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Performance of bitter gourd (*Momordica charantia* L.) hybrids under Chhattisgarh plain

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Abstract
The present investigation was carried out in the field of Horticultural Research and Instruction Farm under Vegetable Science department, IGKV (Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh) to identify potential cross combinations among twenty-four F_1 hybrids for genetic improvement in bitter gourd obtained by crossing of four testers with six lines and are evaluated in RBD design with three replications. The analysis of variance for experimental design revealed that the differences among the mean square due to treatments were found highly significant for all the traits. In case of mean performance of F_1 hybrids Pusa Ausadhi X Pusa Rasdar followed by Kashi Suman X Pusa Rasdar and Pusa Ausadhi X Katahi Karela revealed the best promising hybrid for fruit per plant and average fruit weight while regarding fruit diameter Pusa Ausadhi X Katahi Karela, followed by Pusa Ausadhi X Pusa Rasdar" and Pusa Ausadhi X WBG-1 showed highest magnitude. Regarding earliness, BG-2 X Pusa Rasdar was the first cross to give the first picking followed by BG-2 X WBG-1 in case of days to first harvest, while among all crosses earliest female flower appearance was observed for cross BG-2 X Pusa Rasdar followed by Pusa Ausadhi X Pusa Rasdar and BG-2 X Katahi Karela.

Keywords: *Momordica charantia* L., F1 hybrids, vine length, yield per vine

Introduction
Bitter gourd (*Momordica charantia* L.; 2n= 2x=22), which belongs to family Cucurbitaceae, is an important vegetable mainly valued for its nutritional and medicinal properties. The origin of this crop is probably India with secondary centre of diversity in China (Grubben, 1977) [4]. It is widely cultivated in India, China, Malaysia, Africa, and South America (Miniraj *et al*., 1993; Singh, 1990) [6, 10]. Bitter gourd has been used for centuries in the ancient traditional medicine of India, China, Africa, and Latin America. Bitter gourd fruits also possess antioxidant, anti-microbial, anti-viral, antidiabetic activities (Welihinda *et al*., 1986; Raman and Lau, 1996) [14, 8]. Being a monoecious and highly cross-pollinated crop, large variation is observed in fruit and vegetative characters. Among the cucurbits, it is considered a prized vegetable because of its high nutritive value especially ascorbic acid and iron (Behera, 2004) [1]. It is one of the most important cucurbitaceous crops due to its potential to return profit, nutritional value, and production potential. It is often grown during the rainy season and is economically important to both small and marginal farmers. Variation in bitter gourd is mostly found in shape, size, color, cucurbitacin content, and number of tubercles. All genotypes need to be examined for identification of promising one. Bitter gourd cultivars grown in India have low average yields due to undesirable cultivars or hybrids, genetic drift in cultivars and development of new races of pathogens. Hence, we have done an experiment for development and identification of suitable bitter gourd hybrids for Chhattisgarh plain.

Materials and Methods
The present investigation was carried out in the field of Horticultural Research and Instruction farm under Vegetable Science department (Indira Gandhi Krishi Vishwavidyalaya, Raipur) in Chhattisgarh lies between 21°16‟ N latitude and 81°26‟ E longitude at altitude of 289.56 meters above the mean sea level (MSL). The experimental plot ploughed repeatedly and land was brought to fine tilth. The spacing maintained between rows was 1.5 m and between plants 1 m. Seeds are sown in portrays @ one seed per hole after soaking in water for about 12 hours to improve germination. Transplanting was done in main field after one month at one seedling per hill. Before transplantation and one day after transplantation light irrigation was given. Weeding was carried out whenever needed.

The crop was irrigated once a week and it followed other cultural practices as needed. Seedlings are planted between cemented (7 feet) poles were fixed at a distance of 20 feet and 2 lines of galvanised wire are tied to the fixed poles and gradually when vine grows, the vines were trailed on the wire and loosely tied with jute thread. The experimental material comprised of six lines (Kashi Suman, BG-1, BG-2, Pusa Ausadhi, WBGL and Karela Sel-24) and four testers of broad genetic base (Pusa Rasdar, WBG-1, Katahi Karela and BGLG-1) by using these parents twenty four F1 hybrids were developed and are evaluated in Randomized Block Design (RBD) with three replications and Kashi Suman was used as commercial check. For each replication of each entry, five randomly selected plants were labelled, and used to record the observations. The mean is taken after analysis of the five plants. Observations on various growth parameters and on flowering as well as fruit selection at their respective stages were recorded.

Results and Discussion

In any breeding programme it is essential to eliminate undesirable types, which can be obtained by examination of mean performances of genotypes or hybrids. The mean performance of twenty four crosses (Table 1.) for fourteen characters related to fruit yield and its attributing traits are recorded at their respective stages.

Vine length (cm) is important yield component which indicates the growth and vigour of the plant (Sirohi and Choudhari, 1978) [12]. The mean performance of the crosses for this traits varied from 287.11 cm (Pusa Ausadhi X WBG-1) to 623.56 (Kashi Suman X WBG-1) with overall crosses mean of 466.96 cm. Among twenty four crosses maximum mean of vine length was recorded in Kashi Suman X WBG-1 (623.56 cm) followed by Kashi Suman X Pusa Rasdar (610.11 cm) and Karela Sel-24 X WBG-1 (599.45 cm). In earlier studies also, same results were reported for vine length by Celine and Sirohi, 1996; Tewari and Ram, 1999 [13]; Singh *et al*., 2000 [11], Danareddy, 2005 [3] and Laxuman, 2005 [5].

Primary branch per vine is another important growth parameter contributing for productivity. The mean value ranged from 8.56 (Kashi Suman X WBG-1) to 15.89 (BG-2 X Katahi Karela) with overall crosses mean of 12.62. The mean performance of the crosses for these traits was recorded maximum for BG-2 X Katahi Karela (15.89) followed by BG-2 X Pusa Rasdar (15.33) and WBGL X BGLG-1 (15.11).

The short intermodal length is favourable character in cucurbits. The mean variation for this character ranged from 4.78 (BG-2 X WBG-1) to 9.70 cm (WBGL X WBG-1) with overall crosses mean of 7.25 cm. Among twenty four crosses maximum intermodal length recorded for F1 hybrid WBGL X WBG-1 (9.70 cm) followed by BG-2 X WBG-1 (9.67 cm) and Karela Sel-24 X BGLG-1 (9.04 cm).

Earliness is an important trait in a vegetable like bitter gourd. Earliness is required in such crops for realizing the potential economic yield in as less time as possible which is an important consideration for a vegetable grower. In present study five characters related to earliness were observed *viz*., days to opening of first staminate flower, days to opening of pistillate flower, number of node bearing first staminate flower, number of node bearing first pistillate flower and days to first harvest. A critical examination of the data on these characters in the material studied reveals that the mean of the most of the hybrids in respect of all these characters lower than the corresponding mean values of the commercial check (Kashi Suman). This indicates that the hybrids evaluated were earlier compared to the standard check. Looking at the mean in respect of five characters indicate that extra earliness could be identified.

For example in case of days to first staminate flower appearance mean performance among twenty four crosses ranged from 35.78 (BG-2 X Pusa Rasdar) to 51.00 days (WBGL X Katahi Karela) with overall crosses mean of 43.41. Among all crosses earliest male flower appearance was observed for cross BG-2 X Pusa Rasdar (35.78 days) followed by Pusa Ausadhi X Pusa Rasdar (37.56 days) and BG-2 X Katahi Karela (38.56 days).

The lower node value to first male flower appearance the mean performance extended between 5.67 (BG-2 X Katahi Karela) to 16.22 days (Karela Sel-24 X BGLG-1) with overall crosses mean of 10.79. The cross had lower node value to first male flower appearance was recorded in BG-2 X Katahi Karela (5.67) followed by Pusa Ausadhi X Pusa Rasdar (5.89) and Kashi Suman X Pusa Rasdar (6.33).

The earliest appearance of first pistillate flower is desirable for this character. The mean performance of twenty four crosses for days to first pistillate flower appearance ranged from 39.33 (BG-2 X Pusa Rasdar) to 59.56 days (WBGL X Katahi Karela) with overall crosses mean of 47.97. Among all crosses earliest female flower appearance was observed for cross BG-2 X Pusa Rasdar (39.33 days) followed by Pusa Ausadhi X Pusa Rasdar (40.56 days) and BG-2 X Katahi Karela (43.55 days).

The lower node value to first male flower appearance is desirable for this trait regarding earliness. Among twenty four crosses the mean performance for number of nodes bearing first staminate flower extended between 8.56 (BG-2 X Pusa Rasdar and BG-2 X WBG-1) to 19.45 days (WBGL X BGLG-1) with overall crosses mean of 13.70. The cross had lower node value to first male flower appearance was recorded in BG-2 X Pusa Rasdar (8.56) and BG-2 X WBG-1 (8.56) followed by Pusa Ausadhi X Pusa Rasdar (9.26) and BG-2 X Katahi Karela (9.45).

The lower value of days to first harvest is desirable for this trait. Among twenty four crosses BG-2 X Pusa Rasdar (46.89 days) was the first cross to give the first picking followed by BG-2 X WBG-1(52.56 days) while, WBGL X Katahi Karela (70.67 days) was last to reach the picking stage with overall crosses mean of 59.54 days. Earlier workers also reported similar results for earliness (Tewari and Ram, 1999; Ram *et al*., 1997; Singh *et al*., 2000; Danareddy, 2005; Laxuman, 2005) [13, 7, 11, 3, 5].

In case of number of fruits per vine the mean performance of twenty four crosses extended between 21.33 (WBGL X Pusa Rasdar) to 82.78 (BG-2 X BGLG-1) with overall crosses mean of 40.80. Among all crosses maximum number of fruits per vine was recorded for BG-2 X BGLG-1 (82.78) followed by BG-2 X WBG-1 (79.00) and BG-2 X Pusa Rasdar (75.44).

Number of seeds per fruit should be less to make it more acceptable to the consumer. Crosses varied significantly among themselves for number of seeds per fruit, which ranged from 6.56 (BG-2 X Katahi Karela) to 30.78 (WBGL X Katahi Karela) with overall crosses mean of 17.04. Among all crosses minimum number of seeds was recorded in BG-2 X Katahi Karela (6.56) followed by BG-1 X WBG-1 (7.11) and BG-2 X Pusa Rasdar (7.78). Similar results reported by Celine and Sirohi (1996), Laxuman (2005) [5] and Danareddy (2005) [3] in bitter gourd.

The mean variation for fruit length (cm) ranged from 4.71 cm

(BG-2 X WBG-1) to 28.72 cm (WBGL X Katahi Karela) with overall crosses mean of 13.90 cm. Among all crosses longest fruit was recorded in WBGL X Katahi Karela (28.72 cm) followed by WBGL X WBG-1 (26.11 cm) and WBGL X Pusa Rasdar (25.41 cm) while, smallest fruit was recorded in BG-2 X WBG-1 (4.71 cm) followed by BG-2 X Pusa Rasdar (5.15 cm) and BG-2 X Katahi Karela (5.22 cm). Similar results reported by Ranpise *et al.,* (1992) [9] and Danareddy (2005) [3].

The mean variation for fruit diameter (cm) ranged from 2.49 cm (BG-1 X BGLG-1) to 4.77 cm (Pusa Ausadhi X Katahi Karela) with overall crosses mean of 3.31cm. Among all crosses maximum fruit diameter recorded in Pusa Ausadhi X Katahi Karela (4.77 cm) followed by Pusa Ausadhi X Pusa Rasdar (4.50), Pusa Ausadhi X WBG-1 (4.50 cm) and Karela Sel-24 X BGLG-1 (3.84cm) while, smallest fruit diameter was recorded in BG-1 X BGLG-1 (2.49 cm) followed by BG-2 X WBG-1 (2.51cm) and BG-2 X Katahi Karela (2.63cm).

Among crosses average fruit weight (g) ranged from 17.80 gm (BG-2 X Pusa Rasdar) to 102.85 gm (Pusa Ausadhi X Pusa Rasdar) with overall crosses mean of 57.92 gm. The mean performance of twenty four crosses for average fruit weight was recorded maximum in Pusa Ausadhi X Pusa Rasdar (102.85 gm) followed by Kashi Suman X Pusa Rasdar (92.89 gm) and Pusa Ausadhi X Katahi Karela (91.51 gm). The same trend of results was recorded by Ranpise *et al.,* (1992) [9] and Danareddy (2005) [3].

Yield per vine is the ultimate and the most important trait. Among crosses fruit yield per plant (Kg) ranged from 1.09 (WBGL X Pusa Rasdar) to 2.96 Kg (Pusa Ausadhi X Pusa Rasdar) with overall crosses mean of 1.67 Kg. The mean performance of twenty four crosses for fruit yield per plant was recorded maximum in Pusa Ausadhi X Pusa Rasdar (2.96 Kg) followed by Kashi Suman X Pusa Rasdar (2.79 Kg) and Pusa Ausadhi X Katahi Karela (2.67Kg). Laxuman (2005) [5] and Danareddy (2005) [3] reported the same for yield per vine.

Table 1: Mean performance of hybrid for fruit yield and its components in bitter gourd during spring season 2020 at Raipur

Hybrids	Characters													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Kashi Suman X Pusa Rasdar	610.11	10.33	8.78	43.78	6.33	47.44	10.22	62.67	35.67	21.00	13.89	3.61	92.89	2.79
Kashi Suman X Katahi Karela	596.45	12.22	7.11	41.78	7.11	46.33	9.22	66.67	38.89	25.78	15.08	2.88	76.22	2.19
Kashi Suman X WBG-1	623.56	8.56	8.78	45.33	7.00	49.56	11.11	61.44	36.67	14.44	11.09	2.73	58.33	1.67
Kashi Suman X BGLG-1	595.78	11.11	6.11	50.44	13.78	56.11	16.00	67.67	39.22	19.55	13.74	3.08	68.33	2.44
BG-1 X Pusa Rasdar	391.78	12.00	5.11	42.33	14.11	45.22	14.04	53.78	29.44	8.11	8.53	3.61	55.87	1.18
BG-1 X Katahi Karela	524.55	14.67	8.56	43.78	11.00	46.00	14.00	55.22	38.78	9.11	9.26	2.81	45.11	1.33
BG-1 X WBG-1	495.11	15.11	7.56	40.00	12.22	43.56	15.89	51.22	39.11	7.11	9.62	2.77	41.67	1.27
BG-1 X BGLG-1	383.45	13.67	5.44	40.78	13.33	44.22	13.89	56.56	40.11	7.89	7.20	2.49	35.78	1.20
BG-2 X Pusa Rasdar	376.78	15.33	6.00	35.78	6.89	39.33	8.56	46.89	75.44	7.78	5.15	2.69	17.80	1.10
BG-2 X Katahi Karela	454.00	15.89	6.44	38.56	5.67	43.55	9.45	53.33	69.11	6.56	5.22	2.63	22.67	1.31
BG-2 X WBG-1	379.45	13.89	4.78	40.33	7.67	44.44	8.56	52.56	79.00	7.89	4.71	2.51	18.85	1.27
BG-2 X BGLG-1	300.89	13.22	5.48	40.67	8.78	43.56	10.78	52.00	82.78	8.15	5.54	2.69	20.00	1.19
WBGL X Pusa Rasdar	500.44	12.89	8.59	46.44	13.45	54.33	17.89	66.67	21.33	29.78	25.41	3.31	60.87	1.09
WBGL X Katahi Karela	476.11	13.78	8.04	51.00	15.11	59.56	19.22	70.67	22.67	30.78	28.72	3.22	65.07	1.35
WBGL X WBG-1	557.22	11.00	9.70	47.22	11.89	56.33	17.89	67.78	22.78	29.78	26.11	3.60	66.44	1.33
WBGL X BGLG-1	509.56	15.11	7.15	48.78	14.11	55.48	19.45	67.56	30.22	22.13	19.68	3.47	60.02	1.48
Pusa Ausadhi X Pusa Rasdar	317.00	12.22	7.48	37.56	5.89	40.56	9.26	53.11	33.44	21.00	21.42	4.50	102.85	2.96
Pusaausadhi X Katahi Karela	320.00	10.67	5.59	43.89	7.89	46.78	10.78	59.11	32.89	20.78	23.40	4.77	91.51	2.67
Pusa Ausadhi X WBG-1	287.11	10.22	5.48	45.33	8.33	49.33	9.67	60.00	35.33	21.89	20.78	4.50	85.14	2.44
Pusa Ausadhi X BGLG-1	377.11	11.22	7.00	41.67	10.78	45.56	13.89	56.55	41.44	17.33	13.20	3.66	55.78	1.70
Karela Sel-24 X Pusa Rasdar	400.45	10.00	8.26	42.78	13.00	45.67	15.56	59.56	34.89	17.22	9.98	3.23	65.74	1.68
Karela Sel-24 X Katahi Karela	581.67	13.33	9.67	40.89	15.11	46.11	18.67	61.22	37.89	16.22	11.69	3.39	56.78	1.53
Karela Sel-24 X WBG-1	599.45	14.11	7.93	45.00	13.33	50.89	16.33	62.11	40.11	15.22	10.44	3.46	52.42	1.49
Karela Sel-24 X BGLG-1	549.00	12.33	9.04	47.78	16.22	51.33	18.56	64.67	21.89	23.56	13.83	3.84	73.96	1.48
Mean of hybrids	466.96	12.62	7.25	43.41	10.79	47.97	13.70	59.54	40.80	17.04	13.90	3.31	57.92	1.67
CD at 5%	33.52	3.21	1.85	3.72	3.14	3.64	3.24	4.25	4.94	2.34	1.84	0.47	6.88	0.30
SEd	16.60	1.59	0.92	1.84	1.56	1.80	1.60	2.11	2.45	1.16	0.92	0.23	3.41	0.15
CV%	4.353	15.433	15.498	5.203	17.655	4.602	14.336	4.332	7.351	8.326	8.070	8.528	7.206	10.754

1. Vine length (cm) 2. Number of primary branches per vine 3. Internodal length (cm) 4. Days for first staminate flower appearance 5. Number of nodes bearing first staminate flower 6. Days for first pistillate flower appearance 7. Number of nodes bearing first pistillate flower 8. Days to first harvest 9. Number of fruits per vine 10. Number of seeds per fruit 11. Fruit length (cm) 12. Fruit diameter (cm) 13. Average fruit weight (g) 14. Fruit yield per plant (kg)

Summary and conclusion

Based on above finding it can be inferred that mean performance of F_1 hybrids will be useful breeding method to determine promising genotypes in the subsequent generations for the advancement of yield and its attributing traits in bitter gourd. The most promising crosses identified for fruit yield per plant and average fruit weight were Pusa Ausadhi X Pusa Rasdar followed by Kashi Suman X Pusa Rasdar and Pusa Ausadhi X Katahi Karela. Regarding earliness, BG-2 X Pusa Rasdar was the first cross to give the first picking followed by BG-2 X WBG-1 in case of days to first harvest. Interestingly all three of them among best one involved Pusa Rasdar as one of the parent indicating the potentiality of Pusa Rasdar as a parental line for improving productivity.

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