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Performance of bitter gourd (*Momordica charantia* L.) hybrids for growth, yield and quality under Prayagraj Agro-climatic condition

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Abstract
The present study, titled "Performance of bitter gourd (*Momordica charantia* L.) hybrids for growth, yield, and quality under Prayagraj Agro-climatic condition," was conducted during 2024-2025 at the Vegetable Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (UP). The experiment was set up in a randomized block design with 16 hybrids and three replications. According to the experimental results from the current study, bitter gourd hybrid H16 (AAKASH) was found to be most suitable for Germination percentage, H12 (2021/BIGHYB-4 AVT-II) performed best in terms of Days to Germination and H6 (2023/BIGHYB-6 IET) performed best in terms of Vine length. H10 (2021/BIGHYB-2 AVT-II) had the greatest No. of days to first appearance of female flower and Number of days to 50% flowering. H14 (2021/BIGHYB-6 AVT-II) performed best in terms of Fruit length and Fruit weight while H1 (2023/BIGHYB-1 IET) performed best in terms of Fruit diameter. H12 (2021/BIGHYB-4 AVT-II) performed best in terms of Fruit Yield (kg/plant), Fruit Yield per hectare (t/h), Quality Characters and Economic Returns. The greatest B:C ratio 2.75 was likewise reported in the same hybrid under Prayagraj Agro-climatic Condition.

Keywords: Growth, yield, quality and hybrids

Introduction
India's diverse climatic conditions make it an ideal location for growing various horticultural crops, including fruits, vegetables, flowers, aromatic and medicinal plants, spices, and plantation crops. Fruits and vegetables play a crucial role in the human diet, providing essential minerals, vitamins, and fibers for maintaining health. India is currently the second largest producer of fruits and vegetables globally, with a total production of 184.39 million tonnes from an area of 10.25 million hectares, with a productivity of 17.98 tonne per hectare.

Bitter gourd (*Momordica charantia* L.) is a tropical and subtropical important commercial vegetable crop belonging to the family Cucurbitaceae, genus Momordica. It is widely cultivated in India, Sri Lanka, Philippines, Thailand, China, Malaysia, Japan, Southeast Asia, tropical Africa, and South America. The bitter gourd is known for its bitter tender fruits, which are superior in nutritive value and covered with blunt tubercles (Thamburaj and Singh, 2018) [15].

The genus Momordica comprises 40 species distributed chiefly in Africa, with about 10 species in Southeast Asia, out of which 7 species are reported to occur in India. In India, Karnataka, Maharashtra, Tamil Nadu, and Kerala are the major growing states of this genus. The bitter taste of the fruit is due to the presence of non-toxic alkaloid “momordicine” which is different from “cucurbitacins” present in other genera of cucurbits.

Despite the economic and medicinal importance of bitter gourd, there is a prime need for crop improvement to develop varieties or hybrids suitable to specific conditions. Heterosis breeding is one of the best methods to achieve higher yield and quality in bitter gourd. F1 hybrids offer several advantages such as earliness, high yield, improved quality, uniformity, wider adaptability, and resistance to pests and diseases.

Varietal analysis techniques have been found to be useful tools for obtaining precise information

about gene actions involved in the expression of various traits and predicting the performance of progenies in later segregating generations. Each variety has its own significant effect on yield and yield components as well as quality parameters of the crop. (Lemma *et al*. 2008) [8].

Materials and Methods

"Performance of bitter gourd (*Momordica charantia* L.) hybrids for growth, yield, and quality under Prayagraj Agro-climatic condition," was undertaken at Vegetable Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (UP) during 2024-2025. The experiment was carried out to study the growth parameter, yield and quality parameters of different bitter gourd hybrids. Details are mentioned in this chapter regarding the materials and techniques used throughout the course of the investigation.

Table 1: List of the Bitter gourd hybrids used in the Experiment

S. No.	Hybrids	Symbols	Source
1.	2023/BIGHYB-1 IET	H1	IIVR, Varanasi
2.	2023/BIGHYB-2 IET	H2	IIVR, Varanasi
3.	2023/BIGHYB-3 IET	H3	IIVR, Varanasi
4.	2023/BIGHYB-4 IET	H4	IIVR, Varanasi
5.	2023/BIGHYB-5 IET	H5	IIVR, Varanasi
6.	2023/BIGHYB-6 IET	H6	IIVR, Varanasi
7.	2023/BIGHYB-7 IET	H7	IIVR, Varanasi
8.	2023/BIGHYB-8 IET	H8	IIVR, Varanasi
9.	2021/BIGHYB-1 AVT-II	H9	IIVR, Varanasi
10.	2021/BIGHYB-2 AVT-II	H10	IIVR, Varanasi
11.	2021/BIGHYB-3 AVT-II	H11	IIVR, Varanasi
12.	2021/BIGHYB-4 AVT-II	H12	IIVR, Varanasi
13.	2021/BIGHYB-5 AVT-II	H13	IIVR, Varanasi
14.	2021/BIGHYB-6 AVT-II	H14	IIVR, Varanasi
15.	2021/BIGHYB-7 AVT-II	H15	IIVR, Varanasi
16.	AAKASH	H16	VNR Seeds, Raipur

Results and Discussion

Growth Parameters

Days to Germination

The minimum days to germination of bitter gourd was recorded in H12 (2021/BIGHYB-4 AVT-II) with 7.93 while the maximum days to germination was 9.40 recorded in H11 (2021/BIGHYB-3 AVT-II). A similar study was also conducted in bitter gourd seed in which, the pre-germinated seeds resulted in rapid and uniform germination with better seedling emergence (Thirusenduraselvi and Jerlin, 2010).

Germination Percentage

The maximum Germination percentage was 78.55 recorded in H16 (AAKASH), followed by H8 (2023/BIGHYB-8 IET), while the minimum Germination percentage of bitter gourd was recorded in H3 (2023/BIGHYB-3 IET) with 58.66. The highest germination percentage can be attributed to a combination of soil and environmental factors.

Vine length (m)

The data related to Vine length (m) the maximum 3.33 was recorded in H6 (2023/BIGHYB-6 IET), followed by H8 (2023/BIGHYB-8 IET), while the minimum Vine length (m) of bitter gourd was recorded in H3 (2023/BIGHYB-3 IET) with 1.56. Additionally, external factors such as sunlight exposure, temperature and soil fertility play role in vine length. These improvements were attributed to the increased enzyme activities. Nevertheless, the morphological changes and softening in seed coat and seed treatment-stimulated embryo growth might also play crucial role in speeding up the seedling emergence by Nayak *et al.* (2016) [11].

Floral Parameters

No. of days to first male flower appearance

The minimum No. of days to first male flower appearance of bitter gourd was recorded in H4 (2023/BIGHYB-4 IET) with 37.00 while the maximum No. of days to first male flower appearance 44.53 was recorded in H16 (AAKASH), followed by H14 (2021/BIGHYB-6 AVT-II). The No. of days to first male flower appearance plays an important role in deciding the earliness or lateness of crop in general. Additionally, environmental factors such as temperature, photoperiod and nutrient availability can influence flowering time. Similar finding was reported by Kumar *et al.* (2011) in Bitter gourd. Similar results were also reported by Rao and Rao (2008) [12] in Ridge gourd.

No. of days to first female flower appearance

The minimum No. of days to first female flower appearance of bitter gourd was recorded in H10 (2021/BIGHYB-2 AVT-II) with 36.93, while the maximum No. of days to first female flower appearance was recorded in H2 (2023/BIGHYB-2 IET) with 45.20 followed by H16 AAKASH. The No. of days to first female flower appearance plays an important role in deciding the earliness or lateness of crop in general. Additionally, environmental factors such as temperature, photoperiod and nutrient availability can influence flowering time. Similar finding was reported by Kumar *et al.* (2011) [6].

Node at which first female flower appears

Among the different hybrids minimum node number at which first female flower appears of different hybrids of bitter gourd was recorded in H5 (2023/BIGHYB-5 IET) with 3.33 while the maximum was recorded in H11 (2021/BIGHYB-3 AVT-II) with 16.80, followed by H13 (2021/BIGHYB-5 AVT-II). The node number at which first female flower appears play an important role in deciding the earliness or lateness of crop in general. The occurrence of the first female flower at a minimum node number can be attributed to genetic factors and plants physiological efficiency. The benefit of having the first female flower at a lower node number is that it accelerates the reproductive cycle leading to earlier pollination, fruit set and overall production of the crop. Similar finding was reported by Kumar *et al.* (2011), Bitter gourd. The variation in node number at which first female flower appears might have been due to specific genetic makeup of different genotypes prevailing environment condition. Similar findings were reported by Bairagi *et al.*, Sharma and Bhattarai (2013) [14].

Node at which first male flower appears

Among the different hybrids the minimum node number at which first male flower appears of different hybrids of bitter gourd was recorded in H5 (2023/BIGHYB-5 IET) with 3.00 while the maximum node number at which first male flower appears was recorded in H14 (2021/BIGHYB-6 AVT-II) with 14.00 followed by H16 (AAKASH). The node number at which first male flower appears play an important role in deciding the earliness or lateness of crop in general. Similar finding was reported by Kumar *et al.* (2011) [6] in Bitter gourd. Similar results were also reported by Rao and Rao (2008) [12] in Ridge gourd. Node to first male and female also reported wide range of

variability. Considerable variation for the character was also reported by Thakur *et al*, (1944) [13] in bitter gourd and Varalakshmi in bitter gourd. The occurrence of first male flower is attributed to genetic factors and the plants efficiency. The benefit of having first male flower at a lower node is that it accelerates the reproductive cycle leading to earlier pollination. Earlier pollination enhances fruit set and overall crop yield.

Number of days to 50% flowering

The data related to number of days to 50% flowering the minimum number of days to 50% flowering of bitter gourd was recorded in H10 (2021/BIGHYB-2 AVT-II) with 39.00 while the maximum was recorded in H2 (2023/BIGHYB-2 IET) with 46.00. The results are in agreement with the finding of Aruna and Swaminathan (2012) [1] and Husna *et al.* (2011) [5] in Bottle gourd. Similarly, the variation in number of days to 50% flowering might be due to the specific genetic constitution, inherent character and vigour of different genotypes. Considerable variability was reported by Ram, for number of days to 50% flowering and Yadav, *et al*. (2008) [17]. The minimum no. of days to 50% flowering can be attributed to genetic and environmental factors.

Table 2: Mean Performance of different hybrids of Bitter gourd on growth and floral parameter

Hybrids	Days to Germination	Germination Percentage	Vine length (m)	No. of days to first male flower appearance	No. of days to first female flower appearance	Node at which first female flower appears	Node at which first male flower appears	Number of days to 50% flowering
H1	8.13	76.67	2.70	39.47	40.00	15.33	8.33	42.00
H2	8.53	77.22	2.47	41.80	45.20	12.40	10.40	46.00
H3	8.12	58.66	1.56	39.20	39.21	4.00	3.50	41.00
H4	8.16	60.00	1.67	37.00	40.12	8.87	6.40	42.00
H5	8.00	59.20	1.76	39.00	40.00	3.33	3.00	42.00
H6	8.07	76.80	3.33	38.33	39.00	11.00	9.20	41.00
H7	8.27	76.20	2.63	40.13	41.93	9.60	8.80	43.00
H8	9.13	78.20	3.15	42.13	41.27	13.07	11.93	44.00
H9	8.33	76.85	2.53	37.93	38.73	10.47	8.40	40.00
H10	9.00	76.90	1.83	37.82	36.93	11.80	5.73	39.00
H11	9.40	76.25	3.02	39.40	42.27	16.80	6.87	43.00
H12	7.93	76.80	3.03	40.80	40.67	15.60	11.53	42.00
H13	8.93	76.86	2.57	41.73	42.20	16.60	12.93	43.00
H14	9.27	77.50	2.63	42.67	43.87	15.47	14.00	44.00
H15	8.53	76.67	1.57	39.47	40.40	11.40	9.67	41.00
H16	9.00	78.55	2.37	44.53	44.53	14.47	13.27	45.00
F- test	S	S	S	S	S	S	S	S
SE(m)	0.236	6.082	0.228	3.703	6.309	2.582	1.681	0.759
C. D. (P = 0.05)	0.487	12.553	0.47	7.644	13.022	5.329	3.47	1.567
C.V.	0.01	6.936	0.01	2.572	7.463	1.25	0.53	0.108

Yield Parameters

No. of fruit/plant

Further the data indicates that the maximum No. of fruit/plant (28.07) was recorded in H10 (2021/BIGHYB-2 AVT-II), followed by H8 (2023/BIGHYB-8 IET), while the minimum No. of fruit/plant of bitter gourd was recorded in H16 (AAKASH) with (19.60). This means that the plants continue to produce fruits for a longer period, resulting in an overall increase in fruit yield. Similar observation was recorded by Meerabai *et al.*, 2007 [9]. Additionally environmental factors such as pollination efficiency, availability of nutrients, water and optimal growing conditions can influence fruit production.

Fruit Length (cm)

The maximum Fruit Length (cm) 13.73 was recorded in H14 (2021/BIGHYB-6 AVT-II), followed by H12 (2021/BIGHYB-4 AVT-II), while the minimum Fruit Length (cm) of bitter gourd was recorded in H1 (2023/BIGHYB-1 IET) with 5.93. The better performance of enhanced fruit length can be attributed to genetic factors and environmental condition. The Similar findings were previously reported by Mishra *et al.* (2019) [10], Kumar S, Thakur, P *et al.* (2013) [14] and also reported more or less similar results in Bitter gourd.

Fruit Diameter (cm)

The maximum Fruit Diameter (cm) 5.93 was recorded in H1 (2023/BIGHYB-1 IET), followed by H15 (2021/BIGHYB-7 AVT-II), while the minimum Fruit Diameter (cm) of Bitter gourd was recorded in H3 (2023/BIGHYB-3 IET) with 3.21. The length of fruits may be due to its hybrid vigour and adaptability to Prayagraj Agro-climatic condition and genetic factors. The Similar findings were previously reported by Mishra *et al.* (2019) [10], Kumar, S *et al. (*2018), Thakur, P *et al.* (2013) [14] and also reported more or less similar results in Bitter gourd.

Fruit Weight (g)

The maximum Fruit Weight (g) 90.00 was recorded in H14 (2023/BIGHYB-7 IET), followed by H12 (2021/BIGHYB-4 AVT-II), while the minimum Fruit Weight (g) of bitter gourd was recorded in H15 (2021/BIGHYB-7 AVT-II) with 43.30. The significant variation in weight of fruits might have been due to fruit set percentage, fruit length, number of fruits per vine and fruit width, genetic nature, environmental factor and vigour of the crop and higher uptake of nutrient. The findings were supported by Kumar *et al.* (2018) [7], and Mishra *et al.* (2019) [10] also reported more or less similar results in Bitter gourd.

Yield of fruits kg/plant

The data related to Yield of fruits (kg/plant), the maximum 2.00 was recorded in H12 (2021/BIGHYB-4 AVT-II), followed by H14 (2021/BIGHYB-6 AVT-II), while the minimum Yield of fruits kg/plant) of bitter gourd was recorded in H16 (AAKASH) with 0.9. Increasing of number of fruits plant is mostly influenced by genetic factor, environmental factor, hormonal factor and vigour of the crop. The Fruit plant is one of the major

factors for deciding the yield of the crop. The Similar findings were previously reported by Kumar Sushil, *et al.* (2018), Thakur, P *et al.* (2013) [14], Husna, A *et al.* (2011) [5].

Yield of fruits / hectare (t/h)

Regarding in Yield of fruits per hectare (t/h), the maximum 20.70 was recorded in H12 (2021/BIGHYB-4 AVT-II), followed by H8 (2023/BIGHYB-8 IET), while the minimum Yield of fruits per hectare (t/h) of bitter gourd was recorded in H3 (2023/BIGHYB-3 IET) with 9.05. The higher yield of fruits is due to its inherent characteristics, better adaptability for the environmental condition and efficiently all available factors *viz.* water, nutrient, light and CO_2. None of the treatments significantly influenced the plant stand. The Similar findings were previously reported by Kumar, K *et al*. (2018) [7], Thakur, P *et al*. (2013) [14] Husna, A *et al*. (2011) [5].

Quality Parameters

Total soluble solid (°Brix)

The maximum Total soluble solid (°Brix) 4.70 was recorded in H12 (2021/BIGHYB-4 AVT-II), followed by H8 (2023/BIGHYB-8 IET) and the minimum Total soluble solid (°Brix) of bitter gourd was recorded in H4 (2023/BIGHYB-4 IET) with 3.1. The difference may be due to the inherent character and genetic makeup of the varieties and environmental condition and the similar findings were previously reported by Aruna & Swaminathan *et al.* (2012) [1], Harika *et al.* (2012) and Iqbal, M *et al.* (2018).

Vitamin C (mg/100g)

The data related to Vitamin C (mg/100g), the maximum 60.00 was recorded in H12 (2021/BIGHYB-4 AVT-II), followed by H8 (2023/BIGHYB-8 IET), and the minimum Vitamin C (mg/100g) of bitter gourd was recorded in H2 (2023/BIGHYB-2 IET) with 51.40. The difference may be due to the inherent character and genetic makeup of the varieties and environmental condition the similar findings were previously reported by Aruna & Swaminathan *et al.* (2012) [1], Harika *et al.* (2012) and Iqbal, M *et al.* (2018).

Table 3: Mean Performance of different hybrids of Bitter Gourd on Yield and Quality parameters

Hybrids	No. of fruit/plant	Fruit Length (cm)	Fruit Diameter (cm)	Fruit Weight (g)	Yield of fruits kg/plant	Yield of fruits / hectare (t/h)	Total soluble solid (°Brix)	Vitamin C (mg/100g)
H1	25.27	5.93	5.93	49.53	1.20	12.50	3.30	52.30
H2	22.93	11.13	4.18	51.17	1.10	11.70	3.53	51.40
H3	20.12	8.21	3.21	45.00	0.90	9.05	3.30	53.40
H4	25.73	10.33	3.60	51.30	1.30	13.20	3.10	58.60
H5	21.32	8.36	3.33	43.60	0.90	9.30	4.00	54.30
H6	25.60	9.65	3.42	50.10	1.20	12.80	4.20	52.20
H7	25.13	12.07	3.43	75.26	1.00	18.90	3.60	51.90
H8	26.67	9.13	3.67	76.73	2.00	20.50	4.50	59.60
H9	26.47	12.73	3.45	54.08	1.40	14.30	4.10	57.70
H10	28.07	12.20	4.44	69.30	1.90	19.50	4.30	53.30
H11	24.20	8.73	3.68	45.33	1.00	11.00	4.00	52.20
H12	24.87	13.70	4.34	83.19	2.00	20.70	4.70	60.00
H13	23.27	13.37	3.38	77.41	1.80	18.00	4.10	56.60
H14	21.67	13.73	4.19	90.00	1.90	19.50	4.40	58.80
H15	22.47	8.20	5.77	43.30	0.90	9.70	4.30	57.80
H16	19.60	10.93	3.61	49.08	0.90	9.60	4.20	55.30
F- test	S	S	S	S	S	S	S	S
SE(m)	0.403	0.412	0.114	1.593	0.056	0.201	0.053	1.972
C. D. (P = 0.05)	0.832	0.851	0.236	3.287	0.115	0.414	0.11	4.07
C.V.	0.031	0.032	0.002	0.476	0.001	0.008	0.001	0.729

Economics analysis

Economics of all hybrids were calculated according to the expenditure occurred from then raising till harvesting of fruits *viz*. Cost of cultivation, gross return, net return, and benefit cost ratio has been worked out for 16 hybrids. Maximum gross return was recorded of 538200 Rs./ha was obtained from the hybrid H12 (2021/BIGHYB-4 AVT-II), followed by H8 (2023/BIGHYB-8 IET) 394700 Rs./ha and so on. Maximum net return was recorded of 533000 Rs./ha was obtained from the hybrid H12 (2021/BIGHYB-4 AVT-II), followed by H8 (2023/BIGHYB-8 IET) 389500 Rs./ha and so on. Maximum B:C ratio was recorded of 1: 2.75 was recorded from the hybrid H12 (2021/BIGHYB-4 AVT-II), followed by H8 (2023/BIGHYB-8 IET) 1:2.71 and so on.

Table 4: Cost benefit ratio of different hybrids of Bitter gourd

Hybrids	Cost of cultivation (Rs./ha)	Total yield (t/ha)	Gross return (Rs./ha)	Net return Rs./ha)	Benefit cost ratio
H1	1,43,500	12.5	325000	181500	1.26
H2	1,43,500	11.7	304200	160700	1.12
H3	1,43,500	9.05	235300	91800	0.64
H4	1,43,500	13.2	343200	199700	1.39
H5	1,43,500	9.3	241800	98300	0.69
H6	1,43,500	12.8	332800	189300	1.32
H7	1,43,500	18.9	491400	347900	2.42
H8	1,43,500	20.5	533000	389500	2.71
G9	1,43,500	14.3	371800	228300	1.59
H10	1,43,500	19.5	507000	363500	2.53

H11	1,43,500	11	286000	142500	0.99
H12	1,43,500	20.7	538200	394700	2.75
H13	1,43,500	18	468000	324500	2.26
H14	1,43,500	19.5	507000	363500	2.53
H15	1,43,500	9.7	252200	108700	0.76
H16	1,43,500	9.6	249600	106100	0.74

Conclusion

Based on the above experimental findings, it is concluded that H16 (AAKASH) was found to be most suitable for Germination percentage, H12 (2021/BIGHYB-4 AVT-II) performed best in terms of Days to Germination and H6 (2023/BIGHYB-6 IET) performed best in terms of Vine length. H10 (2021/BIGHYB-2 AVT-II) had the greatest No. of days to first appearance of female flower and Number of days to 50% flowering. H14 (2021/BIGHYB-6 AVT-II) performed best in terms of Fruit length and Fruit weight while H1 (2023/BIGHYB-1 IET) performed best in terms of Fruit diameter. H12 (2021/BIGHYB-4 AVT-II) performed best in terms of Fruit Yield (kg/plant), Fruit Yield per hectare (t/h), Quality Characters, and Economic Returns. The greatest B:C ratio 2.75 was likewise reported in the same hybrid under Prayagraj Agro-climatic Condition. However, because this is based on a one-year investigation, further trials may be required to validate the.

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