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Effect of spacing and micronutrients on yield of bitter gourd (*Momordica charantia*) grown under protected structures

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ABSTRACT

Proper plant spacing and foliar application of micronutrients is necessary for higher yield and quality. The experiment was conducted to determine the effect of spacing and micronutrients on fruit yield of bitter gourd grown under protected structures (nethouse and polyhouse). The variety Pusa Rasdar (27.06 days) showed superior performance over Selection 32 (30.03 days) for opening of first female flower under net house. The wider spacing (30 cm × 50 cm) enhanced early female flower (28.29 days) compared to closer spacing (under nethouse). The Pusa Rasdar was superior for node number of first female flower (11.25 nodes) followed by Selection 32 (13.28 nodes) (under nethouse). The wider spacing (30 cm × 50 cm) had a significant effect on first node of female flower appearance (12.37 and 11.87 nodes) under polyhouse and net house. The maximum fruit weight was in Pusa Rasdar (206.89 g) (under nethouse). The application of boron @0.2% and calcium @0.6% enhanced the number of fruits per plant (11.00 and 10.80) (under net house). The wider spacing (30 cm × 50 cm) also produced the highest number of fruits per plant (11.37) in Pusa Rasdar (under net house) condition. The maximum fruit yield per plant was recorded in Pusa Rasdar (2122.70 g) compared to Selection 32 (1646.61 g) (under net house). The wider spacing (30 cm × 50 cm) also produced maximum fruit yield (2137.25 g) in Pusa Rasdar (under net house). Therefore, higher yield of bitter gourd could be obtained under net house with broader spacing (30 cm × 50 cm) along with proper doses of micronutrients (0.2% boron and 0.6% calcium).

Keywords: Bitter gourd, Micronutrients, Protected structures, Spacing, Yield

Bitter gourd (*Momordica charantia* L.) is one of the important vegetable crop, cultivated across South and South-East Asia. It can be grown under protected structures in the north Indian plain, especially during *kharif* (August-November) and winter (November-March). The crop grown under open field condition during these seasons produces low yield and inferior quality of fruits due to viral diseases, fruit fly attack and low temperature (Maragal *et al.* 2018). The productivity and improved quality of produce could be obtained by increasing photosynthetic rate and better growth under protected environment. It also leads to more fruits per unit area and provides quality fruits that fetch higher market price (Jat *et al.* 2016). One of the main factors affecting crop productivity under protected structures is the plant population, which is mainly governed by plant architecture. Polyhouse/net house production technique of vegetable emphasizes the need for appropriate plant density to boost the production per unit area with good quality by utilizing the available space and nutrients. Plant spacing also plays an important role in yield of the crop plants because competition between and within plants affects ability of plants during vegetative and reproductive growth.

Polyhouse and net houses protect the crops from adverse conditions like excess solar radiation, extreme temperature, rain, pests and diseases (Jat 2011, Singh *et al.* 2021). Singh and Sirohi (2006) reported that insect-proof net houses can be used for virus-free cultivation of many high-value-quality vegetables during *kharif*. The low input protective structures are also suitable for the production of pesticide residue free green vegetables, which can be available for long-duration mainly during off-season (Singh *et al.* 2006). Vertical plant growth (trellising) can improve available light interception, air movement, and microclimates of each plant and promote the efficient use of water and nutrients. There are few reports available in production technology of bitter gourd under protected cultivation in India. Hence, the present study was undertaken to find out the effect of spacing and micronutrients doses on flowering and yield of bitter gourd varieties grown under protected structures, viz. net house and polyhouse.

MATERIALS AND METHODS

The experiment was conducted at Centre for Protected Cultivation Technology (CPCT), ICAR-Indian Agricultural Research Institute (IARI), New Delhi under two different

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conditions; insect-proof net house and naturally ventilated polyhouse. The experimental materials comprised of two bitter gourd genotypes, viz. Pusa Rasdar (a variety released by CVRC suitable for protected cultivation) and Selection 32 (one advance breeding line). The crop was grown by adopting all recommended agronomic practices during late *Kharif* (August to November) 2017-18 under two protected structures, viz. naturally ventilated polyhouse and insect-proof net house with an area of 1000 m^2 each. Three different spacings such as 20 cm × 50 cm (S_1), 25 cm × 50 cm (S_2) and 30 cm × 50 cm (S_3) were maintained in combination with 4 micronutrients levels like boron @ 0.2% (M_1) and 0.4% (M_2) and calcium chloride @ 0.3% (M_3) and 0.6% (M_4). The foliar spraying was done at 30 and 45 days after transplanting. The experiment was design in factorial randomized complete block design (RCBD) with 24 treatments and 3 replications. Two to three seeds per hill of both bitter gourd varieties were sown on 23 August 2017 on raised beds of 50 cm width and plant to plant spacing of 20, 25 and 30 cm. The fertigation was performed on drip system and nozzles were adjusted as per the plant spacing. All the female flowers were hand pollinated as and when appeared in the plants during the period of flowering and fruits were harvested at harvest maturity stage.

Five plants were selected at random in each treatment per replication and utilized for recording observations on the flowering characters like days to opening of first female flower, node at first female flower appearance, fruit weight, number and yield per plant (Table 1). The mean values were subjected to statistical analysis. Data were analyzed using the SAS package (9.3 SAS Institute, Inc, and USA). The 'F' values and 'P' values (≤0.05) were calculated and considered as significant.

RESULTS AND DISCUSSION

Effect on flowering traits: Early female flowering (days to opening of first female flower) was observed in variety Pusa Rasdar (27.06 days) compared to Selection 32 (30.03 days) under nethouse condition. However, under polyhouse condition Pusa Rasdar took 28.53 days, whereas Selection-32 took 31.92 days to opening of first female flower. The application of lower dose of boron (0.2%) and the highest dose of calcium (0.6%) enhanced early female flowering (days to the opening of first female flower, 27.89 days and 28.72 days) under nethouse compared to polyhouse (29.56 days and 30.39 days, respectively). Among the three different spacings, the wider spacing (30 cm × 50 cm) enhanced early female flower appearance (29.79 and 28.29 days) followed by 20 cm × 50 cm (30.67 and 28.71 days) under polyhouse and net house condition. Initiation of the first female flower was found two days earlier under net house than in polyhouse condition (Table 1).

The first node at female flower appearance was on 11.31 node in the variety Pusa Rasdar and 13.67 node in Selection-32 under polyhouse condition. However, under net house condition it appeared on 11.25 nodes in Pusa Rasdar and 13.28 node in Selection 32. The application of lower dose of boron (0.2%) and higher dose of calcium (0.6%) lowered flowering nodes (12.13 and 12.28 nodes) under polyhouse condition and 11.61 and 12.46 nodes under net house condition, respectively. It was noticed that node at female flower appearance was found at par with respect to early female flowering in both conditions. Among the three different spacing, the wider spacing (30 cm × 50 cm) enhanced first node of female flower appearance (12.37 and 11.87 nodes) followed by 20 cm × 50 cm spacing (12.54 and 12.62 nodes) under polyhouse and net house condition. On average, initiation of first node of female flower appearance was found almost similar under both conditions. The findings of present investigation were in accordance with the findings of Premlatha *et al.* (2006). Different genotypes significantly influenced days to first flower initiation, number of total female flower and sex ratio. The results indicated that days to flowers initiation might be controlled by inherent characters of genotypes (Mia *et al.* 2014). Verma *et al.* (1984) reported that application of boron at 3 or 4 ppm gave the highest number of female flowers per plant (28-32) in bitter gourd cv. Pusa Do Mousmi. The superior performance of growth and flowering traits was also reported under insect proof net house in bitter gourd cv. Pusa Hybrid-1 (Jat *et al.* 2015, Jat *et al.* 2017)

Effect on fruit traits: A significant difference in fruit weight, length, diameter and, number of fruits per plant was observed between two varieties (Pusa Rasdar and Selection 32) (Table 1). The fruits weight was recorded 206.89 g in variety Pusa Rasdar whereas 159.36 g in variety Selection 32 under net house condition. Whereas 195.22 and 152.03 g weight of individual fruit was recorded under polyhouse condition in Pusa Rasdar and Selection 32, respectively. The variety Pusa Rasdar performed better than Selection-32 under both the condition. The application of lower dose of boron (0.2%) recorded the maximum fruit weight (187.00 g) as compared to higher dose of boron @0.4% (180.34 g) under net house. Similarly, the maximum fruit weight (180.23 g) was recorded in lower dose of boron (0.2%) compared to higher dose @0.4% (170.94 g) under polyhouse condition. In contrary to the boron application, both the varieties produced maximum fruit weight at higher dose (0.6%) of calcium than the lower dose (03%) under both conditions. Among the three different level of spacings, wider spacing (30 cm × 50 cm) enhanced the individual fruit weight (188.25) followed by 25 cm × 50 cm spacing (180.71) under net house condition. In polyhouse the individual fruit weight was 182.58 g at the wider spacing (30 cm × 50 cm) compared to 176.67 g at 25 cm × 50 cm spacing.

The fruits length was recorded 19.74 cm in variety Selection-32 whereas, 13.84 cm in variety Pusa Rasdar under net house condition. Whereas 18.01 cm and 13.50 cm fruit length was recorded under polyhouse condition in Selection 32 and Pusa Rasdar, respectively. For fruit length, the variety Pusa Rasdar performed better than Selection 32 under both the protected conditions. The lower dose of boron (0.2%) recorded the maximum fruit length (17.14 cm) as compared to higher dose of boron @0.4% (17.09

Table 1 Effect of micronutrient and plant spacing on flowering and yield attributes of bitter gourd grown under protected structures

Treatment	Polyhouse condition							Insect proof net house condition						
	Days to opening of first female flower	Node number of first female flower	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (gm)	Number of fruits per plant	Fruits yield gm/ plant	Days to opening of first female flower	Node number of first female flower	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (gm)	Number of fruits per plant	Fruits yield gm/ plant
V_1	28.53	11.31	13.50	5.87	195.22	09.75	1904.39	27.06	11.25	13.84	5.84	206.89	10.25	2122.70
V_2	31.92	13.67	18.01	4.33	152.03	10.08	1544.50	30.03	13.28	19.74	4.39	159.36	10.33	1646.61
CD 5%	0.08	0.07	0.14	0.04	1.28	0.07	10.66	0.19	0.07	0.15	0.04	1.34	0.07	11.43
SE(m)	0.12	0.03	0.05	0.01	0.45	0.02	03.7	0.07	0.03	0.05	0.01	0.47	0.02	4.01
S_1	30.67	12.54	14.99	5.02	161.63	08.92	1439.08	28.71	12.62	16.07	5.09	180.42	9.25	1676.29
S_2	30.21	12.54	15.80	5.13	176.67	09.71	1722.25	28.62	12.29	16.83	5.01	180.71	10.21	1840.42
S_3	29.79	12.37	16.47	5.14	182.58	11.12	2012.00	28.29	11.87	17.47	5.23	188.25	11.37	2137.25
CD 5%	0.08	0.09	0.18	0.04	1.57	0.08	13.05	0.24	0.09	0.19	0.04	1.64	0.08	14.00
SE(m)	0.14	0.03	0.06	0.02	0.55	0.03	4.6	0.08	0.03	0.07	0.02	0.58	0.03	4.92
M_1	29.56	12.13	16.13	5.40	180.23	10.50	1872.20	27.89	11.61	17.14	5.39	187.00	11.00	2047.75
M_2	30.45	12.66	15.36	5.16	170.94	09.50	1662.00	27.94	12.06	17.09	5.02	180.34	09.90	1794.95
M_3	30.50	12.84	15.58	4.84	167.06	09.72	1636.60	29.61	12.94	16.20	5.03	181.75	09.80	1833.20
M_4	30.39	12.28	15.945	4.98	176.28	09.95	1727.00	28.72	12.46	16.75	5.20	183.43	10.80	1862.80
CD 5%	0.18	0.10	0.21	0.05	1.81	0.09	15.07	0.27	0.10	0.22	0.05	1.90	0.01	16.16
SE(m)	0.17	0.04	0.07	0.02	0.64	0.03	05.30	0.10	0.04	0.08	0.02	0.67	0.03	5.68
Polyhouse v/s IP net house	30.23	12.49	15.76	5.09	173.63	9.92	1724.45	28.54	12.27	16.79	5.16	183.13	10.29	1884.65

Varieties: V_1: Pusa Rasdar; V_2: Selection-32. Plant Spacing: S_1: 20 cm × 50 cm, S_2: 25 cm × 50 cm and S_3: 30 cm × 50 cm (Plant × Plant) and (Row × Row). Micronutrients: M_1: 0.2% Boron; M_2: 0.4% Boron; M_3: 0.3% Calcium Chloride and M_4: 0.6% Calcium Chloride.

cm) under net house. Similarly, the maximum fruit length (16.13 cm) was recorded in lower dose of boron (0.2%) compared to higher dose @0.4% (15.36 cm) under polyhouse condition. In contrary to the boron application, both the varieties produced maximum fruit length at higher dose (0.6%) of calcium than the lower dose (03%) under both conditions. Among the three different level of spacings, wider spacing (30 cm × 50 cm) enhanced the fruit length (17.47 cm) followed by 25 cm × 50 cm spacing (16.82 cm) under net house condition.

The fruits diameter was recorded 5.84 cm in variety Pusa Rasdar whereas, 4.39 cm in variety Selection 32 under net house condition. Whereas, 5.87 cm and 4.33 cm was recorded under polyhouse condition in Pusa Rasdar and Selection 32 respectively. The lower dose of boron (0.2%) recorded the maximum fruit diameter (5.39 cm) as compared to higher dose of boron @0.4% (5.02 cm) under net house. Similarly, the maximum fruit diameter (5.40 cm) was recorded in lower dose of boron (0.2%) compared to higher dose @0.4% (5.16 cm) under polyhouse condition. In contrary to the boron application, both the varieties produced maximum fruit weight at higher dose (0.6%) of calcium than the lower dose (03%) under both conditions. The wider spacing (30 cm × 50 cm) enhanced the fruit diameter (5.23 cm) followed by 25 cm × 50 cm spacing (5.01 cm) under net house condition. In polyhouse the fruit diameter was 5.14 cm at the wider spacing of 30 cm × 50 cm compared to 5.13 cm at 25 cm × 50 cm spacing.

The number of fruits per plant was recorded 10.33 in variety Selection 32 whereas, 10.25 in variety Pusa Rasdar under net house condition. Whereas, number of fruits 10.08 and 9.75 per plant was recorded under polyhouse condition in Selection 32 and Pusa Rasdar, respectively. The variety Selection 32 performed better than Pusa Rasdar under both the condition for number of fruits per plant. The application of lower dose of boron (0.2%) recorded the maximum number of fruits (11.00) as compared to higher dose of boron @0.4% (9.90) under net house. Similarly, the maximum number of fruits per plant (10.50) was recorded in lower dose of boron (0.2%) compared to higher dose @0.6% (9.50) under polyhouse condition. Both varieties produced more number of fruits at higher dose (0.6%) of calcium than the lower dose (03%) under both conditions. The wider spacing (30 cm × 50 cm) enhanced number of fruits per plant (11.37) followed by 25 cm × 50 cm spacing (10.21) under net house condition. In polyhouse the number of fruits per plant was 11.12 at the wider spacing (30 cm × 50 cm) compared to 9.71 at 25 cm × 50 cm spacing. An increase in yield and yield attributes due to the foliar feeding of the mixture of optimum level of micronutrients might be attributed to enhanced photosynthesis, accumulation of carbohydrates, development of cell wall and cell differentiations as they boost overall vegetative growth, the biological activity of the plants and retention of more flowers and fruits which have increased the number of fruits per vine and size of fruits besides increasing yield. This might be due to increased availability of growth favouring components, viz. nutrients, air and moisture at wider spacing. Similar findings have been reported by Abubaker *et al.* (2010), Mamnoie *et al.* (2014) and Oga and Umekwe (2015). Verma *et al.* (1984) found that boron 4 ppm also proved superior for increasing female flower production thereby increased significantly the number of fruits per plant and average weight of fresh fruit in two varieties of bottle gourd.

The significant difference for fruit yield was observed between both the varieties. The fruit yield per plant was recorded 2122.70 g in Pusa Rasdar, whereas 1646.61 g in Selection 32 under net house. Whereas, 1872.2 g and 1727.00 g fruit yield per plant was recorded under polyhouse condition in Pusa Rasdar and Selection 32, respectively. The variety Pusa Rasdar performed better than Selection 32 under both the condition. The lower dose of boron (0.2%) recorded the fruit yield of 2047.75 g compared to higher dose of boron @0.4% (1794.95 g) under net house. Similarly, higher fruit yield per plant (1872.20 g) was recorded in lower dose of boron (0.2%) compared to higher dose (1662.00 g) under polyhouse condition. Both the varieties performed better at higher dose (0.6%) of calcium than the lower dose (03%) under both protected conditions. Among the three different level of spacings, wider spacing (30 cm × 50 cm) enhanced fruit yield (2137.25 g) followed by 25 cm × 50 cm spacing (1840.42 g) under net house condition. In polyhouse condition it was found 2012.00 g at the wider spacing compared to 1722.25 g at 25 cm × 50 cm spacing. Vala and Savalia (2014) reported that among different levels of boron, boron @ 0.1% significantly increased fruit yield (14.96 t/ha) in bitter gourd cv. Pusa Vishesh when grown under open field condition. Verma *et al.* (1984) reported that application of boron at 3 or 4 ppm gave the highest number of fruits per plant (23-26.4) in bitter gourd cv. Pusa Do Mousmi. Gedam *et al.* (1998) observed that application of boron 2, 4 and 6 ppm in bitter gourd increased fruit yield and fruit maturity was earliest in the application of boron @ 4 ppm. The variety Pusa Rasdar performed better under net house condition with respect to earliness (days to opening of first female flower and node number of first female flower) and yield traits (fruit diameter, fruit weight and yield per plant) compared to Selection-32. The lower dose of boron (0.2%), higher dose of calcium (0.6%) and wider spacing (30 cm × 50 cm) enhanced yield in bitter gourd varieties under both the protected conditions.

Therefore, the superior performance of flowering and fruit traits, and higher yield in bitter gourd varieties could be obtained under net house with proper management of micronutrients and plant spacings compared to polyhouse during *kharif*.

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