Effect of Planting Density and Variety on Yield and Growth of Jalapeno Pepper (*Capsicum annum* L.)

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ABSTRACT

Jalapeno Peppers (Capsicum annum L.) play a major role among commonly cultivated Capsicum species in the world. It is mainly targeted for the export market as a processed product. An experiment was carried out to investigate the effect of planting density and variety on the performance of Jalapeno Pepper. It was based on the assessment of morphological, vegetative, reproductive, fruit quality and yield parameters. Three varieties of Jalapeno Pepper (SFPF2, SFM1 and SFBP3) were grown with two different planting densities (60×45cm and 70×40cm). The experiment was arranged in a two factor factorial design (RCBD) with three replications. There was no effect of planting density on most of the parameters except on the thickness of the pericarp. But significant differences could be observed in most of the attributes based on the variety. The variety SFPF2 exhibited better performances over other two varieties in most of the attributes by having triangular fruit shape, medium fruit length (55.0 mm), higher fruit diameter (25.6mm), higher yield per plant (643.2g), higher fruit weight (14.9g), higher average yield(14.1t/ha), medium level of pungency and more tolerance to Anthracnose and Damping off diseases. The variety SFM1 also recorded some important quality attributes such as triangular fruit shape, medium fruit diameter (23.9mm) and higher yield per plant (640.5g). Highest percentage of pods with required specifications were obtained at the 4th pick for the varieties SFPF2 and SFM1.The variety SFBP3 exhibited poor performances for most of the tested attributes. Therefore, the variety SFPF2 can be recommended with 60×45 cm spacing for the commercial cultivation of Jalapeno Peppers.

KEYWORDS: Growth, Jalapeno Pepper, Planting density, Yield

INTRODUCTION

Chilli Peppers (*Capsicum annum L.*) play an indispensable role in every kitchen throughout the world particularly in the Asian region. Botanically Chillies are classified among the family *Solanaceae* and are closely related to Tomato, Potato, Tobacco and Brinjal. They are native to Central and South America (Anon, 2002).

The global production of Chilli Peppers fluctuates between 30 and 35 million metric tons with a production of 32.5 million metric tons recorded in 2003. Vietnam, Indonesia, India, Brazil, Malaysia, Thailand and China are the major producers of Pepper in the world. The global exports of Pepper vary from 20 to 25 million metric tons with 22.9 million metric tons being exported in 2003. Major exporters of pepper are Vietnam, Indonesia, Brazil, Malaysia and India (Anon, 2003). Major importing countries are USA and Germany.

Pepper is one of the most important cash crops grown in Sri Lanka. It has become an essential ingredient in Sri Lankan meals. Per capita consumption of hot Pepper in the form of dry Chilli is estimated as 2.32 kg per annum and the national annual requirement of dry Chilli is around 40,000mt. The annual production of dry Chilli is about 15,000mt. Pepper contributes on an average of Rs.750 millions to GDP and creates employment of 14 million work days annually. Hot Peppers are extensively grown for dry Chilli production, but part of the crop is harvested as green pods. A large extent is cultivated in the Dry zone. At present major Chilli growing districts are Anuradhapura, Moneragala, Ampara, Vavunia, Kurunegela, Hambantota and Mahaweli System H (DOA, 2006).

Chilli Peppers range in hotness from mild to fiery hot. The burning sensation is attributed to chemical compounds called capsaicinoids which are stored in the light coloured veins on the walls and surrounding the seeds. Capsaicin acts on the pain receptors in the mouth (Anon, 2005).

Peppers are not only the most commonly used spice in the world but also being used as a colouring agent, a pharmaceutical ingredient and for other innovative ways (Amarasinghe and Jayasekera, 2005).

Jalapeno pepper plays a significant role among the commonly cultivated *Capsicum* species in the world. The origin of Jalapeno was the Jalapar region in the Mexican state of "Veracruz". It is probably the best known of the Chilli Peppers. They are conical in shape, tapered at the tip and more rounded than pointed. Length and width of pods range from six to eight centimeters respectively. Intense green colour, smooth texture, thick and meaty skin are the prominent characters of Jalapeno. It is aromatic and has a pleasant green veggie flavour when slightly biting (Anon, 2005).Jalapenos can be added to any meal to spice it up. It prefers warm days and cool nights. Ideally sowing can be done March-April and September-October like any other chillies (Anon, 2004).

According to the present market trends, there is a large export potential for Chilli Peppers. Jalapeno Peppers have greater potential for exportation due to its various consumption patterns such as salsas

(sauces) and pickles. It is important to harvest pods at correct maturity stage (45mm to 60mm pod length with 20 to 26 mm pod diameter) to reach the export standard. Jalapenos are processed in wine vinegar or brine salt. Brined pods are debrined and reprocessed before consumption. They are processed and exported in the form of pods or slices. They can be extensively marketed in Japan, Europe and USA (Jayawardena, 2006). Commercially Jalapenos are not cultivated in Sri Lanka. But several private sector firms have started to cultivate Jalapeno Peppers on experimental basis and preliminary studies have been conducted. They have shown that Jalapenos have higher potential to grow in Sri Lankan conditions if introduced. It will enhance the income of the farmers and their life standard. It will also earn foreign exchange and create more employment opportunities within the country. Further it will help to increase the Agricultural productivity of Sri Lanka. Therefore this study was conducted to evaluate the performances of three Jalapeno Pepper varieties with two different planting densities and to prepare a varietal description of each variety tested.

2. MATERIALS AND METHODS

Experimental Site

The experiment was carried out at the Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila (Low country Intermediate Zone) at an elevation of 30m above mean sea level. It was conducted during the period of January to July 2006.

Nursery Management

Seeds of three varieties of Jalapeno Pepper obtained from Sun Frost (pvt) Limited were sown in seedling trays in an indoor condition. Cowdung 3: Top soil 2: Sand 1 mixture was used as a nursery media. Five hundred seeds were sown per variety.

Seedlings were transferred to a commercial rain shelter (Rovero Systems) of 9×12m in size with a covered roof of UV treated, 1000 guage polythene with a 33% light intensity (Amarasinghe and Jayasekera, 2005) 12 days after seed sowing. Daily irrigation was carried out using a hand sprayer. Thiram was applied to control damping off disease. Application of Albert's solution and Maxicrop (0.2g/plant) was carried out once a week. Shade was provided to the seedlings, to keep the temperature at a lower level in the rain shelter.

Treatments

The three varieties of Jalapeno pepper seedlings were transplanted with two different planting densities as follows;

Variety	Spacing
SFPF (V1)	60×45cm (S1)
SFM 1 (V2)	70 ×40cm (S2)
SFBP 3 (V3)	

Following treatment combinations were used.

V1S1	V2S1	V3S1
V1S2	V2S2	V3S2

Field Layout

Each treatment combination was applied in a raised bed (3×2.2m) in an open environment. Eighteen raised beds were prepared with drains (50cm) to overcome water logging conditions. The treatments were arranged in a two factor factorial design with RCBD and with three replications. Randamization was carried out for each treatment combination.

Crop Establishment and Maintenance

The field was ploughed up to 30-35cm depth, harrowed and leveled. Eighteen planting holes were prepared (30×30×30cm) for each treatment combination. An equal amount of cowdung and inorganic fertilizer (Ammonium sulphate 100kg/ha, Triple super phosphate 100kg/ha and Muriate of potash 50kg/ha) were applied to each planting hole and mixed well two days before transplanting. Thirty two day old, healthy, vigorous seedlings were transplanted. Albert's solution and Maxicrop were applied (at the rate of 0.4g/plant at the seedling stage, 0.6g/plant at the flowering stage and 0.8g/plant at the fruiting stage). Four weeks after transplanting Muriate of potash and Ammonium sulphate were applied at the rate of 50kg/ha and 10kg/ha respectively. Thereafter 100kg/ha Ammonium sulphate was applied fortnightly. Hose irrigation was carrid out when necessary. Weeding was done regularly. Harvesting was carried out 10 times according to the standard specifications provided by the Sun Frost (pvt) Limited at 8 to 11 day intervals.

Data Recording

Five randomly selected plants from each plot were used for the purpose of data collection. Following parameters were recorded from each net plot.

2.1 Morphological Characters

2.1.1 Plant growth habit-Recorded when 50% of the plants have well matured fruits. (Anon, 1995).

2.1.2 Fruit shape-Recorded according to the descriptions given by Anon (1995).

2.2 Vegetative and Reproductive Parameters.

2.2.1. Plant height (cm)-Recorded when 50% of the plants have well matured fruits (Anon, 1995).

2.2.2 Days to first flowering-Number of days from transplanting until 50% of plants have at least one open flower (Anon, 1995).

2.2.3. Days to first fruiting-Number of days from transplanting until 50% of the plants bear mature fruits at the first and second bifurcation (Anon, 1995).

2.2.4. Days taken from anthesis to fruit development.-Recorded using randomly selected five plants from each treatment combination.

2.3 Fruit Quality Parameters

2.3.1 Fruit Length (mm)-Measured from stem end to blossom end of the fruit in average of five well matured fruits of the second harvest (Anon, 1995).

2.3.2. Fruit Diameter (mm)-Measured at the widest point in average of five well matured fruits of the second harvest using the Vernier caliper (15-100-500 Monosat).

2.3.3. Pericarp thickness (mm)-Measured at the point of maximum diameter in average of five well matured fruits using the vernier caliper (15-100-500 Monosat).

2.3.4 Pungency-Pungency was evaluated using small pieces of processed pods (Pods were processed in a wine vinegar solution). Thirty panelists were selected for the sensory evaluation. They were asked to rank each sample depending on pungency (Low, Moderate and High).

2.4 Yield Parameters

2.4.1Yield per plant (gm) - calculated using randomly selected five plants from each harvest.

2.4.2. Number of fruits per plant-Calculated using the randomly selected five plants.

2.4.3. Fruit weight (gm) - Five randomly selected pods were used to calculate the fruit weight.

2.4.4. Percentage of pods harvested with required specifications- Calculated using five randomly selected pods from each harvest.

2.4.5. Yield (t/ha)-Calculated using the total weight of pods per each harvest.

2.5 Pest and Disease Resistance.

Pest and Disease incidences were observed and identified which prevailed during the experimental period. Necessary precautions were taken to avoid outbreaks.

Statistical Analysis

The parametric data were subjected to ANOVA in SAS (Statistical Analysis System) and the Non parametric data were analyzed using the Kruskal-Wallis test.

RESULTS AND DISCUSSION

3.1. Morphological Characters

3.1.1. Plant growth habit

The variety SFBP3 exhibited erect growth habit while the other two varieties were intermediate, for both of the planting densities (Table1). When plant growth habit is erect, it reduces the mutual shading of foliage and more solar radiation is allowed to penetrate through the canopy. It would result production and accumulation of more photosynthate in plant tissues. Plants with intermediate growth habit posses more dense canopy than the erect plants. It increases microclimate within the canopy and assist to increase more pest and disease incidences.

3.1.2. Fruit shape

The variety SFPF2 and SFM1 showed triangular fruit shape while the variety SFBP3 were elongate for both of the planting densities (Table1). Anon (1995) has classified the different fruit shapes of *Capsicum species* as elongate, almost round, triangular, campanulate and blocky. Uniform slices can be obtained from the variety SFBP3 due to its elongate nature. It is an additional advantage when processed slices are exported, especially to Japan because, they are highly concerned about the uniformity of a product. When processed pods are exported, there is a higher demand for variety SFPF2 and variety SFM1 due to its triangular nature (Jayawardena, 2006)

Table1- Morphological Characters of the three Jalapeno Pepper Varieties:

Character	V1	V2	V3
Plant growth habit	I	I	ER
Fruit shape	T	T	E

ER-Erect, I-Intermediate, E-Elongate,
T- Triangular

3.2. Vegetative and reproductive parameters

3.2.1. Plant height (cm)

There were no significant differences in plant height between the tested planting densities of Jalapeno pepper. But significant difference in plant height could be observed among the tested varieties (Table 2) and it ranged from 29.9cm to 33.8cm.The variety SFBP3 recorded the tallest plants (33.8cm) while the variety SFM1 exhibited the shortest (29.9cm). Plant height of the variety SFM1 (31.3cm) was not significantly different from the variety SFPF2 and SFBP3. But there was a significant difference in plant height between the variety SFPF2 and SFBP3.

3.2.2. Days to first flowering

There were no significant differences in days to first flowering of Jalapeno Pepper among the tested planting densities and the varieties (Table 2).All the tested varieties had taken 30.0 to 34.7 days in both planting densities for first flowering.

3.2.3. Days to first fruiting

Significant differences could not be observed in days to first fruiting of Jalapeno Pepper based on the tested planting densities and the varieties (Table2). All the three varieties had taken 54.2 to 55.5 days for first fruiting.

3.2.4. Days taken from anthesis to harvesting.

There was no significant effect of both variety and the planting density on days taken from anthesis to fruit development of Jalapeno Pepper (Table 2). Therefore harvesting can be carried out within 24.7 to 25.5 days after the anthesis for all the tested varieties under both planting densities.

Table 2 - Vegetative and Reproductive Parameters of three Jalapeno Pepper Varieties Tested with thtwo Planting Densities:

Treatment	Plant height (cm)	Days to first flowering	Days to first fruiting	Days-Anthesis to harvesting
Variety				
V1	29.9 ^{B}	34.7 ^{D}	54.2 ^{B}	24.5 ^{D}
V2	31.3 ^{AB}	30.0 ^{D}	55.5 ^{B}	25.5 ^{D}
V3	33.8 ^{A}	30.2 ^{D}	54.8 ^{B}	24.7 ^{D}
Spacing				
S1	30.6 ^{A}	29.5 ^{C}	54.4 ^{A}	24.8 ^{C}
S2	29.3 ^{A}	30.3 ^{C}	55.3 ^{A}	24.8 ^{C}
	8.0(CV) 3.2(LSD)	0.98(MLRS)	0.95(MLRS)	0.93(MLRS)

Means in a column followed by the same letter are not significantly different at 0.05 level
MLRS (Maximum Likelihood Ratio Statistics) pr>0.05 not significantly different.

2.3 *Fruit Quality Parameters*

3.3.1. Fruit Length (mm)

There was no significant effect of planting density on fruit length of Jalapeno Pepper (Table 3). But there were significant differences in fruit length among the tested varieties and it ranged from 55.0 mm to 73.4mm.The variety SFBP3 Exhibited the longest fruits (73.4 mm) while the variety SFM1 showed the shortest (55.0 mm).

When processed slices are exported, large number of uniform slices can be obtained from longer pods.

3.3.2. Fruit Diameter (mm)

There was no significant difference between the tested planting densities on fruit diameter of Jalapeno Pepper. But significant varietal effect could be observed on fruit diameter and it ranged from 13.7mm to 25.6 mm (Table 3). The varietySFPF2 exhibited the highest fruit diameter (25.6 mm) while the variety SFBP3 exhibited the lowest (13.7 mm).There was no significant difference in fruit diameter between the varieties SFPF2 and SFM1. But those two varieties were significantly different from the variety SFBP3 in fruit diameter.

There is a higher export demand for pods with highest fruit diameter when processed pods are exported, especially to Japan (Jayawardena, 2006). To obtain a higher export demand for processed pods fruit length and diameter should be in the range of 45 - 60 mm and 22-26 mm respectively. The variety SFPF2 and SFM1 both can be harvested with these required specifications. But the variety SFBP3 has significantly deviated from these specifications (Table 3). Its fruit length and diameter ranged from 60 to 85 mm and 15 to 18mm respectively, giving long and slender pods in relation to other two varieties.

3.3.3. Pericarp thickness (mm)

There was a significant difference in pericarp thickness between the tested planting densities, and it ranged from 4.5 mm to 3.8 mm. Plants with the spacing 60×45cm exhibited the highest pericarp thickness while the spacing 70×40 cm showed the lowest (Table 3). But there were no significant differences in pericarp thickness among the tested varieties.

3.3.4. Pungency

Statistical analysis of probability value (pr=0.000) and average ranks for sensory evaluation revealed that there were significant differences in pungency among the tested varieties (Table 4). The variety SFM1 recorded the highest pungency (lowest average rank); while the variety SFBP3 recorded the lowest (highest average rank).The variety SFPF2 scored a moderate level of pungency.

Table 4 - Probability (pr) Value and Average Rank of Pungency Evaluation of three JalapenoPepper Varieties:

Variety	Average Rank
SFPF2	49.5
SFM1	22.5
SFBP3	64.5
Pr value	0.000

Probability value <0.05 significicantly different

Table 3 - Fruit Quality Parameters of three Jalapeno Pepper Varieties Tested with the two Planting Densities:

Treatment	Fruit length (mm)	Fruit diameter(mm)	Pericarp thickness(mm)
Variety			
V1	60.6 ^{B}	25.6 ^{A}	4.6 ^{C}
V2	55.0 ^{C}	23.9 ^{A}	4.2 ^{C}
V3	73.4 ^{A}	13.7 ^{B}	3.7 ^{C}
Spacing			
S1	61.7 ^{D}	21.4 ^{C}	4.5 ^{A}
S2	64.3 ^{D}	20.7 ^{C}	3.8 ^{B}
CV	6.6	7.7	16.7
LSD	5.3	2.1	0.7

Means in a column followed by the same letter are not significantly different at 0.05 level

Low pungent varieties are highly preferable for processing. The Jalapeno derives its heat from Capsaicin or Capsicutin compound ($C_{18}H_{27}NO_3$). It is a potent chemical that survives both the cooking and freezing processes. They are moderately hot Peppers and hotness is ranged from 2500 to 5000 Scoville heat units (Anon, 2005).

3.4. *Yield Parameters*

3.4.1. Yield per plant (gm)

Significant difference could not be observed in yield per plant between the two planting densities. But there were significant yield differences among the tested varieties and it ranged from 324.5 g to 643.2g. (Table 5) The variety SFPF2 recorded the highest yield per plant (643.2 g) while the variety SFBP3 recorded the lowest (324.5). There was no significant difference in yield per plant between the variety SFPF2 (643.2 g) and the variety SFM1 (640.5).But variety SFM1 was significantly different from other two varieties. Higher yield of the variety SFPF2 could be attributed to its heavier fruits than the other two varieties.

3.4.2. Number of fruits per plant.

There was no significant difference in number of pods per plant between the tested planting densities. But significant differences could be observed among the tested varieties (Figure 1).The variety SFM1 recorded the highest number of pods per plant (58.05) while the variety SFBP3 recorded the lowest (35.0). Lesser yield per plant and the number of pods per plant could be an inherent performance of the variety SFBP3.

3.4.3. Fruit weight (gm)

Significant difference could not be observed in fruit weight between the two planting densities. But there were significant differences among the tested varieties in fruit weight and it ranged from 10.2 g to 14.9 g (Table 5).The variety SFPF2 recorded the heavier fruits (14.9 g) and it was significantly different from the other two varieties.

The variety SFBP3 recorded the less heavy fruits (10.2 g) and it was significantly different from the other two varieties.

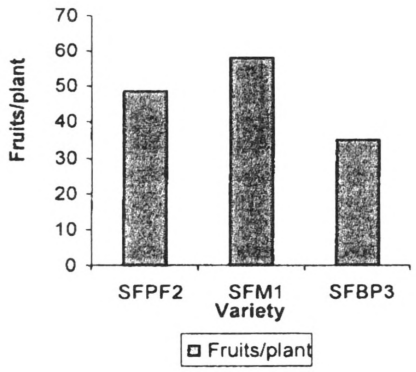

Figure 1 - Number of fruits per plant of three Jalapeno Pepper varieties:

It was noted that the fruit weight has been influenced the size of the fruit. Since the variety SFPF2 possesses large fruit size, fruit weight has been increased.

3.4.4. Percentage of pods harvested with required specifications

Maximum percentage of pods with required specifications was obtained at the 4th pick for the varieties SFPF2 (76.8%) and the SFM1 (83.4%).But comparatively higher percentage was harvested from the variety SFM1 (Figure 2). The percentage gradually reduced with each pick. Required fruit length and diameter could not be obtained after the 9th harvest. . Crack formation on pods was the major reason for reducing the percentage of required specifications. It was a physiological disorder and increased with the aging of the crop. Misshapen pods also contributed to reduce the required length and diameter during the latter picks.

3.4.5. Ayerage Yield (t/ha)

There was no effect of tested planting densities on the average yield of Jalapeno Pepper. But there

was significantly different from the varieties SFPF2 and SFM1 they were not significantly different from each other.

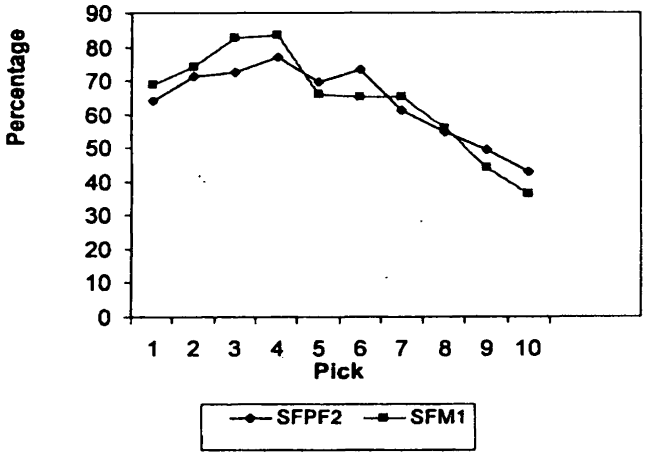

Figure 2 - Percentage of fruits that can be harvested with required specifications at different pick:

The average yield recorded for Jalapeno SFM1 was 15t/ha under South Indian conditions (Anon, 2004.)

Table 5 - Yield Parameters of the three Jalapeno Pepper Varieties Tested with the two Planting Densities.

Treatment	Yield/plant (g)	Fruit weight(gm)	Yield(t/ha)
Variety			
V1	643.3^{A}	14.9^{A}	14.1^{A}
V2	640.5^{A}	12.4^{B}	13.5^{AB}
V3	324.5^{B}	10.2^{C}	7.6^{B}
Spacing			
S1	531.2^{C}	12.5^{D}	12.4^{C}
S2	540.9^{C}	12.9^{D}	11.1^{C}
CV	29.8	11.5	42.5
LSD	201.1	1.8	6.3

Means in a column followed by the same letter are not significantly different at 0.05 level

3.5. Pest and Disease Resistance

Following pests and diseases were observed during the experimental period.

Diseases

1. Choanephora Blight (Fungal disease caused by *Choanephora cucurbitarum*)
2. Anthracnose (Fungal disease caused by *Colletotrichum gloeosporioides*)
3. Bacterial wilt (Caused by *Ralstonia solanacearum*)

The variety SFPF2 exhibited moderate level of susceptibility for Choanephora blight compared with other two varieties. Comparatively higher infection of Bacterial wilt could be observed in the variety SFBP3 and 26% plants get infected. Incidence of Anthracnose was higher in the variety SFBP3 and SFM1.Significant effect of planting density could not be observed on pest and disease resistance.

Choanephora blight causes greatest damage to Pepper especially during the rainy season. Improvement of field drainage and the application of Copper based fungicides are the best control measures of this disease. (Kelaniyangoda, 2006).Crop rotation and the improvement of drainage are the major control methods for Bacterial wilt, since it is a soil borne disease.

Pests

Red spider mite was the major insect pest observed, and they were controlled by using 80% Sulphur powder.

CONCLUSIONS

Jalapeno Pepper. But significantly thicker pericarp of fruits could be obtained with high density planting (60×45 cm spacing) for all the varieties. There were significant differences in most of the attributes among the varieties. The variety SFPF2 and SFM1 exhibited better performances than the variety SFBP3.The variety SFPF2 was best suited for processing due to its triangular fruit shape, medium fruit length, higher fruit diameter, higher yield per plant, higher fruit weight, higher average yield, medium level of pungency and less susceptibility to Anthracnose and Bacterial wilt diseases. The variety SFPF2 also exhibited some better attributes for processing. The variety SFBP3 is not suitable for processing due to its poor attributes.Threfore the variety SFPF2 can be recommended with 60×45 cm spacing for the commercial scale cultivation of Jalapeno Pepper. Further testing should be undertaken in farmer fields to find out the adaptability and acceptance by the farmers.

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