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Research Article

Performance of cucumber (*Cucumis sativus* L.) varieties under different growing conditions

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ABSTRACT

Ten divergent cucumber varieties and hybrids, viz. Heera, K-75, Pusa Barkha, Pant Khira-1, Konkan Kakadi, Japanese Long Green, Phule Shubangi, Swarna Sheetal, Solan Srijan, and Subhra, were grown in open and naturally ventilated polyhouse conditions at the Department of Vegetable Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu in 2021–2022 for vegetative, reproductive traits and yield. In the Japanese long green variety, under protected condition, the maximum vine length (382.6 cm), branches (4.14), length (26.1 cm) and weight of individual fruit (308.94 cm), the early nodal location of the female flower (5.29) and days to fruit set (34.23 days) were recorded among all interactions. The maximum yield of 78.28 t ha^{-1} was obtained in the Heera hybrid, whereas Swarna Sheetal had a maximum fruit diameter of 4.5 m under protected condition. The results of the study revealed that environmental conditions play a major role in determining the vegetative, reproductive and yield parameters of cucumber varieties/hybrids.

***Keywords*:** Automated naturally ventilated polyhouse, cucumber, open condition and protected condition

The gourd family Cucurbitaceae, which comprises 825 species and 117 genera in warmer climates, includes cucumber (*Cucumis sativus* L.). One of the earliest and largest cucurbitaceous crop is cucumber. It is a thermally sensitive and frost-sensitive species that do best in surroundings with temperatures over 20 °C. The crop is grown all over the world and ranks behind tomatoes, cabbage, and onions as the 4th most significant vegetable crop. It is also the second most widely planted cucurbit after watermelon. Salad has a high-water content but little energy. Constant demand throughout the year for cucumber, especially the smooth skinned seedless fruit due to its popular use in salad dishes, sandwiches, pizzas and other preparations (Bisht *et al*., 2011). The fruit possesses medication and astringent properties. Fruits may be beneficial for those with indigestion, constipation, jaundice, and other health issues. Cucurbitacin, a triterpene phytonutrient, and silica are abundant in cucumber. In southern India, the dry season lasts from spring to the end of June, whereas the rainy season lasts from between June and the beginning of October. In the northern part of India, the season of rainfall endures from July to October whereas the dry season lasts from April to July (Ramesh and Arumugam, 2010). Cultivation and management of cucumber crop under protected conditions can increase the cropping period. Vegetable crops grown under controlled environmental conditions obtaining top-grade quality fruits for both domestic and international markets may be a more effective utilization of agricultural land and other assets (Sanwal *et al.,* 2004).

In the current scenario of rising consumer appetite for vegetables and simultaneous substantial reduction of land ownership, secure farming of vegetable crops has been found to be the most successful approach to maximizing the land use. Therefore, this study aimed to identify cucumber varieties suitable to grow in open and protected conditions for assessing the physiological development, yield of 10 cucumber cultivars cultivated in the Theni zone of Tamil Nadu (India).

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MATERIALS AND METHODS

Geographical location of the experimental site

The present study was conducted at Horticultural College and Research Institute (HC&RI), Department of Vegetable Science, TNAU, Periyakulam in the year of 2021-22. Seeds of ten varieties/hybrids, i.e., Heera, K-75, Japanese Long Green (JLG), Konkan Kakadi, Phule Shubangi, Pant Khira-1, Pusa Barkha, Solan Srijan, Swarna Sheetal and Subhra were collected from different institutions/universities of ICAR and sown in polyhouse and open field conditions with recommended agronomical practices and fertigation method. Each cultivar was assigned a plot size of 1.0 x 8.0 m with three. The crop was fertigated with N: P: K at the rate of 85:70:60 kg ha^{-1} along with 50 kg ha^{-1} micro-nutrients, 4 kg ha^{-1} *Trichoderma*, 4 kg ha^{-1} *Pseudomonas fluorescens* at the time of sowing. Each variety/hybrid was trained to single stem system by cutting all the laterals emerging from axials of leaves for proper crop yield per plant. Three replications were employed for every single variety under both sets of circumstances in a Factorial Randomised Block Design with two factors (varieties and growing conditions). Pollination was performed manually for the cucumber varieties/hybrids grown in the polyhouse, whereas in open field condition, bumble bees and honey bees acted as pollinating agents. Morphological observations included plant length at final harvest, internodal length, the nodal position of female flowers, number of days to first female flower appearance, days to first fruit set, and included fruit parameters such as tender fruit length (cm), tender fruit width (cm), yield per ha, and TSS content were noted and analyzed statistically. All the experimental data recorded in the laboratory were statistically analyzed and evaluated by using WASP-Web Agri Stat Package 2.0. The critical difference was worked out for 5% level of significance.

RESULTS AND DISCUSSION

Vine length at 30 days interval (cm) and at harvest (cm), the internodal dimension of the vine (cm), number of initial branches, nodal position for the first female blossom, days to setting of fruit, days until initial picking, and yield variables viz. fruit length, fruit width, fruit weight, and yield per ha were collected and presented in tables 1 - 3.

Vine length (cm)

Vine length on the 30th day had a maximum (25.95 cm) under protected condition and the lowest (13.08 cm) vine length was recorded in open field condition. Among the varieties, vine length at 30 days showed a higher value of 29.43 cm in Heera variety, followed by the Japanese Long Green (29.43 cm). Among all the interactions, a significantly higher vine length (49.60 cm) was observed in the Japanese Long Green (JLG) variety under protected, and a minimum (9.10 cm) was observed in Pusa Barkha under open field conditions (Table 1). An increase in vine length under polyhouse conditions might be higher than under when compared to the open field condition due to high heating and moisture content in air during the growth period of cucumber cultivation. These results were exact to the research outcomes of Veena *et al*. (2012), Safia *et al*. (2015) and Pal *et al.* (2017).

The length of vine at final harvest (259.32 cm) was reported in polyhouse condition and the lowest (206.6 cm) vine length at final harvest was observed under open environmental condition (Table 1). A Significant maximum (299.1 cm) vine length at final harvest was recorded in Japanese Long Green, followed by Heera (277.5 cm), Subhra (257.3 cm), and a minimum (147.6 cm) in Pusa Barkha. Between two growing conditions, the highest vine length at final harvest (382.6 cm) was noticed in Japanese Long Green (JLG) under protected condition and lowest (132.2 cm) in Pusa Barkha under open condition (Table 1). This might be due to an increase in the photosynthesis and respiration rate activities due to the favourable microclimatic conditions in the protected conditions. These findings were similar to the research outcome of Ramesh and Arumugam. (2010), Suhas *et al*. (2022)

Internodal length

The internodal length of the vine showed a significantly high (9.86 cm) in polyhouse condition and the lowt (8.33 cm) in the open filed condition. A significant maximum internodal length (10.24 cm) was recorded in Solan Srijan followed by Konkan Kakadi (10.05 cm), K-75 (9.75) and Heera (9.72). Among all the treatment interactions, the maximum (12.60 cm) internodal length of the vine was obtained in Japanese Long Green in protected condition, followed by Solan Srijan in protected condition (11.80 cm) and the lowest (3.46 cm) internodal length was recorded in Japanese Long Green in protected condition (Table 1). Low intensity and diffused light inside of the naturally ventilated polyhouse may also be a reason for internodal elongation. These findings were similar to the research outcome of Ramesh and Arumugam (2010) in controlled conditions, resulting in more vine length as concluded by Dingal *et al.* (2018) in cucumber.

Table 1: Effect of growing conditions on vegetative growth attributes of cucumber

Varieties (V)	Vine length at 30 days			Vine length at final harvest			Internodal length of vine			Number of primary branches		
	Growing conditions (C)			Growing conditions (C)			Growing conditions (C)			Growing conditions(C)		
	Open	Protected	Mean	Open	Protected	Mean	Open	Protected	Mean	Open	Protected	Mean
Heera	15.50	43.50	29.5	231.4	323.6	277.5	9.84	9.60	9.72	1.98	2.16	2.07
Japanese Long Green	9.26	49.60	29.43	201.6	382.6	299.1	3.46	12.60	8.03	3.14	4.14	3.64
K-75	12.20	23.90	18.05	205.6	248.6	227.1	9.90	9.60	9.75	1.65	3.16	2.4
Konkan Kakadi	13.20	16.00	14.6	211.1	244.9	228.0	10.40	9.70	10.05	1.98	3.28	2.63
Pant Khira-1	18.40	29.20	23.8	241.6	266.1	253.8	8.10	11.20	9.65	3.13	3.54	3.33
Phule Shubangi	12.40	15.20	13.8	201.3	236.1	218.7	8.30	7.40	7.85	1.65	3.34	2.49
Pusa Barkha	9.10	11.40	10.25	132.2	163	147.6	6.80	8.20	7.5	1.02	1.54	1.28
Solan Srijan	10.80	17.60	14.2	209.6	244.5	227.0	8.68	11.80	10.24	1.86	2.17	2.01
Subhra	17.20	35.10	26.15	241.5	273.2	257.3	8.10	9.11	8.6	3.22	2.24	2.73
Swarna Sheetal	12.80	18.00	15.4	190.6	210.6	200.6	9.80	9.40	9.6	2.11	3.24	2.67
Mean	**13.08**	**25.95**	**19.51**	**206.6**	**259.3**	**233.5**	**8.33**	**9.86**	**9.09**	**2.17**	**2.88**	**2.52**
Factor	**C**	**V**	**C × V**	**C**	**V**	**C × V**	**C**	**V**	**C × V**	**C**	**V**	**C × V**
SE(d)	**0.13**	**0.29**	**0.41**	**1.80**	**4.04**	**5.71**	**0.06**	**0.14**	**0.25**	**0.65**	**1.02**	**1.32**
LSD (0.05)	**0.26**	**0.59**	**0.84**	**3.67**	**8.21**	**11.61**	**0.12**	**0.28**	**0.42**	**1.34**	**1.98**	**2.64**

Table 2: Effect of growing conditions on reproductive parameters of cucumber

Varieties (V)	Nodal position of first female flower			Days taken to first female flower appearance			Days to fruit setting			Days to first picking		
	Growing conditions (C)			Growing conditions (C)			Growing conditions (C)			Growing conditions (C)		
	Open	Protected	Mean	Open	Protected	Mean	Open	Protected	Mean	Open	Protected	Mean
Heera	6.14	4.36	5.25	40.34	33.97	37.155	43.71	36.93	40.32	47.15	40.62	43.88
Japanese Long Green	10.6	5.29	7.94	48.76	31.54	40.15	51.22	34.23	42.72	54.29	38.89	46.58
K-75	11.13	10.87	11	56.74	48.52	52.63	58.36	51.32	54.84	62.23	54.64	58.43
Konkan Kakadi	12.8	11.16	11.98	60.43	51.13	55.78	63.43	54.37	58.9	66.76	57.9	62.33
Pant Khira-1	13.14	11.25	12.19	54.62	48.61	51.61	56.8	50.14	53.47	60.87	54.43	57.64
Phule Shubangi	12.61	10.64	11.62	56.21	48.05	52.13	58.83	51.36	55.09	62.23	53.87	58.05
Pusa Barkha	8.13	6.46	7.29	48.54	43.63	46.08	51.32	46.12	48.72	54.54	49.72	52.13
Solan Srijan	11.63	9.42	10.52	54.14	47.46	50.8	56.69	50.61	53.65	60.32	53.91	57.11
Subhra	6.16	4.86	5.51	45.32	35.61	40.46	47.23	38.54	42.88	51.76	41.69	46.72
Swarna Sheetal	12.19	10.16	11.17	54.16	45.67	49.91	56.91	48.84	52.87	59.92	51.3	55.61
Mean	**10.45**	**8.44**	**9.44**	**51.92**	**43.41**	**47.67**	**54.4**	**46.24**	**50.3**	**58.00**	**49.69**	**53.84**
Factor	**C**	**V**	**C × V**	**C**	**V**	**C × V**	**C**	**V**	**C × V**	**C**	**V**	**C × V**
SE(d)	**0.13**	**0.29**	**0.41**	**1.80**	**4.04**	**5.71**	**0.06**	**0.14**	**0.2**	**0.38**	**0.85**	**1.2**
LSD (0.05)	**0.26**	**0.59**	**0.84**	**3.67**	**8.21**	**11.61**	**0.12**	**0.28**	**0.4**	**0.77**	**1.73**	**2.44**

Table 3: **Effect of growing conditions on reproductive parameters of cucumber**

Varieties (V)	Fruit length (cm)			Fruit diameter (cm)			Individual fruit weight (g)			Yield per ha (t ha^{-1})		
	Growing conditions (C)			Growing conditions (C)			Growing conditions (C)			Growing conditions (C)		
	Open	Protected	Mean	Open	Protected	Mean	Open	Protected	Mean	Open	Protected	Mean
Heera	15.2	16.5	15.85	4.11	4.21	4.16	221.16	226.14	223.6	37.78	78.28	58.02
Japanese Long Green	23.8	26.1	24.95	3.44	3.43	3.43	290.53	308.94	299.7	32.63	75.16	53.89
K-75	15.11	15.53	15.32	3.79	3.98	3.88	221.21	231.23	226.2	25.29	49.15	37.21
Konkan Kakadi	16.7	18.4	17.55	3.16	3.26	3.21	167.85	178.34	173.0	15.94	32.08	24
Pant Khira-1	19.4	18.2	18.8	3.51	3.41	3.46	187.47	190.34	188.9	21.08	42.16	31.62
Phule Shubangi	16.15	15.45	15.8	3.81	3.82	3.81	188.02	181.34	184.6	16.49	30.79	23.63
Pusa Barkha	12.16	13.1	12.63	3.42	4.14	3.78	119.44	127.11	122.2	6.78	17.04	11.91
Solan Srijan	18.21	18.1	18.15	3.21	3.43	3.32	234.26	230.54	232.4	22.54	43.81	33.17
Subhra	18.34	17.1	17.72	4.23	4.16	4.19	229.93	220.05	224.9	34.09	70.94	52.51
Swarna Sheetal	14.11	14.9	14.5	4.43	4.5	4.46	182.2	190.67	186.4	17.04	41.06	29.05
Mean	**16.91**	**17.33**	**17.12**	**3.71**	**3.83**	**3.77**	**204.2**	**208.4**	**206.3**	**22.96**	**48.04**	**35.5**
Factor	**C**	**V**	**C × V**	**C**	**V**	**C × V**	**C**	**V**	**C × V**	**C**	**V**	**C × V**
SE (d)	**0.11**	**0.26**	**0.37**	**0.02**	**0.04**	**0.06**	**1.45**	**3.24**	**4.59**	**0.22**	**0.49**	**0.69**
LSD (0.05)	**0.24**	**0.53**	**0.75**	**0.04**	**0.09**	**0.14**	**2.95**	**6.59**	**9.33**	**0.44**	**1.00**	**1.41**

Number of branches

Significantly higher (2.88) branches were obtained under protected climate condition and lower (2.17) number of branches recorded in open field condition. Between the varieties, the maximum (3.64) branches were observed in Japanese Long Green (JLG) because high branches are specific genetic attribute of a variety as well as a high vegetative growth, followed by Pant Khira-1 (3.3), Subhra (2.73) and the lowest (1.27) number of branches in Pusa Barkha. Among all the interactions, a significant maximum value for the number of branches (4.14) was obtained in Japanese long green (JLG) under controlled environmental conditions, followed by Pant Khira-1 under protected condition (3.54) and a lower (1.02) branches (Table 1) was recorded in Pusa Barkha under open field condition. Maximum vine growth especially in indeterminate growth patterns, leads to a greater number of branches. Ramesh and Arumugam (2010) noticed more branches under controlled conditions in eggplant, tomato and chilies and Mehta *et al*. (2010) and Ghosh and Jana (2022).

Nodal position of the first pistillate flower

Significantly the lowest (8.44) nodal position of first pistillate flower obtained in controlled environmental condition and in open condition, pistillate flower emerged at higher nodal stage (10.45). Among all varieties, the hybrid Heera had produced the first pistillate flower in lowest node (5.25). Significantly higher (13.14) nodal position of first pistillate flowers noted in Pant Khira-1 under open condition and minimum (4.36) node noted in Heera variety under protected condition (Table 2). The nodal position of the first pistillate flower was highly influenced by various growing conditions as well as various varieties. These result finding supported with Kumar *et al*. (2021) in protected condition.

Days taken to first pistillate flower appearance

First pistillate flower had appeared in minimum number of days (43.41) in protected condition whereas it took a greater number of days (51.92) in open field conditions. Among all the varieties, Heera hybrid produced pistillate flower early (37.15 days). In interactions, maximum (60.43) days was taking for first pistillate flower appeared in Konkan Kakadi under open conditions and a minimum (31.54 days) days took in Japanese long green variety under protected condition (Table 2). Maximum impact was seen in days taken to first pistillate flower due to various growing conditions and varieties. This was in agreement with the findings of Rao *et al*., 2013.

Days to fruit setting

Open grown condition took the maximum days (54.4) for fruit setting and the minimum (46.24 days) days took in protected environmental condition. Among all the varieties, Konkan Kakadi variety took more days (58.9) for fruit setting and lesser days for fruit setting in Heera (40.32 days). Among all the interactions Konkan Kakadi under open conditions had maximum (63.43) days took for fruit setting and minimum (34.23 days) days in Japanese Long Green (JLG) under controlled conditions (Table 2). The earliness of fruit set is mainly due to the favourable climate mainly under protected grown condition. The results confirm with the study of Kumar *et al*. (2014).

Days to first fruit picking

The maximum (54.4) days for fruit picking was showed in open condition and the minimum (46.24) days taken to first fruit harvest in protected condition. Among all the varieties, a greater number of days took for first harvesting in the variety of Konkan Kakadi (62.33) and lesser days taken to first harvesting in Heera (43.88). Between interactions, more days (66.76) days took for first fruit picking noticed in Konkan Kakadi under open field conditions and lower (38.89) days took for first harvesting recorded in Japanese Long Green under protected condition (Table 2). It might be due to the early appearance of female blossoms, high photosynthetic rate, fast growth and development of cucumber crop under polyhouse influence early harvesting it results fruits fetch a maximum price in the market. Similar findings revealed by Kumar *et al*. (2009).

Fruit length

The maximum (17.33 cm) fruit length was noticed under protected condition and minimum (16.91 cm) fruit length was reported under open field condition. Japanese Long Green (24.95 cm) had the maximum fruit length value among all the varieties minimum fruit length was noticed in Pusa Barkha variety (12.63 cm). In individual interactions, the maximum (26.1 cm) fruit length was noticed in Japanese Long Green (JLG) of controlled conditions and lesser (12.16 cm) fruit length showed in Pusa Barkha under open condition (Table 3). In both open and protected conditions, Japanese Long Green was showed maximum fruit length due to genetic character of the variety. Fruit length was longer in controlled conditions than in unprotected. As a result of moderate light intensity and temperature under polyhouse it enhanced fruit length might be attributed to a maximum rate of photosynthesis and food material accumulated in fruit. Similar research findings revealed by Pinturoy (2014) in

chilli, poly houses produced more fruits with higher lengths and weight.

Fruit diameter

Protected conditions (3.83 cm) were obtained maximum fruit diameter and minimum in open field conditions (3.71 cm). Between varieties, maximum (4.46 cm) fruit diameter recorded in Swarna Sheetal variety and the minimum (3.21 cm) was noted in Konkan Kakadi. Regarding interactions between growing condition and varieties, maximum (4.5 cm) fruit diameter was noticed in Swarna Sheetal under protected condition and minimum (3.16 cm) fruit diameter was recorded in Konkan Kakadi in open condition (Table 3). The variation in diameter might be due to genetic nature, environmental factors and vigour of the crop. These results are also accordance with the findings of Ullah *et al*. (2012), Kumar *et al*. (2013), Patel *et al*. (2013) and Rawat *et al.* (2014) in cucumber.

Fruit weight

Protected condition was noticed maximum (208.4 g) individual fruit weight and lesser (204.22 g) fruit weight was noticed under open field condition. Japanese Long Green had maximum (299.7 g) individual fruit weight among all the varieties, and minimum fruit weight was reported in Pusa Barkha variety (122.2 g). Between interactions, the Japanese Long Green variety under protected condition was showed maximum (308.94 g) individual fruit weight due to the genetic character of the variety, maximum vegetative growth was showed under protected condition, and minimum (119.44 g) individual fruit weight was obtained in Pusa Barkha under open field condition (Table 3). This is due to the genetic trait of individual variety and also optimum temperature and humidity in polyhouse condition. Anbarasan (2002) and Reddy *et al*. (2006) reported that the weight of capsicum was more under controlled conditions than in uncontrolled conditions.

Fruit yield per ha

Polyhouse conditions obtained maximum yield per ha (48.04 t ha^{-1}) and open field conditions was noticed minimum yield per ha (22.96 t ha^{-1}). Between varieties, maximum (58.02 t ha^{-1}) yield per ha was noticed in Heera hybrid, and minimum fruit yield per ha was recorded in Pusa Barkha (11.91 t ha^{-1}). Among all interactions, the maximum yield was noticed (78.28 t ha^{-1}) in the Heera variety under protected conditions, and the minimum (6.78 t ha^{-1}) yield per ha was obtained in Pusa Barkha under open field conditions (Table 3). Pusa Barkha requires a cool climate which is suitable for northern conditions, but in southern climatic conditions, very low yield due to high temperature and relative humidity. The favourable microclimate factors in the Naturally Ventilated Polyhouse, such as low soil and air temperature, optimum radiation, and high humidity, benefited cucumber plant development and physiological processes, as evidenced by the high aerial biomass, subsequently increasing fruit yield. Similar results were revealed by Kumar and Arumugam. (2010) in chili, cluster bean brinjal and okra.

CONCLUSION

Growing environmental conditions influence cucumber quantity and quality. Vine length at 30 days (25.95 cm) and at final harvest (259.3 cm) internodal length of the vine (9.86 cm) and branches (2.88) had expressed maximum under polyhouse conditions than under open field condition. Among all the varieties, Japanese long green (JLG) showed the maximum vine length (299.1 cm) and fruit length (24.95 cm), the maximum number of branches (3.64) and individual fruit weight (299.7 g) except fruit diameter and yield per ha in protected. Among the interactions, the more vine length, branches, length, and weight of individual fruit, the early nodal place of female blossom and fruit setting days were noted under protected condition in the Japanese long green variety. The maximum yield of 78.28 t ha^{-1} was obtained in Heera hybrid, whereas Swarna Sheetal had a maximum fruit diameter of 4.5 m under protected condition. Among two growing conditions, protected conditions gave maximum yield and the Heera hybrid showed better performance under protected conditions.

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