

SHORT COMMUNICATION

**EFFECT OF PLANT DENSITY ON YIELD AND QUALITY OF
CAPSICUM (*Capsicum annuum* L.) IN UPCOUNTRY INTERMEDIATE
ZONE**

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INTRODUCTION

Capsicum (*Capsicum annuum* L.) can be grown throughout the year up to an elevation of about 1500m (Technoguide, 1990). The total extent of capsicum cultivated in Sri Lanka was 3193 ha in 2007 and the annual production was 14,089 mt. (Agstat, 2008). The extent cultivated in Badulla and Moneragala district was 667 ha and it was around 20 % of the total extent of capsicum cultivated in 2007. (Agstat, 2008). Two varieties of capsicum, CA-8 and Hungarian yellow wax (HYW) are recommended for cultivation by the Department of Agriculture in Sri Lanka (Technoguide, 1990). HYW is the most popular variety in Up Country Intermediate Zone (UCIZ) due to its fruit quality and high yield potential. High level of management is required to produce a successful capsicum crop with acceptable quality. Poor management of the crop can seriously affect the yield and pod quality (Lovatt *et al.*, 2005). Capsicum plants grown at close spacing generally produce more upright plants, higher fruits yield and more pods per unit area, but fruit yield per plant is low. Similarly, growth and reproductive potential of individual plants are reduced at high plant densities, but this is compensated by plant populations (Macengahama *et al.*, 2009). Determinate Capsicum cultivars in general, occupy less space and can thus be planted more densely (Guptha, 1992).

In the Upcountry Intermediate Zone, vegetable cultivation in paddy fields is done during the *yala* season and to some extent in upland during *maha* season. Yield of capsicum vary considerably depending on climatic conditions of the cropping season, pest and disease incidence and cultural practices. Capsicum-growers use different planting densities especially for intra row spacing. Most farmers use very high plant densities, with high fertilizer rates, that results in high cost of cultivation (Rs. 250,040 ha) (DOA,2008). Therefore some farmers make profit while others failed heavily. Sub optimal plant population results in high weed infestations and yield reduction. To overcome these problems, it is necessary to determine optimum plant densities for capsicum production in the region.

MATERIALS AND METHODS

An experiment was conducted at the Regional Agriculture Research and Development Centre, Bandarawela during 2007 and 2008 *yala* seasons. The experimental design was randomized complete block design with four replicates. Variety Hungarian Yellow Wax was used for the trials. Four different spacing (30x8cm, 30x10cm, 30x20 cm and 30x25cm) were evaluated along with the Department of Agriculture (DOA) recommended spacing of 30x15cm. The DOA recommended spacing between rows (30cm), for the variety Hungarian Yellow Wax was not changed among the treatments while spacing within the row was changed depending on the treatments. All the other crop management practices were carried out as the recommended by the DOA.

The number and weight of good quality pods in every pluck were measured as the marketable yield (Table 1). Border effects were avoided by not harvesting border rows.

Pod quality analysis

Pod length, girth and the pod quality were measured using randomly selected samples. Length was measured from the calyx margin to the apex of the pod and highest girth was taken around the pedicel of the pod. Three different parameters were used for the evaluation of pod overall quality (Table 1). Pod quality variations were analyzed by ranking method.

Table 1. Used criteria to evaluate the pod quality

<i>Quality</i>	<i>Size</i>	<i>Appearance</i>	<i>Pest disease Damages</i>
Bad	Small or normal	Deformities, wrinkled or curled	Pods with Pest disease damages
Good	Normal	With shiny appearance Cone or normal shaped	Without Pest and disease damages

Small pods- length - 8 cm \geq .Girth \geq ; Normal sized pods-Length- 8 cm $<$, Girth- 6 cm $<$

Light interception and Ground cover by the canopy

Light interception: To identify the effect of light harvesting index by the crop and light penetration to the ground, light intensity around canopy at one foot above ground level was measured using a light meter (VU Fong, Model YF 172) at 50% flowering.

Ground Cover by the Foliage: Four square feet frame was used to measure the ground cover. It was placed randomly over the canopy between two plants

and visual estimates on ground cover by the canopy was recorded in 5 places each plot.

Weed infestation: Percentage of weed coverage in each density level was also measured in two randomly selected four square feet area in each plot. The area covered by the weeds was taken as a percentage in each sample.

RESULTS AND DISCUSSION

Variations in plant populations significantly influenced ($p < 0.05$) the total yield/ha during *yala* seasons (Table 3). As plant spacing within the row decreased from the recommended plant spacing of 30x15 cm to 30x10 cm, or increasing plant population from 167,000 to 250,000, the total yield per hectare increased by 87% in 2008 and 27% in 2007. Further decrease in within row spacing below 10cm, the yield decreased by 28% in 2008 and 38 % in 2007. Macengahama *et al.* (2009) found a similar trend when Capsicum plant population increased from 35,000 through to 65,000 plants/ha, total fruit yield increased by 22-65 % but yield declined by 24 % at 80,000 plants/ha. Increasing within row plant spacing above 10 cm also had a significantly negative effect on yield and the lowest yield was observed at 30x25cm spacing in both years (Table 2). Pod yield per plant was also significantly affected by the differences in densities (Table 2). Higher per plant yield as well as the total number of pods per plant were observed in the 30x10cm spacing level in both years. Similar behavior was also suggested by Bosland and Votava (2000).

Table 2. The effect of plant density on marketable yield, yield per plant and pod number per plant of capsicum in 2007 and 2008 *yala*

Treatments	Plant population No/ha	Marketable yield (Mt/ha)		Yield / plant (g)		Total Number of pods per plant	
		2008	2007	2008	2007	2008	2007
30x 08 cm	312500	17.07b	11.4bc	81.94 b	58.3b	10.0b	10b
30x10 cm	250000	23.68a	18.26a	142.12a	73.04a	19a	17a
30 x 15 cm	167000	12.68b	14.4ab	114.1ab	63.2b	14ab	15ab
30 x 20 cm	125000	17.71b	15.2ab	92.53b	68.0b	14.75ab	14ab
30 x 25 cm	100000	15.57b	10.7bc	79.06b	56.1bc	10.25b	10b
CV		23.5	25.2	24.5	25.9	22.1	23.2

Means with the same letters are not significantly different at $p=0.05$.

Although Bosland and Votava (2000) stated that by reducing the plant spacing of capsicum, the pods have become small. The density levels in this experiment did not significantly affect the pod quality parameters (Table 3). Hence, normal sized pods in length and girth (length 8cm<, Girth-6cm<) could be harvested by all treatments densities (Table 3):

Table 3. The Effect of plant spacing on variations of pod quality.

<i>Treatments</i>	<i>Length (CM)*</i>	<i>Girth(cm)*</i>	<i>Pod quality</i>
30x 08 cm	13.6	7.9	Good
30x10 cm	13.9	8.5	Good
30 x 15 cm	14.3	8.9	Good
30 x 20 cm	13.5	8.2	Good
30 x 25 cm	13.7	7.6	Good
CV	9.19	10.1	25.25

* Mean were significantly not different at $p=0.05$.

Dry and hot weather conditions in *yala* increased incidences of Thrips and Mites damages. Pest damages were recognized by leaf curls, leaf and pod deformities and patches on leaves and pods. Less number of pest damages were observed in the spacing level of 30x10cm (37.5% in 2008 and 17.0 % in 2007) though the differences were not significant (Table 4).

Table 4. Pest and Disease incidences in different plant densities of capsicum

<i>Treatments</i>	<i>(%) plants with Disease symptoms</i>		<i>(%) plants damaged by Pests</i>	
	<i>2008</i>	<i>2007*</i>	<i>2008</i>	<i>2007*</i>
30x 08 cm	87.0a	14.9	55.0ab	20.0
30x10 cm	61.0b	15.5	37.5b	17.0
30 x 15 cm	77.9ab	20.3	57.5ab	23.3
30 x 20 cm	81.3ab	20.3	51.3ab	21.0
30 x 25 cm	86.0a	19.7	65.0a	23.1
CV	17.9	18.9	20.0	14.6

Means with the same letters are not significantly different at $p=0.05$. * Mean were significantly not different at $p=0.05$.

Light intensity is comparatively low around the canopy level in high densities (Lovatt *et al.*, 2005). Though there is a significant reduction in light intensity under close spacing in this study, it did not significantly affect the plant height recorded (Table 5). Since the row spacing was same in all treatments, the branching was not significantly affected with the density changes in both seasons (Table 5). At higher densities close spacing has given more than 85% of spatial coverage in 2008 (Table 5). Hence the close spacing results changes in microclimatic conditions around the canopy. It reduces the light intensity and temperature and increases the relative humidity inside the canopy. The results were similar in both seasons. Low temperature and slow wind speed has negatively affected on spreading of mites and Thrips in *yala*. The heavy canopy coverage and low light intensity in close spacing reduced the weed population on the ground.

Table 5. The effect of plant density on growth parameters and microclimatic conditions in surrounding area in 2008 yala

<i>Treatment</i>	<i>Light intensity (lux x10)</i>	<i>Plant height (Inches)</i>	<i>Branching* (no. of branches)</i>	<i>Ground cover by canopy (4 sqft)%</i>	<i>Percentage of weeds(4 sqft)</i>
8 x30 cm	560c	14.6ab	8	88a	24d
10 x 30 cm	593c	14.7ab	10	85a	26d
15 x 30 cm	659bc	13.4b	10	57b	40cd
20 x 30 cm	827ab	16.1a	9	55b	46c
25 x 30 cm	1025a	14.6ab	9	50b	62ab
CV	18.73	8.7	23.4	32.7	19.38

Means with the same letters are not significantly different at $p=0.05$. *Mean were significantly not different at $p=0.05$.

CONCLUSIONS

Higher yield of capsicum (23.68 mt/ha) can be obtain by using 30x10 cm in Up country intermediate zone instead of using DOA recommendation while using fertilizer rates as recommended by the Department of Agriculture in yala season.

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