.67 ± 1.2	13.40 ± 0.9	192.40 ± 3.6	14.39 ± 0.5	13.13 ± 0.4	83.01 ± 0.9	15.80 ± 0.3	1311.81 ± 31.0
30.	VRBTG-31	10.00 ± 0.7	44.00 ± 1.3	14.53 ± 0.8	174.00 ± 7.9	14.42 ± 1.3	12.77 ± 0.3	80.28 ± 0.9	16.07 ± 0.1	1289.97 ± 16.2
31.	VRBTG-33	10.27 ± 0.5	36.33 ± 0.7	12.27 ± 0.4	178.33 ± 11.3	10.85 ± 0.3	15.15 ± 0.4	97.90 ± 0.9	15.40 ± 0.2	1508.01 ± 29.8
32.	VRBTG-41	11.07 ± 0.6	41.33 ± 1.0	14.07 ± 0.3	171.77 ± 14.8	15.50 ± 0.5	11.43 ± 0.5	93.73 ± 1.0	18.27 ± 0.2	1712.19 ± 26.4
33.	VRBTG-3	10.27 ± 0.5	40.33 ± 1.1	12.07 ± 0.8	162.90 ± 10.4	10.83 ± 0.3	13.16 ± 0.5	98.69 ± 0.5	16.53 ± 0.3	1632.18 ± 37.2
34.	VRBTG-27	11.80 ± 0.8	42.00 ± 0.5	13.73 ± 0.7	194.10 ± 3.7	15.90 ± 0.3	11.74 ± 0.2	84.93 ± 1.8	14.47 ± 0.4	1230.90 ± 62.4
35.	VRBTG-39	11.20 ± 0.6	41.33 ± 0.7	14.40 ± 0.6	182.60 ± 4.6	16.97 ± 0.8	13.32 ± 0.4	100.79 ± 0.8	15.93 ± 0.6	1604.48 ± 47.6
36.	VRBTG-6	9.80 ± 0.3	36.67 ± 1.2	11.67 ± 1.0	154.87 ± 6.8	15.21 ± 0.4	11.96 ± 1.6	86.09 ± 0.7	15.33 ± 0.3	1319.84 ± 25.7
37.	VRBTG-1	9.07 ± 0.1	36.33 ± 0.7	14.00 ± 0.3	195.60 ± 3.5	14.15 ± 0.6	13.57 ± 0.5	99.46 ± 0.4	16.60 ± 0.2	1651.18 ± 24.7
38.	VRBTG-2	10.07 ± 0.2	42.00 ± 0.9	15.00 ± 0.8	155.00 ± 9.4	14.03 ± 0.4	13.47 ± 0.4	96.81 ± 1.4	16.80 ± 0.2	1625.96 ± 17.5
39.	VRBTG-62	9.13 ± 0.1	45.00 ± 0.5	11.93 ± 0.6	199.77 ± 3.7	16.15 ± 0.4	13.38 ± 0.5	98.62 ± 0.5	16.73 ± 0.4	1650.77 ± 45.2
40.	VRBTG-11	9.13 ± 0.3	43.67 ± 1.2	14.00 ± 1.6	160.70 ± 7.5	15.19 ± 0.5	11.61 ± 0.3	90.53 ± 0.4	16.93 ± 0.4	1533.45 ± 39.1
41.	VRBTG-37	11.20 ± 0.2	42.67 ± 1.1	12.40 ± 0.7	138.03 ± 3.8	14.24 ± 0.4	14.70 ± 0.6	89.90 ± 0.6	17.27 ± 0.5	1551.63 35.8
42.	IC-44438	10.67 ± 0.3	35.67 ± 0.7	11.40 ± 0.6	185.83 ± 3.1	13.46 ± 0.6	12.80 ± 0.9	92.98 ± 1.2	17.53 ± 0.5	1629.17 ± 33.7
43.	VRBTG-30	9.60 ± 0.1	36.67 ± 1.0	13.33 ± 0.6	155.77 ± 8.4	14.67 ± 0.2	13.58 ± 0.6	91.91 ± 0.4	17.20 ± 0.3	1580.43 ± 25.2
44.	DVBTG-3	11.00 ± 0.4	39.33 ± 1.0	12.60 ± 0.9	159.87 ± 5.8	14.03 ± 0.7	15.68 ± 0.5	92.09 ± 3.5	16.53 ± 0.4	1521.57 ± 61.6
	Mean	10.25	39.14	13.42	171.20	13.53	12.80	93.46	17.42	1632.19
	CD at 5%	0.24	0.94	0.41	4.91	0.67	0.43	2.24	0.71	86.21
	CV (%)	7.71	7.94	10.02	9.42	16.32	10.93	7.89	13.33	17.37

DFG: Days to first germination, D50%F: Days to 50% flowering, NBFPF: Node bearing first pistillate flower, VL: Vine length (cm), FL: Fruit length (cm), FC: Fruit circumference (cm), FW: Fruit weight (g), NF/P: Number of fruits per plant, and Y/P: Yield per plant (g)

Among all the accessions under investigation in both the seasons, VRBTG-5 was found to be the highest yielder with values of 1736.67 ± 36.3 g and 1934.44 ± 90.6 g in season I and II, respectively. In season I, VRBTG-5 was statistically at par with VRBTG-10 (1686.85 ± 14.5 g) followed by IC-212504 (1564.55 ± 22.5 g), whereas in season II, it was followed by VRBTG-10 (1819.28 ± 22.6 g) and IC-212504 (1715.71 ± 23.2 g).

Selection of superior gynoecious line: Pertaining to the trait days to first germination in season I, the minimum value was observed in Gy-323 (10.33 ± 0.5 days) followed by Gy-2135 (10.73 ± 0.5 days) and Gy-318 (10.93 ± 0.6 days). In season II, the accession Gy-2135 (9.80 ± 0.1 days) was found to be the quickest in germination which was statistically at par with the accessions Gy-2116 (9.87 ± 0.5 days) and Gy-323 (10.00 ± 0.5 days). Similarly, for days to 50% flowering, accession Gy-318 exhibited the minimum values of 33.67 ± 1.5 days and 35.33 ± 1.4 days in season I and II, respectively followed by Gy-333 (35.00 ± 1.2 days) and Gy-323 (35.33 ± 1.0 days) in season I; and Gy-333 (36.33 ± 1.2 days) and Gy-144 (37.33 ± 0.7 days) in season II.

Furthermore, considering the node bearing the first pistillate flower, the lowest value was found in Gy-323 (10.27 ± 0.4 node) which was statistically at par with Gy-318 (10.47 ± 0.6 node) followed by Gy-2135 (13.07 ± 0.6 node) in season I. Also, in the season II, Gy-323 (11.40 ± 0.5 node) possessed the lowest value followed by Gy-2135 (13.53 ± 0.6 node) and Gy-144 (13.80 ± 0.8 node). For the trait vine length, Gy-2116 was the longest in both the seasons with values of 172.53 ± 5.6 cm (season I) and 182.83.27 ± 7.1 cm (season II). In season I, Gy-2116was followed by Gy-2135 (157.00 ± 9.7 cm) and Gy-323 (149.20 ± 11.3 cm), whereas in season II, it was followed by Gy-323 (176.03 ± 4.6 cm) and Gy-2135 (171.37 ± 11.1 cm).

In case of fruit length, maximum value was observed in Gy-144 in both the seasons. In season I, Gy-144 (11.85 ± 0.2 cm) was statistically at par with Gy-323 (11.53 ± 0.4 cm) and Gy-318 (11.49 ± 0.3 cm). Likewise, in season II, Gy-144 (12.93 ± 0.1 cm) was found to be statistically at par with Gy-318 (11.60 ± 0.5 cm) and Gy-323 (11.41 ± 0.3 cm). For the parameter fruit circumference over the seasons, Gy-144 exhibited the highest values (13.44 ± 0.3 cm in season I and 15.26 ± 0.7 cm in season II). In season I, Gy-144 was statistically at par with Gy-323 (13.29 ± 0.6 cm) and Gy-318 (13.02 ± 0.5 cm), whereas, in season II, it was followed by Gy-2116 and Gy-2135 with values of 13.26 ± 0.2 cm and 13.22 ± 0.5 cm, respectively. In case of fruit weight, Gy-323 possessed the highest values in both the seasons, viz., 102.32 ± 0.5 g in season I and 106.71 ± 1.1 g in season II. In season I, Gy-323 was statistically at par with Gy-318 and Gy-144 with values of 102.22 ± 1.4 g and 101.85 ± 1.5 g, respectively. Also, in season II, Gy-323 was found to be statistically at par with Gy-318 (105.91 ± 1.5 g) followed by the accession Gy-144 (103.96±1.0 g).

In season I, pertaining to the number of fruits per plant, Gy-323 (21.87 ± 0.5) and Gy-2116 (21.87 ± 0.4) were found to possess the highest values which were statistically at par with the accession Gy-318 (21.53 ± 0.5), whereas, in season II, Gy-323 (23.40 ± 0.5) exhibited the highest value which was statistically at par with Gy-2116 (23.13 ± 0.5) followed by Gy-318 (22.33 ± 0.6). In case of yield per plant, Gy-323 was found to possess the highest values of 2237.26 ± 53.9 g and 2495.92 ± 46.0 g in the season I and season II, respectively. In season I, Gy-323 was statistically at par with Gy-318 (2200.98 ± 53.8 g) followed by Gy-144 (2075.24 ± 30.1 g), whereas, in season II, Gy-323 was followed by Gy-318 (2367.68 ± 90.1 g) and Gy-144 (2251.40 ± 57.8 g).

From the *per se* performance of bitter gourd accessions involving yield and yield-related traits, significant differences were observed among all the lines under study. Gynoecious lines, due to the prevalence of only female flowers, are superior to most of the monoecious lines in terms of the number of fruits per plant and ultimately regarding yield per plant (Behera et al. 2009, Dey et al. 2010, Shukla et al. 2014, Sunny et al. 2022, Minnu et al.2022). The range of variation in both seasons was observed to be highest for the trait yield per plant (1145.65 g - 2495.92 g) followed by vine length (114.27 cm - 201.77 cm), and fruit weight (77.42 g - 110.25 g).

Earliness is one of the important considerations in the breeding program of bitter gourd. Due to the prolonged harvestings observed in the crop, earliness can be further exploited to facilitate continuous harvesting at regular intervals over a long period of days to avoid any market glut and ultimately, the farmers can fetch higher prices for their produce (Talukder et al. 2018, Sagar et al. 2022, Alhariri et al. 2021). For the traits like days to first germination, days to 50% flowering, and node bearing first pistillate flower, the lowest values are desirable and these traits are contributory to the earliness. In the current study, the best performing accession over both the seasons in reference to the days to first germination was found to be VRBTG-10, whereas Arka Harit and IC-212504 were superior for days to 50% flowering. Similarly, for the trait node bearing first pistillate flower, Gy-323 was observed to be the best performer over both the seasons. This is in accordance with the earlier studies of Dey et al. 2010 and Moharana et al. 2017.

Vine length is mainly associated with the number of fruits per vine. The accession Kalyanpur Baramasi was found to be superior regarding the trait vine length (cm) over both seasons among all the lines. Gupta et al. 2016 and Sagar et al. 2022 also reported similar results in agreement regarding the vine length in bitter gourd. Concerning fruit length (cm), VRBTG-10 was the best performer, while for fruit circumference (cm), the accession VRBTG-4 was found to be the superior one over the seasons. The traits like fruit weight and number of fruits per plant are directly linked with the yield per plant. In this study, for fruit weight (g), Kalyanpur Baramasi and VRBTG-5 were found to be the best ones among the monoecious lines, whereas, Gy-323 was the superior one among the gynocious lines. Similarly, for the number of fruits per plant across the seasons, the best monoecious line was VRBTG-12; and both Gy-323 and Gy-2116 were the best performers in the case of gynoecious lines. Yield is ultimately the most important concern in most of the studies. In our study, concerning the yield per plant (g), VRBTG-5 was the best performer among the monoecious lines, whereas, Gy-323 was the best gynoecious line. Both these lines have exhibited superior performance over all other accessions across the seasons. These outcomes are consistent with the findings of Rao et al. 2017, Alhariri et al. 2018, Reshmika et al. 2019, and Alhariri et al. 2021.

It can be concluded that the genotypes VRBTG-5 and Gy-323 among monoecious and gynoecious lines, respectively were identified to be the superior ones with respect to the yield and major yield contributing characters over both the seasons. These accessions may be further exploited in various hybridization programmes for development of varieties.

सारांश

करेला उच्च आर्थिक महत्व वाली महत्वपूर्ण कद्दू वर्गीय फसलों में से एक है। विशेष रूप से गाइनोइकिज्म जैसेनवीन लक्षणों का दोहन और सामान्य रूप से उपज करेला में भविष्य के फसल सुधार कार्यक्रमों में महत्वपूर्ण योगदान दे सकती है। वर्तमान परीक्षण में, वसंत–ग्रीष्म और खरीफ के दो मौसमों में भाकृअनुप – भारतीय सब्जी अनुसंधान संस्थान, वाराणसी के प्रायोगिक फार्म में 9 महत्वपूर्ण मात्रात्मक रूपात्मक लक्षणों से संबंधित 38 एकलिंगाश्रयी और 6 स्त्रीलिंग वंश क्रम का मूल्यांकन किया गया। अध्ययन के तहत सभी प्राप्तियों के औसत प्रदर्शन विश्लेषण से, वीआरबीटीजी–5 को एकलिंगाश्रयी वंश क्रमों में सबसे अच्छा प्रदर्शन करने वाला पाया गया, जबकि जीवाई–323 प्रति पौधा उपज (ग्राम) के संबंध में सबसे अच्छा प्रदर्शन करने वाली स्त्रीलिंग वंश क्रम थी। इसके अलावा, अन्य सभी प्रमुख उपज–योगदान गुणों के लिए, इन दोनों पंक्तियों ने सभी मौसमों में अन्य सभी परिग्रहणों पर बेहतर प्रदर्शन किया है और फसल सुधार कार्यक्रमो मे इसका और अधिक फायदा उठाया जा सकता है।

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