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Anurag Singh
M.Sc. Scholar, Department of Vegetable Science, ANDUA&T, Ayodhya, Uttar Pradesh, India

Anil Kumar
Assistant Professor, Department of Vegetable Science, ANDUA&T, Ayodhya, Uttar Pradesh, India

Abhishek Singh
M.Sc. Scholar, Department of Vegetable Science, ANDUA&T, Ayodhya, Uttar Pradesh, India

Sonu Ram
M.Sc. Scholar, Department of Vegetable Science, ANDUA&T, Ayodhya, Uttar Pradesh, India

Vipin
Ph.D. Scholar, Department of Vegetable Science, ANDUA&T, Ayodhya, Uttar Pradesh, India

Virendra Kumar
Ph.D. Scholar, Department of Vegetable Science, ANDUA&T, Ayodhya, Uttar Pradesh, India

Corresponding Author:
Anil Kumar
Assistant Professor, Department of Vegetable Science, ANDUA&T, Ayodhya, Uttar Pradesh, India

Evaluation of yield parameters and quality characteristics in bitter gourd (*Momordica charantia* L.)

Anurag Singh, Anil Kumar, Abhishek Singh, Sonu Ram, Vipin and Virendra Kumar

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Abstract
The present study was conducted at the College of Horticulture and Forestry, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj during the Zaid season of 2023. Planting material consisted of 36 genotypes of bitter gourd along with one check namely Kashi Pratistha laid out in Randomized Block Design with three replications. Evaluation was done for different yield and quality traits. Among the test entries, range for fruit yield per plant varied from 1177.98 g to 3510.91 g and it was highest in NDBG-16/22 (3510.91 g/plant) followed by NDBG-11/22 (3362.24) and NDBG-14/22 (3255.38) performed better over the check, while it was lowest in V-204 (1177.98/plant). number of fruits per plant, average fruit weight, vine length, number of primary branches per plant, ascorbic acid content and dry weight was found to be maximum in NDBG-16/22 having value (34.35), (102.21 g), (3.25 m), (3.35), (119.20 mg/100 g) and (5.60 g) respectively.

Keywords: Bitter gourd, earliness, quality traits, variability, yield per plant

Introduction
Bitter gourd (*Momordica charantia* L.) is a well-known vegetable crop from the cucurbitaceae family, often referred to as bitter melon, karela or balsam pear. It is believed to be originated in tropical Asia especially in eastern region of India. In India primary state producing bitter gourd include Uttar Pradesh, Orissa, Maharashtra, Andhra Pradesh, Tamil Nadu, Kerala, Gujrat, Rajasthan and Punjab. The genus *Momordica* derive its name from latin word ‘mordicus’ (momordi = to bite), referring to seeds grooved margins that appear bitten. Bitter gourd is one of the most important summer season vegetables grown nationwide among the cultivated cucurbits. It belongs to family Cucurbitaceae, sub family Cucurbitoideae, tribe Joliffeae and sub tribe Thalithaneae. The genus Momordica comprises approximately 59 species (Schefer and Rener, 2010) [7]. Six closely related species of bitter gourd have been recently found in India and are used for nutritional and medicinal properties (Bharathi and John, 2013) [3].
It is an ancient medicinal vegetable crop rich in nutritive value including vitamin and minerals. Bitter gourd extracts, traditionally referred to as vegetable insulin containing hypoglycemic, antioxidative and antidiabetic agents that are beneficial for diabetes patients (Behera *et al*. 2010) [2]. The tender fruits of bitter gourd are highly popular and are consumed in various form such as boiled, curried, stuffed or fried (Singh *et al*. 2016) [8]. Bitter gourd fruits possess antidiabetic properties due to presence of hypoglycemic substance called “cheratin”, which helps in reducing blood sugar level.
Tropical and subtropical regions are best suited for growth and development of bitter gourd. Optimum temperature for bitter gourd cultivation is 24° to 27 °C. Plants are vulnerable to frost and low temperatures retard its growth and development. Bitter gourd can be grown under diverse tropical conditions at different levels and soil types
Genetic parameters such as the genotypic coefficient of variation, heritability and genetic advance provide a solid foundation for selection. Effective selection can enhance yield but relying solely on yield for selection can be misleading due to its complexity and dependance on various components for complete expression.

To improve yield, it is essential to estimate correlation coefficient to understand the relationship between yield and its component traits.

Materials and Methodology

The experimental plant material comprised 36 genotypes of bitter gourd laid out in Randomized Block Design having spacing of 3.0 m x 0.5 m with three replication during zaid season of 2023 at the College of Horticulture and Forestry, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj. Seeds of thirty-six genotypes of bitter gourd were sown during first week of March. The crop was cultivated following recommended package of practices of vegetables by Department of Vegetable Science, ANDUA&T, Kumarganj, Ayodhya.

Geographically, Kumarganj falls under humid sub-tropical climate and is located in between 24.470 and 26.560 N latitude and 82.120 and 83.980 E longitude at an altitude of 113 m above the mean sea level in the Gangetic alluvial plains of Eastern Uttar Pradesh.

The data were collected on 14 quantitative characters such as days to first staminate flower anthesis, days to first pistillate flower anthesis, node number to first staminate flower appearance, node number to first pistillate flower appearance, number of primary branches per plant, internodal length, vine length, days to first fruit harvest, average fruit weight, fruit equatorial circumference, fruit length, number of fruits per plant, fruit yield per plant, fruit yield per plot and three qualitative characters such as ascorbic acid content, total soluble solid and dry weight.

List of genotypes and their source of collection

S. No.	Name of genotypes	Source of collection
1.	NDBG-5/22	ANDUAT, Ayodhya
2.	NDBG-6/22	ANDUAT, Ayodhya
3.	NDBG-7/22	ANDUAT, Ayodhya
4.	NDBG-8/22	ANDUAT, Ayodhya
5.	NDBG-9/22	ANDUAT, Ayodhya
6.	NDBG-11/22	ANDUAT, Ayodhya
7.	NDBG-13/22	ANDUAT, Ayodhya
8.	NDBG-14/22	ANDUAT, Ayodhya
9.	NDBG-15/22	ANDUAT, Ayodhya
10.	NDBG-16/22	ANDUAT, Ayodhya
11.	NDBG-17/22	ANDUAT, Ayodhya
12.	NDBG-18/22	ANDUAT, Ayodhya
13.	IC-065635	IIVR, Varanasi
14.	IC-065636	IIVR, Varanasi
15.	IC-065637	IIVR, Varanasi
16.	IC-065638	IIVR, Varanasi
17.	IC-065639	IIVR, Varanasi
18.	IC-065640	IIVR, Varanasi
19.	IC-065642	IIVR, Varanasi
20.	IC-065643	IIVR, Varanasi
21.	Daral-43	IIVR, Varanasi
22.	BBGS-09-01	IIVR, Varanasi
23.	V-21-14	IIVR, Varanasi
24.	V-204	IIVR, Varanasi
25.	V-221	IIVR, Varanasi
26.	V-65-2	IIVR, Varanasi
27.	V-193	IIVR, Varanasi
28.	V-5	IIVR, Varanasi
29.	V-74	IIVR, Varanasi
30.	V-198	IIVR, Varanasi
31.	V-158	IIVR, Varanasi
32.	V-26	IIVR, Varanasi
33.	V-169	IIVR, Varanasi
34.	V-194	IIVR, Varanasi
35.	V-63	IIVR, Varanasi
36.	Kashi Pratistha (Check)	IIVR, Varanasi

Results and Discussion

NDBG-16/22 reported minimum days to first staminate flower anthesis (43.35) followed by NDBG-11/22 (44.26), while NDBG-18/22 (55.32) took maximum days to first staminate flower anthesis followed by IC-065636 (53.65). Study conducted by Singh *et al.* (2019) [9] showed similar result where he observed days to anthesis of first staminate flower range from 34.57 (Padma) to 51.47 days (Ratna).

Minimum days to first pistillate flower anthesis after seed sowing reported by NDBG- 16/22 (47.66) followed by NDBG-11/22 (48.66), whereas IC-065637 (60.00) followed by IC-065635 (58.33) took maximum days. Similar result was found by Singh *et al.* (2019) [9] that days to anthesis of first pistillate flower ranged from 41.10 (Ramali Karela) to 61.33 (CH-65).

Genotype NDBG-16/22 (6.25) followed by NDBG-11/22 (6.85) recorded the lowest node number to first staminate flower whereas V-63 (12.60) followed by NDBG-17/22 (12.12) recorded maximum number for node number to first staminate flower appearance. In a similar study, Thakur *et al.* (2018) [12] founded that node no to first staminate flower ranges from 9.21 (Punjab-14) to 22.34 (Preeti).

NDBG-16/22 (10.33) flowered pistillate flower on the lowest node followed by NDBG- 11/22 (10.85). In contrast, V-63 (17.20) followed by NDBG-17/22 (16.93) flowered on the highest node. Similar observation was reported by Thakur *et al.* (2018) [12] where he reported that node number to first pistillate flower appearance varies from 11.57 (Solan Hara) to Preethi (25.53).

Maximum number of primary branches per plant at the time of final harvesting was reported by NDBG-16/22 (3.35) followed by NDBG-11/22 (3.30), while V-63 (2.13) followed by V-158 (2.13) showed minimum no of primary branches per plant. Similarly, Kumar *et al*. (2020) [5] reported that minimum number of primary branches was found in Kahelgoan Local (3.90) while it was maximum in Small B.G. (16.50).

Maximum internodal length was assessed in NDBG-17/22 (5.73 cm) followed by V-74 (5.61cm) and minimum internodal length was observed for NDBG-16/22 (3.20 cm) followed by NDBG-11/22 (3.25cm). In a similar study, Kumar *et al.* (2020) [5] observed that minimum internodal length was reported in Small B.G. (4.94cm) and highest in US 6214 (8.05cm).

Genotype NDBG-16/22 (3.25 m) closely followed by NDBG-11/22 (3.10 m) recorded longest vine length at the time of final harvest. In contrast, V-204 (1.90 m) followed by IC- 065642 (2.05 m) recorded minimum vine length. Similarly, Singh *et al.* (2023) [10] reported that vine length was observed lowest in hybrid AVT-1/2020/BIGHYB-6 (2.67 m) and highest in hybrid KSP 120 (4.10 m).

NDBG-16/22 (54.25) showed earliness for days to first fruit harvest followed by NDBG-11/22 (55.36) and V-65-2 (71.00) took maximum days for first fruit harvest followed by V-198 (71.00). Singh *et al.* (2019) [9] also observed that Ramali Karela (52.13) took minimum days for first fruit harvest, while CH-65 (75.67) took maximum days.

Result of average fruit weight showed that it was maximum in NDBG-16/22 (102.21 g) closely followed by NDBG-11/22 (101.12 g) and minimum in V-221 (52.52 g) followed by IC-065635 (57.59 g). These findings are consistent with Singh *et al.* (2024) [11] where he founded that average fruit weight varies from 77.76 g (NDBG-6) to 52.96 g (NDBG-12).

In case of fruit length, genotype NDBG-11/22 (21.86 cm) followed by NDBG-16/22 (20.16 cm) showed longest fruit length while it was minimum for V-21-14 (9.26 cm) followed by V-204 (9.76 cm). Singh *et al.* (2023) [10] reported similar study where he founded that AVT- I/2020/BIGHYB-3 (14.13 cm) has highest fruit length and AVT-II/2019/BIGHYB-4 (7.83 cm) showed minimum fruit length.

Genotype NDBG-16/22 (14.40 cm) followed by NDBG-11/22 (14.30 cm) showed maximum fruit equatorial circumference, whereas it was minimum in V-198 (10.12 cm) followed by V-63 (10.69 cm). The result is in line with Triveni *et al*. (2021) [13] where maximum fruit width was observed for IC-113875 (5.82 cm) and minimum for IC-85626 (4.21 cm).

Maximum number of fruits per plant was found in NDBG-16/22 (34.35) followed by NDBG-11/22 (33.25) while it was minimum for V-65-2 (19.33) followed by V-158 (19.34). Similar result was reported by Priyadarshini *et al.* (2018) [6] where the genotype MCM-23 (89.67) have highest number of fruits per plant.

The result showed that significant difference observed between the genotypes for fruit yield per plant which varies from 3510.91 g (NDBG-16/22) to 1177.98 g (V-204) with an average of 2093.24 g. The highest amount of fruit yield per plant was observed in NDBG-16/22 (3510.91 g) followed by NDBG-11/22 (3362.24 g) and NDBG-14/22 (3255.38 g) which were found significant over check variety Kashi Pratistha (3247.16 g). In a similar study, Thakur *et al.* (2018) [12] reported that lowest fruit yield was founded in Solan Hara (0.57 kg) and maximum in Prachi (2.68 kg).

NDBG-16/22 (17.55 kg) followed by NDBG-11/22 (16.80 kg) showed highest fruit yield per plot whereas V-204 (5.88 kg) followed by IC-065635 (6.13 kg) showed minimum yield per plot. Khan *et al.* (2021) [4] also observed similar result in which he found that Kiran (12.01 kg) showed maximum yield per plot and Peshawar Local (8.76) showed minimum.

Genotype NDBG-16/22 (119.20 mg/100 g) followed by NDBG-11/22 (118.24 mg/100 g) contains highest ascorbic acid content while it was lowest in IC-065638 (69.33 mg/100 g) closely followed by NDBG-5/22 (70.33 mg/100 g). Similar result observed by Behera and Kaur (2006) [1] here he reported that highest amount of ascorbic acid was found in genotype DBTG-3 (122.07 mg/100 g) and lowest in DBTG-5 (92.15 mg/100 g).

The variation in T.S.S. varied from 2.20 (NDBG-16/22) to 5.12 (V-63) while its general mean was found to be 3.56. The lowest T.S.S. was found in NDBG-16/22 (2.20) closely followed by NDBG-11/22 (2.30) while it was highest in V-63 (5.12) followed by V-74 (4.87). Similar study was done by Kumar *et al*. (2020) [5] where he reported that minimum T.S.S. was observed by Vivek (4.26) while maximum in BRBG-1 (8.17).

Dry weight was found to be lowest in V-204 (4.83 g) followed by V-74 (4.87 g) while it was highest in NDBG-16/22 (5.60 g) followed by NDBG-11/22 (5.55). These findings are consistent with Singh *et al.* (2024) [11] who observed that highest dry weight was found in NDBG- 12 (12.81 g) and lowest in NDBG-7 (7.66 g).

Table 1: Mean performance of 36 genotypes for seventeen characters in bitter gourd

Genotypes	Days to first staminate flower anthesis	Days to first pistillate flower anthesis	Node no to first staminate flower appearance	Node no to first pistillate flower appearance	Vine length (m)	No of primary branches / plant	Internodal length (cm)	Days to first fruit harvest	Fruit equatorial circumference (cm)	Average fruit weight (g)	Fruit length (cm)	No. of fruits per plant	Fruit yield per plant (g)	Fruit yield per plot (kg)	Ascorbic acid content (mg/100 g)	Dry weight (g)	T.S.S (°Brix)
NDBG-5/22	52.33	57.66	10.23	14.26	2.74	2.66	5.46	67.33	11.23	74.13	13.06	27.00	2001.51	10.00	70.33	5.00	3.55
NDBG-6/22	48.66	54.33	8.46	13.45	2.35	2.40	4.58	65.66	12.96	71.95	12.36	27.00	1942.83	9.71	91.00	4.99	3.67
NDBG-7/22	47.33	49.32	8.64	11.49	2.33	3.05	3.50	59.35	14.10	97.25	17.52	32.66	3176.19	15.88	98.66	5.43	2.70
NDBG-8/22	52.66	58.00	10.25	14.60	2.82	2.46	4.89	68.66	12.30	78.49	16.20	25.67	2014.66	10.07	80.00	5.23	4.01
NDBG-9/22	49.66	53.66	9.00	14.13	2.28	2.33	4.96	64.66	11.50	73.00	15.33	22.33	1630.33	8.15	85.33	5.38	3.29
NDBG-11/22	44.26	48.66	6.85	10.85	3.1	3.30	3.25	55.36	14.30	101.12	21.87	33.25	3362.24	16.80	118.24	5.55	2.30
NDBG-13/22	49.66	53.66	9.80	14.80	2.24	2.40	5.73	65.66	13.30	82.85	15.68	26.00	2154.19	10.75	88.00	5.02	4.23
NDBG-14/22	44.86	48.99	7.21	11.02	2.99	3.19	3.30	57.27	14.19	98.35	18.50	33.10	3255.39	16.27	117.25	5.50	2.40
NDBG-15/22	51.00	55.00	9.94	14.20	3.09	2.33	4.94	67.00	13.40	92.33	14.86	21.33	2136.59	10.68	95.33	5.38	3.71
NDBG-16/22	43.35	47.66	6.25	10.33	3.25	3.35	3.20	54.25	14.40	102.21	20.16	34.35	3510.91	17.55	119.20	5.60	2.20
NDBG-17/22	52.99	58.00	12.12	16.93	3.09	2.20	4.81	68.00	12.96	64.42	15.20	28.67	1846.71	9.23	84.33	5.13	4.67
NDBG-18/22	55.32	58.00	10.26	15.26	2.44	2.26	4.23	70.33	12.73	78.62	11.90	24.33	1913.25	9.56	81.33	5.23	3.67
IC-065635	53.65	58.33	9.84	14.86	2.24	2.46	4.47	70.00	12.53	57.59	11.93	21.33	1228.59	6.14	84.00	5.34	4.29
IC-065636	51.66	58.33	9.86	14.80	2.53	2.26	4.71	69.00	11.47	85.62	15.93	25.33	2169.12	10.84	70.33	5.31	3.53
IC-065637	53.33	60.00	9.88	14.73	2.21	2.53	5.01	66.00	12.73	75.67	15.06	27.00	2043.27	10.21	80.67	5.25	3.17
IC-065638	53.33	57.00	10.13	14.60	2.34	2.46	4.15	69.33	12.36	82.42	15.56	21.33	1758.37	8.79	69.33	5.26	3.55
IC-065639	49.35	50.65	9.02	11.89	2.49	3.02	3.60	60.20	14.05	96.30	17.40	31.25	3009.37	15.04	97.25	5.40	2.80
IC-065640	52.00	57.33	9.98	14.60	2.74	2.26	4.45	68.66	13.17	78.38	13.20	26.67	2090.13	10.45	72.67	5.28	3.45
IC-065642	53.33	58.67	9.66	14.79	2.05	2.60	4.73	68.33	13.97	65.03	10.86	23.67	1539.20	7.69	80.67	5.34	4.18
IC-065643	51.66	56.33	11.06	15.73	2.75	2.40	4.58	68.33	11.73	68.56	13.33	27.00	1851.21	9.25	75.33	5.13	3.63
Daral-43	52.66	58.33	10.60	15.26	2.68	2.46	5.52	69.00	12.00	91.46	15.36	21.33	1951.29	9.75	82.00	5.38	3.19
BBGS-09-01	49.66	52.35	9.46	12.90	2.36	2.87	4.10	62.10	14.01	94.24	17.20	29.33	2764.06	13.82	93.25	5.40	2.90
V-21-14	53.33	57.66	8.86	13.93	2.32	2.26	4.40	69.66	12.46	67.19	9.26	24.67	1657.44	8.28	84.33	5.36	3.70
V-204	52.31	52.33	8.86	13.85	1.90	2.60	5.54	63.66	12.63	57.93	9.76	20.33	1177.98	5.88	79.33	4.83	4.39
V-221	51.24	53.33	10.66	15.05	2.28	2.20	5.10	65.00	13.46	52.52	13.40	24.33	1278.07	6.39	88.00	5.37	3.87
V-65-2	52.32	57.00	9.97	14.40	2.72	2.40	4.59	71.00	12.43	91.24	14.16	19.33	1763.97	8.81	81.00	5.33	3.47
V-193	48.66	51.31	9.03	12.06	2.79	2.98	3.65	61.25	14.02	95.14	17.30	30.66	2916.99	14.58	94.33	5.36	2.60
V-5	50.00	53.66	10.87	14.00	2.33	2.46	4.74	64.00	12.66	70.73	11.63	23.33	1650.52	8.25	88.33	5.33	3.63
V-74	49.00	52.66	10.56	13.33	2.47	2.26	5.61	68.00	11.00	72.51	13.53	27.67	2006.20	10.03	85.00	4.87	4.75
V-198	52.31	56.33	9.46	14.09	2.87	2.46	3.65	71.00	10.12	68.01	11.93	28.00	1904.28	9.52	81.67	5.32	4.35
V-158	49.33	53.33	10.23	14.05	3.18	2.13	5.42	69.33	11.46	76.72	13.26	19.34	1483.38	7.41	79.67	5.31	4.43
V-26	51.33	56.33	9.93	14.66	2.67	2.40	4.11	70.66	12.23	76.30	15.50	25.00	1907.50	9.53	88.00	5.34	3.51
V-169	52.66	57.66	10.97	14.20	2.38	2.33	5.59	68.33	13.40	74.36	16.96	27.33	2032.51	10.16	84.33	5.39	3.45
V-194	52.33	56.66	9.33	14.53	2.82	2.53	4.46	63.33	12.56	70.76	14.03	23.00	1627.52	8.13	84.33	5.30	3.17
V-63	52.33	57.00	12.60	17.20	2.34	2.13	5.17	68.66	10.69	65.50	13.13	20.67	1353.80	6.76	86.00	5.39	5.12
Kashi Pratistha (Ch)	45.66	48.70	8.53	11.25	2.73	3.10	3.40	58.32	14.16	98.25	17.10	33.05	3247.16	16.23	116.33	5.44	2.50
Mean	50.71	54.84	9.67	13.94	2.58	2.54	4.54	65.74	12.74	79.09	14.71	26.02	2093.24	10.46	87.64	5.29	3.56
C.V.	7.15	6.78	9.49	9.78	6.63	5.66	6.22	4.98	8.25	6.58	11.37	6.67	6.12	6.12	3.64	2.33	3.89
S.E.	2.09	2.14	0.53	0.78	0.09	0.08	0.16	1.89	0.60	3.01	0.97	1.00	73.98	0.37	1.84	0.07	0.08
C.D. 5%	5.90	6.05	1.49	2.22	0.27	0.23	0.46	5.33	1.71	8.48	2.72	2.83	208.66	1.04	5.19	0.20	0.23
C.D. 1%	7.84	8.04	1.98	2.95	0.37	0.31	0.61	7.08	2.27	11.26	3.61	3.75	277.02	1.38	6.89	0.27	0.30
Range Lowest	43.35	47.66	6.25	10.33	1.90	2.13	3.20	54.25	10.12	52.52	9.26	19.33	1177.98	5.88	69.33	4.83	2.20
Range Highest	55.32	60.00	12.60	17.20	3.25	3.35	5.73	71.00	14.40	102.21	21.87	34.35	3510.91	17.55	119.20	5.60	5.12

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Discussion
Bitter gourd (*Momordica charantia* L.) is one of the major summer season cucurbitaceous crops. This study aimed to evaluate 36 genotypes of bitter gourd for fourteen quantitative and three qualitative traits. The genotypes NDBG-16/22 followed by NDBG-11/22 and NDBG-14/22 performed better than the check variety i.e. Kashi Pratistha in term of fruit yield per plant. The result shows a wide range of variation in almost all economically important traits, indicating substantial potential for improvement through various breeding methods.

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