



Influence of spacing and pruning on growth, yield and economics of off-season long melon (*Cucumis melo*)

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ABSTRACT

Long melon [*Cucumis melo* var. *utilissimus* (Roxb.) Duthie & Fuller] cultivation in open field condition in northern India is hampered due to extremes of the temperature from September to January. Therefore, the present study was carried out to explore possibility for off-season production of long melon under protected conditions at Center for Protected Cultivation Technology (CPCT), ICAR-IARI, New Delhi in 2016–17 and 2017–18. Seedlings were transplanted as per five different spacing and branch pruning methods. The combination of closer spacing with maximum branch node pruning method under polyhouse structure was found better for off-season long melon production. Flowering appeared earlier by 4.02 days, first fruit picking by 5 days, additional number of pickings (5 times) and harvesting period extended by 60 days in polyhouse compared to insect proof net-house structure. The closer spacing S₁ (50 cm × 20 cm) exhibited maximum weight of fruits, fruit yield, gross income as well as net-income and B: C ratio. Among pruning methods, complete branch pruning method P₁ (single stem cultivation or branch less cultivation) contributed positively significant effect on all parameters of long melon. The combination of polyhouse structure with closer spacing (50 cm × 20 cm) and optimum branch pruning (after one node cutting) gave highest yield and net income per unit area for off-season cultivation of long melon.

Keywords: IP net-house, Long melon, Polyhouse, Pruning, Spacing

Long melon [*Cucumis melo* var. *utilissimus* (Roxb.) Duthie & Fuller] is an important summer crop used as a fresh fruit. It is used in salad, cooked as a vegetable, and preserved in the form of sweets. It is a good source of important minerals and vitamins. It is very popular during summer months in most parts of the country.

The crop is mainly grown in tropical, sub-tropical and arid zones of India. It is particularly grown on river beds or *Diara* land area and requires temperature, humidity and sunshine in the range of 25–30°C, 60–70% and 700–800 w/m², respectively, which is not usually available in the northern plains especially in winters. In addition, this particular crop is highly susceptible to insects-pests and yield losses of up to 30–40% are reported (Singh *et al.* 2021, Sabir *et al.* 2021). In fact, the demand for off-season long melon is always high in the market because of its domestic and export potential, but its availability remains seasonal as it is grown in open field conditions during summers. Hence, it is a vegetable with very high potential of income generation within short period if grown during off-season under protected conditions. Off-season long melon cultivation is highly remunerative for urban and peri-urban farmers of the country in economic perspective.

Prevailing low temperature and frost injury during winter (off-season) are limiting factors for growing long melon in north Indian plains. It is possible only when it is cultivated in polyhouse. In general, the long melon varieties are not at all suitable for cultivation under controlled polyhouse due to lack of pollinators, wastage of male flowers, and hence it requires expensive and cumbersome hand-pollination. Very limited information is available in India on cultivation of long melon under polyhouse structure especially during off-season (Singh *et al.* 2021). Therefore, the present study was conducted to find out the optimum spacing and pruning method of long melon for harnessing higher yield with economic gain in the plain regions of India during off-season under protected condition.

MATERIALS AND METHODS

The experiment was conducted for two consecutive seasons under naturally ventilated polyhouse and IP-net-house, at Centre for Protected Cultivation Technology (CPCT), IARI, New Delhi, during off-season (August–February) of 2016–17 and 2017–18. The experiment was carried out in randomized block design comprising 20 treatment combinations of spacing and pruning methods with three replications in two protected structures of 1000 m² size each. Twenty days old seedlings of the cultivar Chitrlekha were transplanted in the polyhouse and net house. Plastic ropes were used for vertical cordoning, trellising and training,

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Table 1 Effect of different spacing and pruning methods on growth and development of long melon under protected structures during off-season production

Treatment	Polyhouse (NVPH)							Insect-Proof Net-House (IPNH)								
	Plant height (m)	No. of leaves	No. of branches	Fresh wt. of green biomass at last harvest (kg)	Length of fresh roots at last harvest (cm)	Fresh wt. of roots at last harvest (g)	Fruits setting per plants at last harvest (%)	Plant mortality by biotic stress (%)	Plant height (m)	No. of leaves	No. of branches	Fresh wt. of green biomass (g)	Length of fresh roots at last harvest (cm)	Fresh wt. of roots at last harvest (g)	Fruits setting per plants at last harvest (%)	Plant mortality by biotic stress (%)
Plant spacing																
S ₁ (50 cm × 20 cm)	2.30	56.50	9.54	2.41	23.23	83.6	20.43	9.18	2.04	42.76	7.43	1.66	21.58	79.8	18.59	10.15
S ₂ (50 cm × 30 cm)	2.82	73.22	10.37	2.59	24.59	87.29	21.45	7.10	2.05	56.16	8.68	2.22	22.64	83.31	19.61	8.12
S ₃ (50 cm × 40 cm)	3.20	80.95	11.87	2.93	27.34	91.76	22.61	5.12	2.39	62.98	10.04	2.51	24.16	87.56	20.77	6.02
S ₄ (50 cm × 50 cm)	3.49	88.41	13.05	3.25	33.21	97.03	24.28	3.50	2.56	67.18	10.72	2.68	26.13	92.61	21.97	4.56
S ₅ (50 cm × 60 cm)	3.49	88.41	13.05	3.25	33.21	97.07	24.28	3.50	2.56	67.18	10.72	2.68	26.13	92.61	21.97	4.56
CD at 5%	0.24	6.38	0.70	0.17	2.00	2.69	0.77	1.14	0.10	4.88	0.66	0.20	0.91	2.56	0.68	1.12
Pruning method																
P ₀ (Control/no pruning)	2.79	120.15	10.24	4.72	21.93	97.7	18.94	9.06	2.13	96.02	9.01	4.06	20.00	82.37	17.10	10.06
P ₁ (All branch pruning)	3.33	32.67	12.41	1.45	32.05	123.19	19.8	3.09	2.67	28.04	11.18	1.27	29.10	103.82	17.96	4.09
P ₂ (One node pruning)	3.06	56.95	11.33	1.83	30.95	113.47	21.24	4.06	2.40	47.12	10.1	1.82	27.26	95.64	19.40	5.06
P ₃ (Two node pruning)	2.91	73.64	10.74	2.36	28.02	106.54	24.84	5.01	2.25	59.91	9.51	2.22	24.20	89.81	23.00	6.08
P ₄ (Three node pruning)	2.80	95.84	10.30	3.19	25.78	103.48	28.24	7.15	2.19	78.51	9.27	2.92	22.23	87.23	26.40	8.15
CD at 5%	NS	4.86	0.01	0.31	0.77	1.16	1.86	0.38	NS	3.50	0.05	0.23	0.45	0.97	1.86	0.38
Polyhouse vs. IP net-house structure	2.98	75.85	11.00	2.71	27.75	108.88	22.61	5.67	2.33	61.92	9.81	2.46	24.56	91.77	20.77	6.69

Pooled data of two years from 2016–18 under protected structures. NS, non-significant.

Table 2 Temperature and Relative humidity (%) under protected structure and ambient field condition during crop season

	Polyhouse (NVPH)				Insect-Proof Net-House (IPNH)				Ambient condition			
	Temperature °C		RH%		Temperature °C		RH%		Temperature °C		RH%	
Month	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
August	34.50	22.26	87.50	50.60	32.61	15.38	84.57	50.55	28.95	18.78	82.20	47.67
September	31.72	20.45	80.20	48.50	31.5	14.86	78.57	47.20	27.95	16.57	76.35	44.19
October	28.57	18.52	75.50	45.70	27.28	12.87	75.07	43.80	24.95	14.72	72.53	42.15
November	21.75	14.00	78.30	48.60	20.06	9.46	77.57	44.70	17.95	11.22	75.50	43.60
December	18.25	11.74	83.85	51.25	16.55	7.81	83.07	47.80	14.45	9.47	80.52	46.80
January	16.28	10.45	90.50	54.60	14.95	7.05	89.57	51.85	12.45	8.47	87.25	50.58
February	20.24	13.03	78.70	47.15	19.2	9.06	76.57	44.75	16.45	10.47	74.15	43.02
Mean	24.47	15.78	82.08	49.49	23.16	10.93	80.71	47.24	20.45	12.81	78.36	45.43

Pooled data of two years from 2016–18.

and pruning of all primary branches after 1st node, 2nd node, and 3rd node in all plants at weekly interval under both structures. The crop was irrigated by drip-system and the necessary cultural operations were followed. Hand pollination was done during morning hours (7.00-9.00 am). Data were recorded on growth, flowering, yield and economic parameters during both the years (Table 1). Fruits were picked from September to January during both the years. Average of two years pooled data was analyzed using suitable statistical methodology SPSS-21. The cost of cultivation and net income was calculated using the given formulae.

$$\text{Yield} = \text{Fruits wt. kg/plant} \times \text{No. of plants/m}^2 = \text{yield kg/m}^2 \times 100/700 = \text{yield q/1000 m}^2 \times 3000/700 = \text{yield q/Acer}$$

$$\text{Net income} = \text{Gross income (₹/m}^2/\text{season)} - \text{Cost of cultivation (₹/m}^2/\text{season)}$$

$$\text{Benefit:Cost ratio (BCR)} = \frac{\text{Gross income (₹/m}^2/\text{season)}}{\text{Cost of cultivation (₹/m}^2/\text{season)}}$$

RESULTS AND DISCUSSION

Climatic conditions of the experiment: Monthly mean values of temperature and relative humidity were calculated from daily records for two years. Comparison of temperature and relative humidity inside the insect-proof net-house and ambient conditions revealed that maximum temperature was higher inside insect-proof net-house condition than ambient conditions. But the minimum temperature showed reverse trend. Relative humidity followed the same trend as air temperature under both conditions (Table 2). This might be due to low circulation of atmospheric air inside insect-proof net-house. Similar findings have been reported by Singh *et al.* (2017, 2021), Maragal *et al.* (2018a).

Effect of structures: Growth, yield and quality data revealed that polyhouse out-performed IP net-house structure during both the years. Flowering was earlier by 4.02 days, first fruit picking by 5 days, five additional pickings and harvesting period extended by 60 days in polyhouse compared to IP-net-house structure. Plant height (2.98 m,

2.33), number of leaves (75.85, 61.92), number of main branch (11.15, 9.81), weight of fresh plant biomass (2.72, 2.46 kg), length of roots (22.6 cm, 24.56 cm), weight of fresh roots (108.88, 91.75 kg), fruits setting percentage (22.61, 20.77 %), yield attribute: number of fruits per plant (6.20, 5.45), diameter of fruit (2.99, 2.86 cm), length of fruits (56.06 cm, 53.24 cm), weight of fruit (348.32, 314.98 g), weight of fruits per plant (2.16, 1.61 kg), weight of fruits per meter square (9.81, 7.91 m²), total yield (64.65, 55.40 q/1000 m²), gross income (₹274631/, ₹221602/1000m² area), net income (₹50227/, ₹31016/1000 m²) and B:C ratio (1.22, 1.53) were found maximum in polyhouse structure as compared to IP-net-house structure. However, cost of cultivation (₹22486/, ₹193436/1000m²) was lower in IP net house as compared to polyhouse. The plant mortality (5.67%, 6.69%) and unmarketable fruits (5.14%, 7.87%) were found minimum under polyhouse structure as compared to IP net house (Supplementary Table 1, 2, 3). This might be because polyhouse structure created a favorable microclimate for plant growth and development with minimum biotic and abiotic stress during off-season and also increase in 3–4°C of temperature and RH. It was noticed during crop season that IP net house protects against insect-pests only but could not avoid abiotic stress especially cold wind, frost, rainfall and low temperature. Though, the cost of cultivation under IP net-house was low because of low installation cost but overall profit in terms of net return was always higher in polyhouse owing to higher marketable yield besides producing better quality fruits. The same trend has also been depicted in present study (Supplementary Table 3, 4, 5). These findings were supported by Singh *et al.* (2012), Jat *et al.* (2015, 2016), Maragal *et al.* (2018b) and Prakash *et al.* (2019).

Effect of spacing: The main yield attributing parameters showed decreasing trend upon increasing plant spacing under both the protected structures during both the years. The closer spacing S₁ (50 cm × 20 cm) exhibited maximum average weight of fruits per m² total fruit yield, gross income as well as net-income and B:C ratio followed by S₂ (50 cm × 30 cm) (Supplementary Tables 1, 2, 3). Closer

spacing exhibited more vigorous growth and development of plants and their roots, which promoted higher yield and its attributes. Similar findings have been reported by Singh *et al.* (2015, 2016). Wider spacing was statistically inferior in comparison to closer spacing but in terms of earliness of flowering, fruit harvesting period, number of fruits, weight of fruits, it remained at par with S_4 and S_5 . However, it produced fruit 6 days later than the closer spacing S_1 (Supplementary Table 1). Considering the facts, closer spacing over wider spacing could be a better option for small and marginal polyhouse and IP net-house farmers to accommodate more number of plants for better profitability during off-season. Similar finding has been reported by Singh *et al.* (2015, 2016). Though, in wider spacing i.e. S_4 and S_5 (50 cm $\times$ 50 cm; 50 cm $\times$ 60 cm) plant height, number of leaves, number of main branch, fresh weight of plant biomass, length of roots, weight of fresh roots, fruits setting percentage, number of fruits per plant, diameter of fruit, length of fruits, fruit weight, un-marketable fruits and cost of cultivation were at par but were higher compared to closer spacing in both protected structures (Supplementary Table 1). These attributes increased with increasing pattern of plant spacing (S_1 to S_5). These factors exhibited maximum growth and development of plant individually, which produced maximum fruit numbers, weight, diameter, length and even enhanced yield per plant, however, total yield has reduced (10.9 kg/m²) and also net income from per unit area also reduced due to less plant population per unit area as compared to closer spacings (Supplementary Table 2, 3). Similar findings have been reported by Jat (2011), Maragal *et al.* (2018c) Singh *et al.* (2021). There was no significant effect of spacing in terms of days of flowering, fruit setting, fruit picking, total picking, harvesting period and total crop period (Supplementary Table 1).

Effect of pruning methods: The complete branch pruning method P_1 (single stem cultivation or branch less cultivation) was contributing positive significant effect on plant height, number of branches per plant, root length per plant, root weight per plant, diameter of individual fruit, weight of individual fruits and minimized plant mortality followed by P_2 pruning method. This pruning method was observed superior under polyhouse condition as compared to insect-proof net house structure (Supplementary Table 1, 2, 3). This pruning method also exhibited earliness by 1 to 4 days in flowering, picking, and enhanced number of pickings and total harvesting period over other pruning methods (Supplementary Table 1). This could be due to the fact that the single stems cultivation pruning method P_1 (branch less cultivation) was provided more sunshine, aeration and ventilation up to soil surface and around plant canopy. These factors create microclimate inside both the structures, hence, the activity influences soil microflora, temperature, RH and photosynthesis for promotion of water uptake and nutrient. Similar findings have been reported by Maragal *et al.* (2018d) and Singh *et al.* (2021).

Average fruits weight per plant, total yield of fruits, gross income, net-income and B:C ratio were found

maximum in P_2 (cutting all main branches after 1st node) over other pruning methods under both structure (Supplementary Table 1 and 2). However, the maximum branch node pruning method (P_2) could be a very good option for small and marginal protected cultivation farmers for economical gain during off-season production of long melon. The pruning method P_2 (cutting all main branches after 1st node) retained optimum flower bud nodes and provided optimum canopy management of each plant and minimized leaves and branch crowd load on plants. This type of pruned plants received more sunshine, aeration and ventilation up to soil surface and around plant canopy, this factor created microclimate inside the structure. This activity influences soil microflora, temperature, and RH which in turn enhanced photosynthesis for promotion of optimum uptake of water and nutrient. This nutrient uptake was used by main plant and selected branch nodes that gained more energy which in turn gave better growth, development and physiological performance of plant and provided maximum yield and economics under both structures. Similar findings have been reported by Singh *et al.* (2021). The excessive vegetative growth caused suboptimal use of photosynthesis resulting in decreased yield and production. The shoots of pruned main stem might be able to inhibit the production of auxin in the main stem and increase cytokinin hormone and this affects the extension of the lateral branches. Pruning essentially reduced unproductive parts of the plant so that the assimilates of the photosynthetic process were more widely allocated to enhance other plant growth processes such as cell enlargement. Similar findings were reported by Jat *et al.* (2017), Prakash *et al.* (2016) and Singh *et al.* (2016).

From the present study, it has been inferred that long melon production under polyhouse structure could be very good option for small and marginal farmers under plain conditions of India during off-season. Among the cultivation practices spacing and pruning method are two very important and critical operations under protected conditions which have direct impact on production, productivity and net income. The combination of polyhouse structure with closer spacing of 50 cm $\times$ 20 cm and optimum branch pruning (after one node cutting) gave highest yield and net income per unit area in long melon cultivation for off-season long melon.

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