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Response of long melon to spacing and pruning methods under insect proof net house during off-season

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ABSTRACT

The demand of long melon (*Kakari-Cucumis melon* var. *utilissimus* Duthic & Fuller) fruits during off-season are quite high in towns and cities. The off season cultivation of long melon in open field is not remunerative due to heavy losses to crop caused by infestation of insect–pest, birds and wild animals. Insect proof net house structures are suitable options to grow off-season long melon crop for high yield and good returns. An experiment was conducted under insect proof net house at CPCT, IARI, New Delhi, during off-season (August–November) 2016–17 for growing long melon var. *Chitralekha* with five plant spacings and five branch pruning methods. Plant spacing and pruning methods revealed significant positive influence on yield and net return. Fruit yield decreased with increasing plant spacing and it was found maximum in closer spacing of 50 cm × 20 cm. Net return and B:C ratio also followed similar trend. Amongst pruning methods, node branch pruning method (P_3) gave highest yield (67.96 q/1000 m^2) with maximum net return of ₹ 78391/1000 m^2 and BC ratio 1:1.40 compared to other pruning intensity or no pruning (control). Three node branches pruning method was close to two node branch pruning method in total yield, net return and BC ratio. Study showed that off season cultivation of long melon under insect proof net house protected structure is a good option to farmers for generating more income and employment.

Keywords: Insect proof net house, Long melon, Plant spacing, Pruning methods, Protected structure

Long melon, known as *kakari* (*Cucumis melon* var. *utilissimus* Duthic & Fuller) in north India, is cultivated during summer months. It is grown in river bed and Diara land in tropical, sub-tropical and milder zones, covering the states of Bihar, Uttar Pradesh, Madhya Pradesh, Rajasthan etc. Suitable climatic condition for long melon requires temperature 25–30^{0}C, humidity 60-70% and sun shine 700-800 w/m^2. *Kakari* is available in summer months and eaten fresh by all people to beat the heat. It is good source of water, minerals and vitamin C. It is also used as salad, vegetable and preserved in the form of sweets. *Kakari* fruits are long (40-50 cm), straight, thin; light green in color and cylindrical in shape. The supply of *kakari* fruits is restricted to summer months only. The demand of fruits in the cities and towns goes up to early winter. The supply of *kakari* fruits cannot be assured during off-season (from rainy months to early winter months) because of heavy loss in yield due to infestation of insect–pest, damage by birds and wild animals of *kakari* fruits grown during these months in open field. Off season *kakari* cultivation in insect proof net house structure is suitable option for farming community to produce quality fruits to meet the demand of cities and towns. Success of long melon cultivation under net house may give high yield and more return. Limited information is available on long melon cultivation under net house structure. The present study was undertaken during off-season (August to November) to assess the response of spacing and pruning methods on long melon variety *Chandralekha* under insect proof net house protected structure.

MATERIALS AND METHODS

The experiment was conducted at the Centre for Protected Cultivation Technology (CPCT), IARI, New Delhi, during 2016–17. Long melon (*kakari*) var. Chandralekha was grown with five plant spacing and five pruning methods treatments. The plant spacing were S_1 (50 cm × 20 cm), S_2 (50 cm × 30 cm), S_3 (50 cm × 40 cm), S_4 (50 cm × 50 cm) and S_5 (50 cm × 60 cm) and pruning methods were P_0 (control: no pruning), P_1 (all branches pruned: single stem cultivation), P_2 (all branches retained, pruned after 1st node), P_3 (all branches retained, pruned after 2nd node) and P_4 (all branches retained, pruned after 3rd node). Experiment was conducted under GI pipe made Quonset

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type naturally ventilated insect proof net house structure. The total area of net house was 1000 m^2 (size of length 50 m, width 20 m, side height 3 m and centre height 5m was net house structure). Net house was covered with nylon make white colour UV stabilized 40 mess size insect proof net. The insect proof net had quality to maintain 0.5–2^{0}C more temperature and 5–7% more humidity inside the net house, comparing to temperature and humidity in ambient condition. This net structure received rainfall inside if rains. The experiment was laid down in randomized block design with three replications and 25 treatments combinations.

The seed of the *kakari* (var. Chandralekha) were treated with trichodermavirdi and sown in the plastics pro-tray with soilless medium in sprat nursery polyhouse during 2nd week of July in both years. The 20 days old seedlings were transplanted in the net house. The soil was sandy loam with *p*H 8 and EC up to 2 micro mahos. The experimental plots size was 1m× 2.5m. Compost @ 200 q/1000 m^2 and 50% of NPK dose (@ 25:17:26 kg/1000 m^2) was incorporated in the plots as basal before 15 days of planting. Remaining 50% of NPK was applied in the form of water soluble fertilizer (20:20:20 NPK) through drip-fertigation twice in a week. The application of water soluble fertilizer started after 2 weeks of transplanting. The concentration of applied nutrients increased from 100 ppm, 150 ppm and then 200 ppm with increasing age of crop. Before planting the seedbeds of *kakari* crop, the soil of experimental plots was disinfected from soil borne diseases by Solorization technique. Double line 2 LPH, 16 mm drip irrigation system was installed in all plots before transplanting. The planting of seedlings was done during late afternoon in first week of August in both years. After planting, plants were irrigated immediately using drip irrigation system to reduce the water stress on the plants. Vertically cordon trimming method was used to prune the *kakari* plant at weekly interval after 20-25 days of transplanting. Cultural operation GAP (IPM, IDM, and INM) protocols were practiced at weekly intervals. Daily visit was compulsory for hand pollination during morning hours (7-9 AM). The infestation of fungal and insect pest on crop was controlled by need based of Bavistin or Indofil M-45, or regent or confidor dicofol or Neemgold pesticides @ 0.5-1 g or ml per litre water.

Four plants were tagged in each plot for weekly data recording. The data on plant growth, initiation of flowering, start of first picking total number of picking duration, plant height, number of leaves, branches plant, fresh biomass length of roots, weight of roots, fruit setting (%) was calculated on the basis of total number of marketable and unmarketable fruits within number of female flowers per plant, % plant mortality was calculated all kind of dead plants from transplanting to last day and % of unmarketable fruits was calculated. Through each harvest during grading per plant and yield contributing factors (fruits per plant, fruits diameter, length of fruits, fruit weight, and fruits weight kg/plant) were recorded, and expressed as kg/m^2 and quintal per 1000 m^2

The data were analyzed using standard statistical methods (SPSS-21). Fruit yield of long melon per 1000 m^2 was calculated on the basis of fruit weight per plant multiplied by number of plants per square meter multiplied by 700 m^2, because 700 m^2 areas is generally covered with crop in 1000 m^2 under net house protected structure.

Yield (q/1000 m^2) = (Fruit weight kg/plant × number of plants/m^2 × 700 m^2) ÷100.

Gross income = Total yield × Price of fruit

Net income = Gross income – Cost of cultivation

$$\text{Benefit: cost ratio (B:C)} = \frac{\text{Gross income}}{\text{Cost of cultivation}}$$

RESULTS AND DISCUSSION

Long melon var. Chandralekha was grown in insect proof net-house protected structure during off-season (August to November) with five spacing (S_1, S_2, S_3, S_4, and S_5) and five pruning methods (P_0, P_1, P_2, P_3 and P_4). The growth characters, yield attributes and economic return were analysed and the results were discussed under following sections climate condition, growth and development characters and yield attributes and economic returns.

Climate conditions: Monthly mean values of temperature and relative humidity inside the net-house vis-a-vis ambient condition calculated from daily records for two years. Comparison of temperature and relative humidity data between inside the insect proof net house condition and ambient condition revealed that maximum temperature was higher inside insect proof net house condition than ambient condition. But the minimum temperature showed reverse trend. Relative humidity followed the same trend as air temperature under both conditions (Table 1). This might be due low circulation of atmospheric air inside insect proof net house. Similar finding reported is also by Singh *et al.* (2017), Sharma *et al.* (2005) and Margal *et al. (*2018)

Growth characters: Spacing between the *kakari* plants influenced the growth contributing characteristics (plant height, number of leaves per plant, number of branches per plant, green biomass weight, root depth and fresh root weight). Plant height, number of leaves per plant, number of branches per plant, biomass weight, root length and fresh root weight per plant increased significantly with increased plant spacing from S_1 (50 cm × 20 cm) to S_5 (50 cm × 60 cm) in the Table 2. Due to fact that wider spacing provided optimum sunshine, aeration, root space and minimized nutrient uptake. These factors are responsible for maximum growth and development of plants (Singh *et al*. 2005& 2016). Plant spacing also influenced fruit setting percent significantly. Male-females flower ratio was recorded maximum (79:21) on wider spacing (S_5) and successive fruit (%) recorded maximum (39%) but almost at par in the spacing S_1 to S_4 and showed no significant difference between spacing to spacing treatments. However, wider spacing S_5 produced maximum female flowers per plant but influence lower % of successive fruit setting (36%) and sowing significant effect with 3% difference between closer to wider spacing. The female flowers were increased

Table 1 Air temperature and humidity under insect proof net house and ambient condition during crop growth period

Month	Pooled data 2016 and 2017							
	Insect proof net house condition*				Ambient condition*			
	Temperature (°C)		RH (%)		Temperature (°C)		RH (%)	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
August	35.37	27.32	95.50	79.2	33.10	25.05	89.95	73.69
September	36.22	25.37	92.40	63.4	33.95	23.10	88.10	59.11
October	35.72	18.47	92.70	44.3	33.95	16.70	89.35	40.90
November	29.37	11.27	91.70	46.6	27.9	9.80	88.00	42.90
December	24.17	7.07	94.30	54.8	23.15	6.05	90.40	50.90
Mean	32.17	17.90	93.30	57.6	30.41	16.14	89.16	53.50

*Air temperature and humidity were recorded daily during crop growth and converted to monthly average

with increase in spacing (S_1 to S_5). Due to fact that wider spacing (50 cm × 60 cm) produced maximum marketable fruits and total number of fruits while recorded less from other closer spacing. Similarly found lower fruits setting (%) from others spacing. Similar finding also reported by Oga and Umekewe (2016), Singh *et al*. (2016) and Singh *et al*. (1995). Data revealed that increasing plant spacing significantly decreased the percent of unmarketable fruits and plant mortality (Table 2). The unmarketable fruit was less (1.88%) in wider spacing (S_5) but higher (3.19%) in closer spacing (S_1). Similar trend was observed in case of plant mortality (Singh *et al*. 2003, 2005, and 2016). The reasons might be minimum competition between plant for space, nutrients, water and light etc. There was no significant effect of spacing on flower initiation days, first fruit picking days and total number of fruit picking. But, the initial flowering and first fruit picking were delayed by 5 and 4 days, respectively at spacing S_1 than S_4 and S_5. Total number of fruit picking increased with increased spacing (Table 2). Similar results were also reported by Devi and Verma (2014) and Singh *et al*. (2003, 2005 and 2016).

Pruning methods also influenced the growth characteristics of *kakari* (Table 2). Plant height of *kakari* was significantly influenced by pruning methods. Maximum plant height was recorded when all branches of plants were pruned (P_1) followed by P_2, P_3, and P_4. The reason of more height at P_1 might be nutrient availability only to main stem in absence of branches. Number of branches, leaves, green biomass, root length and root weight per plant were significantly affected by pruning methods. Pruning methods significantly influenced the number of branches (8.55), number of leaves (123.87), green biomass (1.22 kg), root length (28.97cm) and root weight (51.24) per plant were found maximum in un-pruned plant or zero pruning (P_0) and minimum in P_1 (all branches pruned plant). These all characters were increased as per decreasing pattern of branch node pruning. The best ratio (75:25) of male/female flower or maximum female and minimum male flower was found on three node pruned branch P_4 the fruit setting showed significant response to pruning and it was found highest (46%) in pruning. Un-marketable fruit percent was decreased significantly from complete branch pruning or branchless plant pruning. Plant mortality was high at P_0 and low at P_1 pruning methods, similar finding was also reported by Oga and Umekewe (2016) and Ekwu *et al*. (2012). There was no significant effect of pruning methods on flowering initiation, days of first fruit picking and total number of fruit picking (Table 2). Observation showed that number of fruit picking was less (10) at P_0 and more (16) at P_3 followed by P_4 methods of pruning. Similar observations also recorded by Mardhana *et al*. (2017) and Utobo *et al*. (2010).

Yield and income: Yield of *kakari* crops was influenced by number of fruits per plant, individual fruit diameter, length, weight and fruits weight (kg per plant). It was observed that these characters of *kakari* crop were significantly influenced by plant spacing (Table 3). Number of fruits per plant, fruit diameter, fruit length, single fruit weight and fruit weight (kg per plant) increased from closer spacing (S_1) to wider spacing (S_4).There was no difference in these characters of *kakari* fruit at wider spacing S_4 and S_5. Similar observations were also recorded by Devi and Verma (2014), Mohamed (2001) with yield attributes with increasing of spacing. However, between above mentioned fruit characters and total *kakari* yield per 1000 m^2 showed reverse trends. It indicated that not only fruits' characters but weight of *kakari* fruits per square meter was dominant factor for high yield, leading to high gross return, net income and B:C ratio. *Kakari* fruits' characters were increased with increased plant spacing. The reasons might be due to more space; sun light and nutrients under wider spacing. These results are in confirmation with the finding of Singh *et al*. (2003, 2005, 2016) who also reported an increased yield and economics with closer spacing. Reduction in *kakari* fruit yield per 1000 m^2 with increased plant spacing might be due to reduced number of plant population per unit area. *Kakari* cultivation under insect proof net house structure gave maximum return (Gross income: ₹ 275308, net income: ₹ 86261 and B:C ratio: 1: 1.42) at close spacing S_1 (50 cm × 20 cm) followed by S_2, S_3 and S_4 spacing. Economic return obtained from *kakari* yield under widest spacing S_5 (50 cm × 60cm) was negative with the loss of ₹ 16050/1000 m^2.

Table 2 Effect of spacing and pruning methods on growth characters of long melon grown under insect proof net house during off-season (pooled data 2016 and 2017)

Treatment	Mean values of growth characters*													
	Flowering initiation (days)	First fruit picking (days)	Number of fruit picking	Total picking period (days)	Plant height (m)	Number of leaves per plant	Number of branches per plant	Green biomass weight (kg)	Length of fresh roots (cm)	Fresh roots weight (gm)	% of male and female flower ratio	% of success fruit setting	% of Un-success fruit setting	% of Un-mar-ketable fruits	% of plant mortality
*Plant spacing's***															
S_1	31	40	12	76	2.45	40.26	4.42	0.52	20.85	39.22	83:17	39	61	3.19	11.20
S_2	28	38	13	83	3.13	53.71	5.82	0.79	23.27	41.23	82:18	38	62	2.83	10.42
S_3	27	37	14	89	3.51	58.53	6.41	0.93	24.56	42.87	81:19	39	61	2.59	8.84
S_4	26	36	15	95	3.56	59.18	7.33	1.27	26.58	44.68	80:20	39	61	2.16	7.32
S_5	26	36	15	95	3.80	63.65	8.50	1.51	27.43	45.27	79:21	36	64	1.88	6.89
CD (P=0.05)	NS	NS	NS	3.70	0.52	1.35	0.43	0.12	0.80	1.08	NC	0.32	0.35	0.49	0.40
*Pruning methods****															
P_0	29	39	10	78	3.10	123.87	8.55	1.22	28.97	51.24	85:15	46	54	3.73	10.02
P_1	26	35	13	81	3.64	22.67	0.00	0.48	19.85	29.42	84:16	34	66	1.61	7.32
P_2	27	37	14	91	3.37	34.25	8.18	0.92	21.88	40.78	82:18	44	56	2.89	8.52
P_3	28	38	16	94	3.22	43.34	7.89	1.04	25.24	45.07	79:21	37	63	2.35	8.96
P_4	28	38	16	94	3.11	51.20	7.85	1.13	26.75	47.25	75:25	31	69	2.08	9.85
CD (P=0.05)	NS	NS	NS	3.18	0.24	1.95	NS	0.14	0.31	1.72	NC	1.08	0.86	0.23	0.27

*Mean values of two seasons (2016 to 2017); NS: Non significant, NC: Not calculated; ** Spacing were S_1 (50 cm × 20 cm),S_2 (50 cm × 30 cm), S_3 (50 cm × 40 cm), S_4 (50 cm × 50 cm), S_5 (50 cm × 60 cm); *** Pruning methods were P_0 (control: no pruning), P_1 (all branches pruned: single stem cultivation); P_2 (all branches retained and pruned after 1st node), P_3 (all branches retained and pruned after 2nd node) andP_4 (all branches retained and pruned after 3rd node).

Table 3 Effect of spacing and pruning methods on yield and economic return of Long melon grown under insect proof net house structure during off-season (pooled data 2016 and 2017)

	Mean values of Yield and Income Characters*										
Treatment	Number of fruits per plant	Fruit diameter (cm)	Fruit length (cm)	Fruit weight (gm)	Fruits weight (kg/plant)	Fruit weight (kg/m^2)	Total yield (q/1000 m^2)	Cost of cultivation (₹/1000m^2)	Grass income (₹/1000 m^2)**	Net income (₹/1000 m^2)	B.C. ratio
*Plant spacing****											
S_1	3.47	2.28	52.13	309.10	1.09	9.83	70.05	193921	275308	86261	1.42
S_2	3.87	2.46	55.08	315.16	1.24	8.67	62.07	193480	242691	54788	1.25
S_3	4.80	2.61	58.78	341.30	1.60	8.02	58.87	193369	224618	31281	1.16
S_4	5.67	2.82	61.76	345.96	1.90	7.61	53.79	193259	213085	21903	1.10
S_5	5.40	2.91	62.06	345.86	1.89	6.29	44.83	193151	176049	-16050	0.91
CD (P =0.05)	0.11	0.10	0.73	2.33	0.06	0.42	2.92	NC	NC	NC	NC
*Pruning methods*****											
P_0	3.27	2.14	49.52	284.05	0.95	4.68	32.75	193445	131013	-62431	1.12
P_1	3.93	3.10	64.62	382.95	1.54	7.74	54.15	193423	216585	23162	1.25
P_2	4.80	2.66	61.52	344.03	1.68	8.61	60.26	193423	241040	47617	1.40
P_3	5.47	2.61	56.89	323.54	1.79	9.71	67.96	193445	271835	78391	1.40
P_4	5.73	2.58	57.06	322.80	1.78	9.69	67.82	193445	271278	77834	1.17
CD (P =0.05)	0.08	0.03	0.40	1.35	0.03	0.16	1.09	NC	NC	NC	NC

*Mean data of two season (2016 and 2017; **Two season average of sale price of *kakari* @₹ 40 /kg; NS : Non significant; NC: Not calculated; *** Spacing were S_1 (50 cm × 20 cm), S_2 (50 cm × 30 cm), S_3 (50 cm × 40 cm), S_4 (50 cm × 50 cm), S_5(50 cm × 50 cm); **** Pruning methods were P_0 (control: no pruning), P_1 (all branches pruned: single stem cultivation); P_2 (all branches retained and pruned after 1st node), P_3 (all branches retained and pruned after 2nd node) and P_4 (all branches retained and pruned after 3rd node).

Pruning methods also influenced the fruit characters and fruit yields of *kakari* crop grown under insect proof net house significantly. There were significantly close competition between P_1 and P_2 pruning methods on fruit diameter, fruit length, single fruit weight, compared other pruning methods (Table 3). However, number of fruits per plant, weight of fruits (kg/plant) fruit weight per square meter and fruit yield (kg/1000 m^2) were recorded maximum in P_3 and P_4 both are found together near too much closed on the minimum node pruning method. These resulted high gross return, net return and benefit cost ratio (Table 3). Due to fact that 2 and 3 node branch pruning method exhibited more number of fruits per plant, that commensurate higher fruit weight (kg/plant) and total yield and thus enhanced total income (Table 3).The present finding is inline of basic principal of pruning as it intended to control the optimal number of leaves thereby improving the yield. Pruning is attempted to create a better state of the plant, so that sunlight can enter to whole interception of light into the canopy of plant part of the plant, increase the availability of air circulation and CO_2 in the canopy. The sufficient light and CO_2 and other supporting factors will increased photosynthesis rate which lead to increase the availability of photosynthesis. The excessive vegetative growth caused a suboptimal use of photosynthesis result and led to decrease the yield production. The shoots of pruning of the main stem might be able to inhibit the production of auxin in the main stem and increase cytokine hormone and this affects the extension of the lateral branch (Coggins and Lovatt 2014). The result of the photosynthesis allocated for cell enlargement in the fruit tissue since the meristematic cell in the fruits will result in increasing the volume size so that the cell growth is in line with the increased of fruit diameter. Pruning essentially reduce unproductive part of the plant so that assimilate of the photosynthesis process is the more widely allocated to enhance other plant growth processes such as cell enlargement. These findings were reported by Coggins and Lovatt (2014), Meier and Leuschner (2008), Yu *et al*. (2013), Mardhiana*et al*. (2017), Buwalda and Freeman (1986), Prakash *et al*. (2016) and Singh *et al*. (2016).

The present study on off-season production of long melon var. Chandralekha, under insect proof net house conditions conferred that plant spacing and branch nodes pruning were responsible for higher yield and net return. Close plant spacing (50 cm × 20 cm and 50 cm × 30 cm) produced higher fruit yield per unit area and gave more net return. The 2 or 3 node branch pruning were optimum to give highest total yield and net return. The study provided new information that branch/shoot node pruning from the main branch could increase the earliness and quality (fruit weight, size) of long melon under insect proof net house protected structure in the plain reasons of India during off-season Findings of present study was therefore established the fact that off-season cultivation of long melon is beneficial to farmers in terms of both productivity and net return.

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