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Response of capsicum varieties to varying pruning systems under protected conditions

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Abstract
The present investigation was conducted at experimental field of Division of Vegetable Sciences, SKUAST-Kashmir to assess the influence of pruning systems on growth, yield, and quality of capsicum (*Capsicum spp.* L) under protected conditions of Kashmir valley. The trail was carried out in capsicum with three varieties namely Indra (V_1) Bomby(V_2) and Orobelle (V_3) and two systems of pruning namely Po (no pruning) and P_1 (pruning to four stems treatments) consisting of six treatments T_1 =P_oV_1, T_2= PoV_2, T_3= PoV_3, T_4= P_1V_1, T_5= P_1V_2 and T_6 = P_1V_3, replicated thrice with Randomized Block Design. Pooled analysis of two years revealed that amongst the treatments, treatment T_4 (P_1V_1) recorded maximum values of plant height (149.81cm), no. of leaves per plant (102.03), leaf area (165.10 cms), no. of fruits per plant $^{-1}$ (20.90), fruit yield per plot (17.18 kg plot^{-1}) and fruit yield per hectare (542.13 q ha^{-1}) which was significantly superior to rest of other treatments but at par to treatments T_3, T_5 and T_6 in case of no. of leaves per plant and to treatment T_1 in case of fruit number per plant. Further it was also observed that maximum quality parameters as T.SS Brix^0 (8.05), Vitamin C content (223.61 mg/100 gm) and Protein content (1.11%) were found maximum with treatment T_4 also which was significantly superior to all other treatments but at par toT_1, T_2, T_5 and T_6 in case of T.S.S and to T_1, T_5 and T_6 in case of Vitamin C content respectively.

Keywords: Capsicum, pruning, growth, yield, and quality, varieties

1. Introduction
Capsicum (*Capsicum annuum* L.) also known as sweet pepper or bell pepper is one of the most popular vegetable crops grown in India as well as in several other parts of the world. It is believed to be the native of tropical South America (Shoemaker and Tesky, 1995) [17]. In India, capsicum occupies an area of 24,000 hectares with an estimated production of 33,000 metric tonnes. (NHB., 2016-17) [14]. The productivity of capsicum is very low in India. Capsicum under open field cultivation yields between 20-40 t/ha, where as in a greenhouse the yield ranges from 100 to 120 t/ha. Bell pepper (*Capsicum annuum*) is among the most grown vegetables in greenhouses worldwide. From a nutritional perspective, bell pepper is rich in vitamins; chiefly, vit. C and provitamin A. Concentrations of vitamin C is ranged from 63 to 243 (mg 100 g^{-1}) depending on fruit colour (Howard *et al.*, 1994) [9]. In a survey on content of vitamin C in fruits and vegetables, bell peppers represented the highest fourth out of 42 choices (Frank *et al.*, 2001) [6]. A 100 g of edible portion of pepper provides 24 Kcal of energy, 1.3 g of protein, 4.3 g of carbohydrates and 0.3 g of fat (Zende, 2008) [19].
Also, it is one of the valuable medicinal plants in pharmaceutical industries, owing to high amounts of health promoting substances, particularly antioxidant, capsaicin and capsanthin (Aminifard *et al.*, 2012) [2]. Greenhouse bell pepper cultivars are mostly hybrids that have bellshaped or blocky-type fruits with varied colors. While green is the most favored color in bell peppers, red and yellow are also preferred with higher price in fresh market. Market shares in USA are about 80%, 10%, and 8% for the three colors, respectively (Frank *et al.*, 2001) [6]. Pepper plants have a branching habit; therefore, fruit development is controlled by restricting the branching pattern to 1, 2, 3 and 4 main branches. The reasons for pruning bell pepper under greenhouse conditions are to train plant to grow upright in order to facilitate light penetration all over the leaf canopy, improve fruit set and obtain early fruit ripening and high yield of large sized fruits (Jovicich *et al.*, 2004; Zende 2008) [11, 19].
Pruning is effective in improving air circulation which reduces relative humidity and limits the spread of diseases (Esiyok *et al.*, 1994) [5]. Pruning methods vary with different branching habits of Capsicum cvs. and under different plant densities (Maniutiu *et al.*, 2010) [13]. The prime objective of the pruning practice is obtaining proper balance between fruit number and fruit size by improved canopy management. Due to the heavy vegetative growth and fruit load

on the colored pepper plants (Shaw and Cantliffe, 2002) [16], shoot pruning is important factor in proper utilization of production area (Maniutiu *et al*., 2010) [13]. Pruning plants to 2, 3 or 4 shoots was reported to be effective in increasing yield and reducing fruit size. Thus, the limitation of shoot number allows the increase in fruit quality (Cebula, 1995) [3]. Several studies have reported an increase in fruit yield of sweet pepper with increase in shoot number under soilless media in protected agriculture (Jovicich *et al.*, 2004; Maboko *et al*., 2012) [11, 12]. Therefore the present investigation has been taken to assess the response of capsicum varieties namely Indra, Bomby and Oreblle to different systems of pruning.

Greenhouse production technology of vegetables emphasizes the need for having appropriate plant densities, plant structure and use of optimum levels of growth regulators in order to boost up the production per unit area by utilizing the available space and nutrients applied. Since not much information is available on greenhouse cultivation of sweet pepper with respect to varying levels of pruning and growth regulators, there is an imminent need to assess the optimum levels of pruning and growth regulators for its cultivation in greenhouse. Therefore, this experiment was carried out to study the influence of pruning and growth regulators on the growth of capsicum plants

Pruning is effective in improving air circulation which reduces relative humidity and limits the spread of diseases (Esiyok *et al*., 1994) [5]. Pruning methods vary with different branching habits of capsicum cvs. And under different plant densities (Dasgan and Abak, 2003; Maniutiu *et al*., 2010) [4, 13]. The prime objective of the pruning practice is obtaining proper balance between fruit number and fruit size by improved canopy management. Due to the heavy vegetative growth and fruit load on the colored pepper plants (Shaw and Cantliffe, 2002) [16], shoot pruning is important factor in proper utilization of production area (Maniutiu *et al*., 2010) [13]. Pruning plants to 2, 3 or 4 shoots was reported to be effective in increasing yield and reducing fruit size. Thus, the limitation of shoot number allows the increase in fruit quality (Cebula, 1995) [3]. Several studies have reported an increase in fruit yield of sweet pepper with increase in shoot number under soilless media in protected agriculture (Jovicich *et al*., 2004; Maboko *et al*., 2012) [11, 12]. Therefore the present investigation has been taken to assess the response of capsicum varieties namely Indra, Bomby and Orobelle to different systems of pruning.

Materials and Methods

A field experiment was conducted at experimental field Division of Vegetable Sciences, SKUAST-Kashmir. The experiment was laid in a randomised block design with three replications. The seeds of capsicum varieties were sown in first week of March in polyhouse and transplanted after 30 days in april at a spacing of 60 × 45 cms under controlled conditions. Recommended package of practices were followed.

The plant protection measures were taken up to control pest and diseases as and when required along with intercultural operations. In each plot 10 plants were tagged for taking all observations. Plant height, was recorded at final pickings in cms. Number of leaves per plant and leaf area were observed at full vegetative stage. Number of fruits were counted by total number of fruits in each picking. Fruit yield / plot, was recorded by weighing total no. of fruits in all pickings on per plot basis and then converted in fruit yield / hectare in quintals.

T.S.S^0 Brix was recorded with Digital Refractometers, ascorbic acid (mg/100g) content of fruits from each treatment was determined by 2, 6 dichlorophenol indophenols visual titration method suggested by A.O.A.C (1975) [1] and expressed in milligram per 100 g of fresh weight for all the treatment combinations in all replications. The protein content was calculated by multiplying a factor 6.25 (protein factor) with total nitrogen content in fruits. Total nitrogen content in bulbs was determined by Kjeldahls method as outlined by Tandon (1993) [18].

Data recorded were tabulated and statistically analysed as per (Gomez and Gomez, 1984) [8]. Significant difference between treatment means was tested through 'F' test and critical difference (CD) was worked out wherever 'F' value was found to be significant for treatment effect.

The treatment details are

T_1= P_0V_1 (P_0=no pruning, V_1=Indra)
T_2= P_0V_2 (P_0= no pruning, V_2= Bomby)
T_3= P_0V_3 (P_0= no pruning, V_3 = Orobelle)
T_4= P_1V_1 (P_1= pruning to four stems, V_1=Indra)
T_5 = P_1V_2 (P_1= pruning to four stems, V_2= Bomby)
T_6 = P_1V_3 (P_1= pruning to four stems, V_3 = Orobelle)

Results and Discussion

1) Influence of different systems of pruning on growth and yield parameters of capsicum under protected conditions (Table-1 &Table -2)

The effect of different treatments on the growth and yield parameters of capsicum is described here as under: As per table -1 pooled data revealed that treatment T_4 = P_1V_1 (P_1= pruning to four stems, V_1=Indra) recorded maximum values of plant height (149.80 cms), no of leaves per plant (102.03), leaf area (165.10 cm^2) which was significantly superior to rest of other treatment but at par with treatment T_3 and T_5 in case of no. of leaves per plant only. Further as Table-2 revealed that the maximum no of fruits per plant (20.90),fruit yield per plot (17.18 kg/plot) and fruit yield per hectare (542.13 q ha^{-1}) was found with treatment T_4 = P_1V_1 (P_1= pruning to four stems, V_1=Indra) which was significantly superior to rest of all treatments but at par to treatment T_1 &T_5 in case of no. of fruits per plant and also at par with T_1 in case of fruit yield per plot respectively (pooled data). Pruning to 4 branches per plant restricted the side branches and stimulated the plants to flower early and set the fruit. Increase in flowering and per cent fruit set might be due to the production of more number of branches in such plants and optimum vegetative growth **(**G. R.Shetty and R. K. Manohar 2008) [7]. Similar result was found by (I. Singh and A. Kaur 2018) [10] in capsicum. This might have resulted due to more number of shoots which may have contributed in producing more number of fruits. Similar work has been reported by (Jovicich *et al.* 2004) [11]; (Satpute *et al.* 2013) [15] in capsicum.

Table 1: Influence of different systems of pruning on growth attributes of capsicum under protected conditions

	Plant Height (cm)			No. of Leaves plant^{-1}			Leaf area (cms)		
	Ist Year	2nd Year	Pooled	Ist Year	2nd Year	Pooled	Ist Year	2nd Year	Pooled
T_1 =	138.00	139.88	138.94	91.97	93.33	92.65	156.26	157.91	157.08
T_2	131.09	133.36	132.22	95.71	98.00	96.95	147.95	150.67	149.30
T_3	135.04	136.05	135.54	97.33	99.19	98.26	147.39	148.97	148.18
T_4=	149.37	150.43	149.81	100.82	103.20	102.03	164.26	165.97	165.10
T_5 =	127.94	129.19	128.61	99.00	100.44	99.71	153.32	155.65	154.48
T_6 =	125.94	127.71	126.83	95.80	98.68	97.24	153.28	154.93	154.11
C.D≤.0.5	5.79	5.49	5.54	5.00	4.95	4.85	3.31	4.41	3.56

Table 2: Influence of different systems of pruning on yield and yield related attributes of capsicum under protected conditions

	No. of fruits /plant			Fruit Yield (kg/ plot)			(Fruit Yield q/hac)		
	Ist Year	2nd Year	Pooled	Ist Year	2nd Year	Pooled	Ist Year	2nd Year	Pooled
T_1	18.15	20.58	19.36	15.45	15.38	15.29	476.79	474.47	475.63
T_2	13.56	14.64	14.09	10.30	10.33	10.31	317.86	318.86	352.36
T_3	16.25	16.91	16.58	11.00	11.10	11.37	339.46	342.62	341.04
T_4	20.40	21.39	20.90	17.50	17.64	17.18	540.05	544.22	542.13
T_5	18.04	19.05	18.45	12.15	12.20	12.00	374.95	376.49	375.72
T_6	16.75	18.15	17.45	11.90	11.94	11.75	367.23	368.55	367.89
C.D≤.0.5	2.14	2.75	2.13	1.60	1.72	1.96	49.38	53.06	44.87

2) Influence of different systems of pruning on quality parameters of capsicum under protected conditions (Table -3)

Pooled analysis revealed that as per table-3 the treatment T_4 = P_1V_1 (P_1= pruning to four stems, V_1=Indra) recorded maximum values of T.S.S Brix^0 (8.05), Vitamin C (223.61 mg /100 g) and Protein content (1.11%) and the values were at par with all treatments in case of protein content, at par with treatment T_1, T_2, T_5 and T_6 in case of T.S.S (Brix^0), T_1, T_6 and T_6 in case of Vitamin C content.(Table -3, pooled). Pruning the plants brings better management, permit closer planting, early maturity of fruits, higher yield of larger sized fruits as well as uniform light penetration in the plant canopy. Due to the heavy vegetative growth and fruit load on the colored pepper plants shoot pruning proves to be one of the important factor in proper utilization of production area (Maniutius *et al.* 2010) [13].

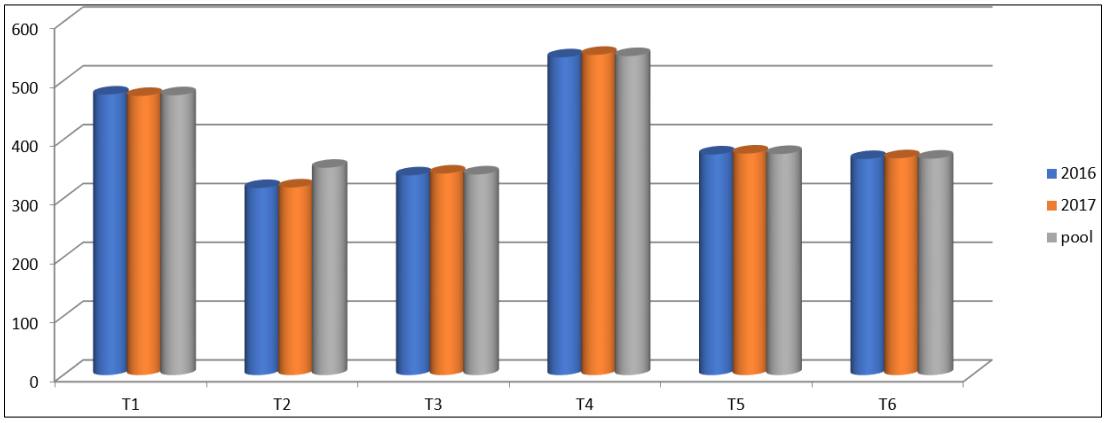

Fig 1: Capsicum Fruit Yield per hectare in quintals during Ist Year 2nd Year and after pooling data

Table 3: Influence of different systems of pruning on quality attributes of capsicum under protected conditions

	T.S.S (Brix)			Vitamin C mg/100 g			Protein content %		
	Ist Year	2nd Year	Pooled	Ist Year	2nd Year	Pooled	Ist Year	2nd Year	Pooled
T_1	7.71	7.75	7.73	223.65	222.77	223.21	1.05	1.02	1.01
T_2	7.42	7.49	7.45	207.33	205.98	206.08	1.03	1.05	1.03
T_3	7.25	7.31	7.28	207.14	207.45	207.29	1.04	1.04	1.04
T_4	8.02	8.10	8.05	224.22	223.00	223.61	1.11	1.12	1.11
T_5	7.71	7.78	7.74	223.46	221.68	222.35	1.05	1.00	1.02
T_6	7.72	7.76	7.74	212.86	213.77	213.31	0.98	0.98	0.98
C.D≤.0.5	0.64	0.63	0.63	10.21	10.66	10.60	0.12	0.09	0.25

Conclusion

The results can be summarised as, the treatment T_4 = P_1V_1 (P_1= pruning to four stems, V_1=Indra) was recorded significantly maximum values for most of the growth, yield, and quality parameters and therefore is recommended for farmers trials. However, further research trials should carried in different locations to assess the best possible results.

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