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Impact of Different Shade levels on Growth and Yield Performance of Different Varieties of Bell pepper (*Capsicum annuum* L.)

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Abstract: Bell pepper (*Capsicum annuum* L.) is an important Solanaceous family vegetable in the world, but commercial cultivation are limited in Sri Lanka. An experiment was conducted to access the effect of different shade levels on the growth and yield of bell pepper (*Capsicum annuum* L.**)** at Department of Agronomy, Faculty of Agriculture, Ariviyal Nagar, Kilinochchi during March to July in 2018. Two factor factorial experiment was carried out in Complete Randomized Design (CRD) with six replicates. Four shade levels (25%, 50%, 75% and 85% shade levels) and three varieties; Yellow (Polaris), Green (Ganga) and Red (Hercules) were used as treatments. Weather, growth and yield parameters were recorded and data were analyzed in ANOVA using SAS 9.1 package. The means were compared by using Duncan Multiple Range test. All other management practices were performed based on the farmer practices adopted in Badulla District. Light intensity was significantly differed among shade levels and the lowest in the 85% shade level and highest in the 25% shade and the temperature and relative humidity were not much varied among the shade levels. There was a significance difference in vegetative growth traits (plant height, number of leaves and branches per plant) and yield parameters (fruit length, fruit diameter, fruit weight, number of fruits per plant and yield) of bell pepper among shade levels and varieties. In the growth parameters, the plant height was highest in 85% shade level in yellow variety and other parameters of growth were highest in 25% shade level in green variety. In the yield parameters, the number of fruit was highest in 25% shade level in red variety and other yield parameters such as fruit length, fruit diameter and fruit weight were highest in 85% shade level in yellow variety. It can be concluded that 85% shade level and yellow variety can be recommended as the best combination for growing of bell pepper in Kilinochchi District during *Yala* season based on the growth and yield performance of the plant.

Keywords: Bell pepper, Shade level, Varieties, Vegetative growth traits, Yield parameters

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Introduction

Vegetables are grown throughout Sri Lanka and large numbers of farmers are engaged in this cultivation (Rupasena, 1999). Approximately eighty different vegetables varieties are grown in Sri Lanka at different agro-climatic zones. Bell pepper *C. annuum* L.) is an important solanaceous family vegetable gaining in popularity throughout the world. Bell pepper, which is available in different colours, size and taste. It is rich in vitamin A, E, K, C, low in calories, contain antioxidant and various carotenoids and with health benefits.

Among the vegetables cultivated in Sri Lanka, bell pepper is commonly grown in higher elevations in the central hill country areas especially most intensively cultivated in Badulla district (Bandarawela, Walimada). During the growth cycle of pepper, they are subjected, many unfavo urable environmental conditions such as high temperature and high radiation especially during *Yala* season in Sri Lanka. These particular conditions may exert a negative effect on plant growth and yield (Lopez-Marin *et al.,* 2011). According to Schwarz *et al.* (2010), the main negative effects exerted by high temperature and radiation are the reduction in growth, a decrease in photosynthetic rate, increased respiration and reduced water and ion uptake. Therefore, the use of different shading screens is thought to be an alternative to overcome this problem.

The shading also affected fruit set, number of fruits per plant, fruit development and yield. It has been reported that the response of pepper plants to shading will probably vary in different geographical areas, seasons and cultivars and from different agricultural practices (Lopez-Marin *et al.* 2011, 2012).

Even though several studies available regarding bell pepper cultivation in the world, there was no study available in Sri Lanka regarding effects of shade levels on growth and yield performance of bell pepper especially in Northern Province. By considering this, the present study was conducted with the main objective of evaluating the performance of the bell pepper under different shade levels in Kilinochchi District.

Specific Objectives

1. To study effect of different shade levels on growth and yield parameters of bell pepper
2. To identify the suitable variety of bell pepper and shade level for Northern Region.

Materials and Methods

An experiment was carried out at the Faculty of Agriculture, Ariviyal Nagar, Kilinochchi located in the Northern Province of Sri Lanka which belongs to the agro-ecological region of Low Country (DL_3) to evaluate the impact of

shade levels on growth and yield performance of Bell pepper (*Capsicum annuum* L.) during the period of February to July 2018. Experiment was conducted in two factor factorial experiment in Complete Randomized Design (CRD) with six replicates. In this experiment four shade levels (25%, 50%, 75% and 85% shade levels) and three varieties (Yellow (Polaris), Green (Ganga) and Red (Hercules)) were used as treatments as given in the Table 1.

Table 1: Treatment Combinations of Different Shade levels and Varieties

Treatments	Shade levels	Varieties
Treatment 1	25% shade	Green (V_1)
		Red (V_2)
		Yellow (V_3)
Treatment 2	50% shade	Green
		Red
		Yellow
Treatment 3	75% shade	Green
		Red
		Yellow
Treatment 4	85% shade	Green
		Red
		Yellow

Seeds were sown in a nursery tray using commercially available coir dust media. Watering was done daily according to the media moisture. Seedling trays were placed in a warm and sunny place. The seed were germinated 15-20 days after planting. For the crop establishment soilless media was used. Media was prepared by using half burn paddy husk, coir dust and cow dung at 1:1:1 ratio. Media was treated with Metham Sodium pesticide and kept 21 days for the incubation reduced the pest and diseases native to the growth medium. Six weeks old, 25cm tall seedlings with 4 leaves on the main stem which started branching were transplanted in to the pots. The seedlings were hardened a week before transplanting.

Shade houses covered with black nets of 25%, 50%, 75% and 85% shade levels were used in this experiment. The pots were arranged at the spacing of 45 cm × 30 cm in each shade level. Adequate watering was applied based on the moisture content of media, growing stage and weather condition. Albert's solution was used as the only source of a fertilizer due to its high-water solubility, nutrient balance and ability to absorb from both foliage and roots. Albert's solution was applied in 2 days interval at the rate of one gram per plant. Supporting was provided by using threads to plants when they were in the flowering stage in order to prevent bending and break down of

branches as a result of weight of the fruits. During the crop growth period three weeding were done by manually inside the pots and surrounding. Plants were affected by viral disease, Anthracol and Abamactine were applied to minimize the spreading of the condition. Harvesting was done 85 days after transplanting. The harvesting was done at one week interval and it was induced the more flower and fruits production.

***Measurements*:**

1. *Weather Parameters*

Light intensity, average temperature and average humidity at each shade levels were measured.

2. *Growth Parameters*

Plant height, number of leaves per plant and number of branches per plant were recorded at biweekly interval commencing from 2weeks after transplanting.

3. *Yield Parameters*

Fruit length, diameter, weight, number of fruits per plant and yield were measured at the time of harvesting.

Data Analysis

The ANOVA was performed by using the SAS 9.1 computer software package. Mean separation was done using Duncan's Multiple Range Test (DMRT).

Results and Discussion

The results obtained from the research study to evaluate the impact of shade levels on growth and yield performance of bell pepper (*C. annuum* L) are discussed below.

Data Analysis

Weather Parameters

1. Light Intensity

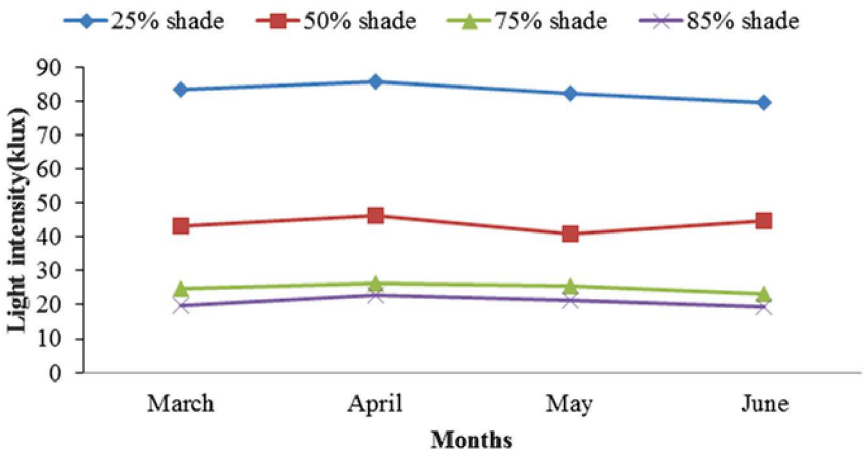

Figure 1: Mean light intensity (klux) from March to June during Experimental period

Mean light intensity was higher in open field condition and maximum light intensity was observed during the month of April than the other months (Figure 1). Nangare *et al.* (2015) reported that shade nets reduced both light intensity and heat effectively during the daytime while changing the spectrum. He also stated that the significant difference was observed in solar radiation in open condition and inside the shade nets.

2. *Average Temperature and Relative Humidity*

There was no much variation observed in average temperature and relative humidity during the experimental period of March to July among different treatments. Nangare *et al.* (2015) also stated that there was no significant difference found in average monthly temperature and humidity inside shade net house and under open field condition.

Plant Growth Parameters

1. *Plant Height*

There was a significant difference in plant height among the treatments and varieties. There was no interaction effect between shade levels and varieties. The maximum average height was observed in 85% shade level and the lowest average height was observed in 25% shade level. Among the varieties, the highest plant height was observed in yellow colour variety at 4th weeks after transplanting. Different shade levels could alter the other environmental conditions and develop suitable micro climate inside the shade nets which may be the reason for differences in plant height and number of leaves under different shade levels. Similar results were reported by Swagatika *et al.* (2006), Elad *et al*. (2007), Vethamoni and Natarajan (2008), Haque *et al*. (2009) and Rajasekar *et al*. (2013).

2. *Number of Leaves*

Formations of leaves in bell pepper were significantly influenced by different shade levels among the varieties. A significant difference was observed in the number of leaves of bell pepper under different shade levels and varieties. There was no interaction effect between shade level and variety. The highest average number of leaves was obtained under 25% shade level and the lowest average number of leaves was obtained in 85% shade level. Among the varieties of bell pepper, the highest average number of leaves was observed in the red bell pepper variety. This might be due to the favourable effect of 25% shade net which had increased photosynthetic process in bell pepper due to favourable micro climate. Similar result was reported in Israel that shading increased the plant growth (Rylski and Spigelman, 1986) and especially in bell pepper, individual leaf area also increased and specific leaf weight was decreased with increased shade level (Diaz-Perez, 2013).

3. ***Number of Branches***

There was significant difference observed in the number of branches of bell pepper under different shade levels and the varieties after 4th weeks of transplanting. There was no interaction effect between shade levels and varieties. The highest average number of branches was obtained at 25% shade level and the lowest average number of branches was obtained from 85% shade level. Among the varieties of bell pepper, the highest average number of branches was observed in red bell pepper variety under 25% shade level. Number of branches in bell pepper was affected either by too much of shade or too much of light. Rama Pandurang Mundhe, (2013) stated that a significant low number of leaves per plant was noticed under 85% shade intensity during crop growth period in bell peppers.

Yield Parameters

1. ***Number of Fruits per Plant***

There was a significant different in number of fruits /plant among shade levels and varieties (Figure 2 and 3). The maximum number of fruits was recorded in 25% shade level for all three varieties and the minimum number of fruits was recorded under 85% shade level. The highest number of fruits per plant was observed in the red colour variety. The maximum number of fruits (20) was observed in the red colour variety in 25 % shade level and the minimum number of fruits (14) was observed in yellow colour variety at 85% shade level. It may be due to high photosynthetic rate in 25% shade level due to the highest number of leaves and branches.

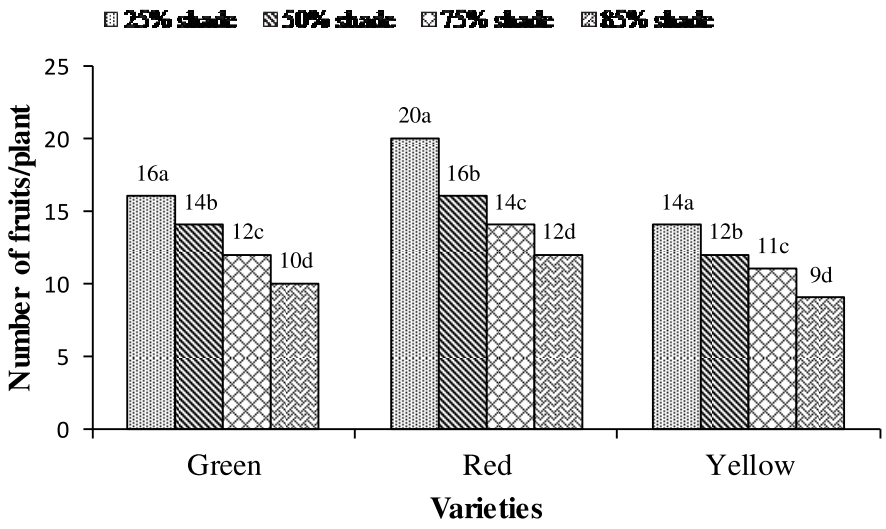

Figure 2: Number of Fruits in Different Varieties of Bell Pepper among the Shade Levels. Mean with the same letter within a given variety are not significantly different at *p=0.05.*

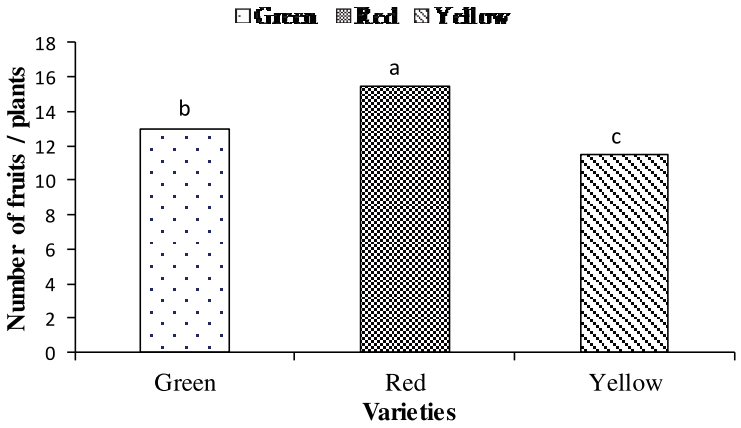

Figure 3: Number of Fruits among the Varieties of Bell Pepper. Mean with the same letter between the varieties are not significantly different at *p=0.05.*

2. *Fruit Length*

There was a significant difference between fruit length among the shade levels (Figure 4). The maximum fruit length was observed at 85% shade level and minimum fruit length was observed at 25% shade level. The maximum fruit length (16cm) was observed in red bell pepper variety in 85% shade level. The minimum fruit length (8.2cm) was observed in green bell pepper variety in 25% shade level. Also a significant difference in fruit length was observed among varieties (Figure 5).

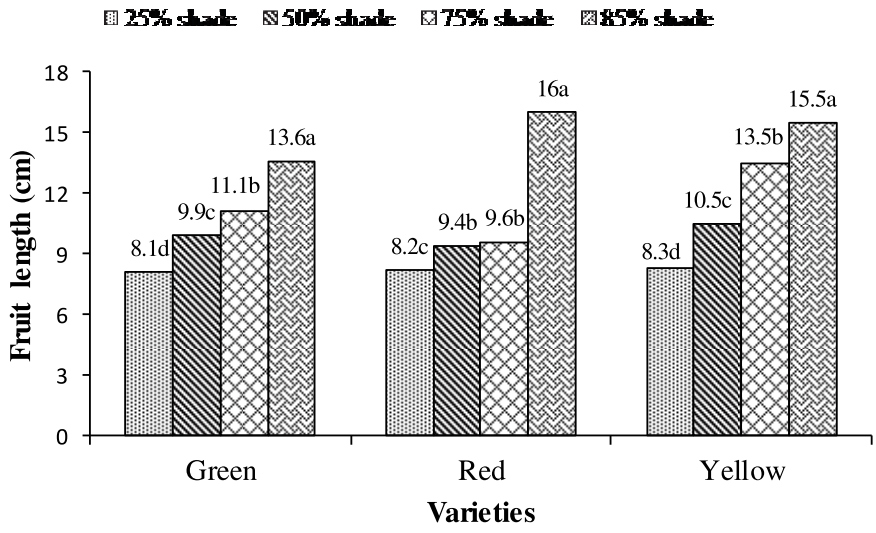

Figure 4: Fruit Length in Different Varieties of Bell Pepper among the Shade Levels. Mean with the same letter within a given variety are not significantly different at *p=0.05.*

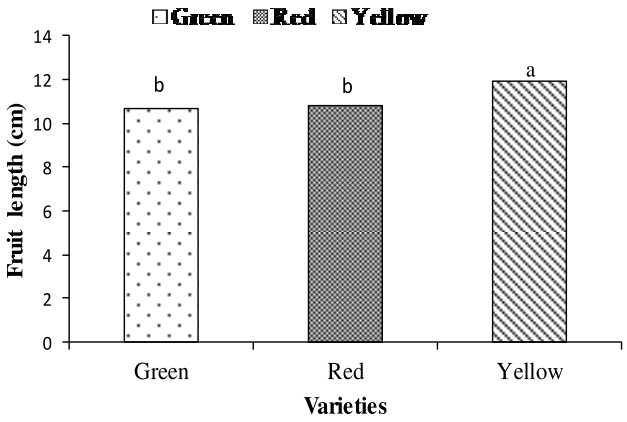

Figure 5: Fruit Length among Varieties of Bell Pepper.Mean with the same letter between the varieties are not significantly different at *p=0.05.*

3. *Fruit Circumference*

Fruit circumference was differed significantly among shade levels and varieties (Figure 6 and Figure 7). The maximum fruit circumference (25.2 cm) was observed in yellow bell pepper variety in 85% shade level and the minimum fruit circumference (18.8 cm) was observed in red bell pepper variety at 25 % shade level.

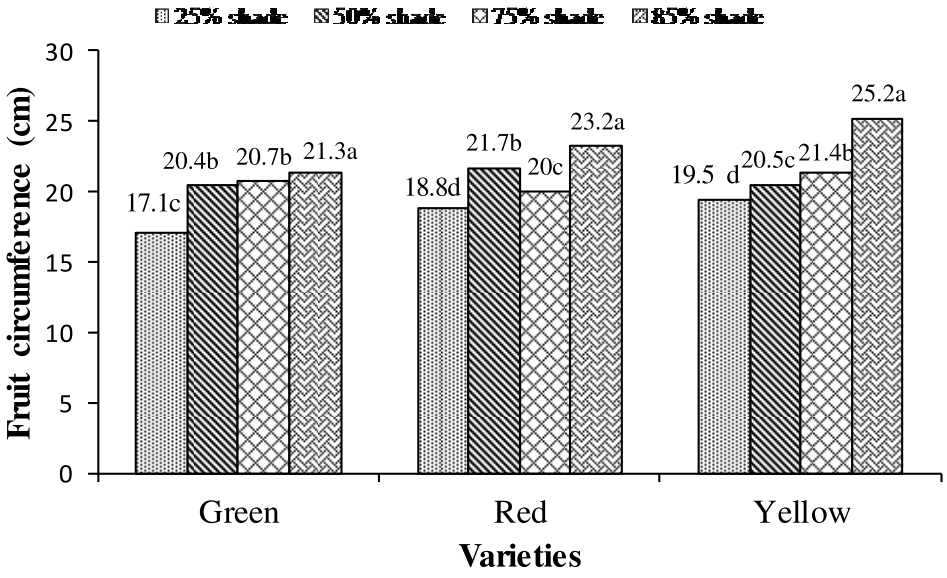

Figure 6: Fruit Circumference in Different Varieties of Bell Pepper among the Shade Levels. Mean with the same letter within a given variety are not significantly different at *p=0.05*

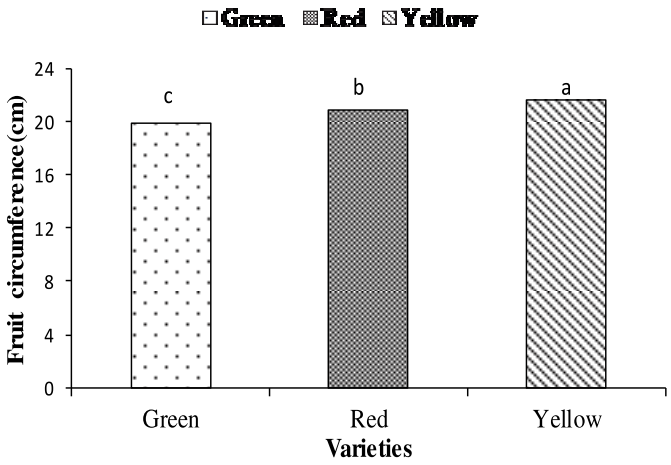

Figure 7: Fruit Circumference among Varieties of Bell Pepper.Mean with the same letter between the varieties are not significantly different at *p=0.05.*

4. ***Average Fruit Weight***

There was a significant difference in fruit weight between shade levels (Figure 8). The maximum fruit weight (170 g) was observed at 85 % shade level in the yellow colour variety and minimum fruit weight (60.8 g) was observed in 25 % shade level in the red colour variety. Among the bell pepper varieties tested, there was a significant difference fruit weight was shown in yellow variety as compared to other varieties (Figure 9). There was no interaction effect between variety and the shade level. This might be due to the favourable environmental

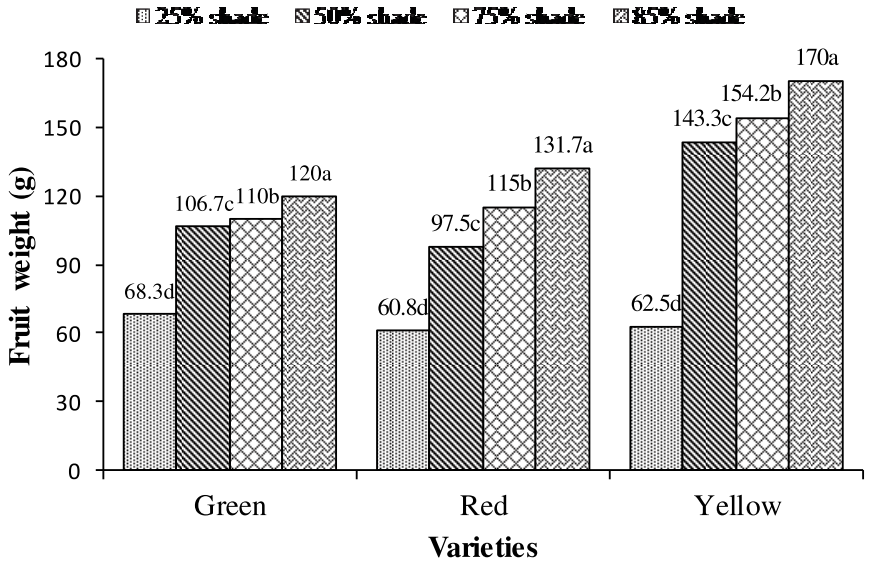

Figure 8: Fruit Weight of Different Varieties of Bell Pepper among the Shade Levels. Mean with the same letter within a given variety are not significantly different at p=0.05.

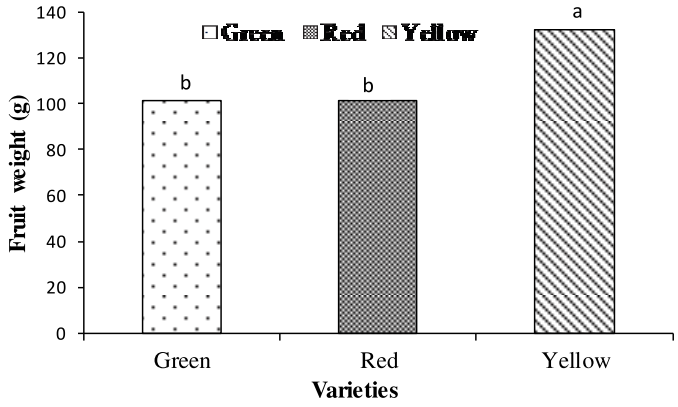

Figure 9: Fruit Weight of Bell Pepper among the Varieties. Mean with the same letter between the varieties are not significantly different at *p=0.05*

5. ***Average Yield per Plant (kg)***

There was a significant difference in yield between the lowest (25%) and the highest (85%) shade levels in all three tested varieties of bell pepper, but not significantly different among 50% and 75% shade levels in red and yellow varieties (Figure 10). The maximum yield per plant (1.8 kg) was observed at 85% shade level in the yellow variety. Average yield per plant was differed significantly among varieties (Figure 11). This might be due to the favourable environmental conditions for fruit formation, fruit quality and partioning of photosythates in 85% shade level which had increased photosynthe tic process in bell pepper. This result agreed with Rylski and Spigelman, (1986). They stated that shade levels affected fruit yield, quality, post-harvest attributes and incidence of Phytophthora blight in plants. Total marketable (Fancy and US1) fruit yields were increased with increasing shade level to a maximum at 85% shade level and then decreased with further increments in shade levels.

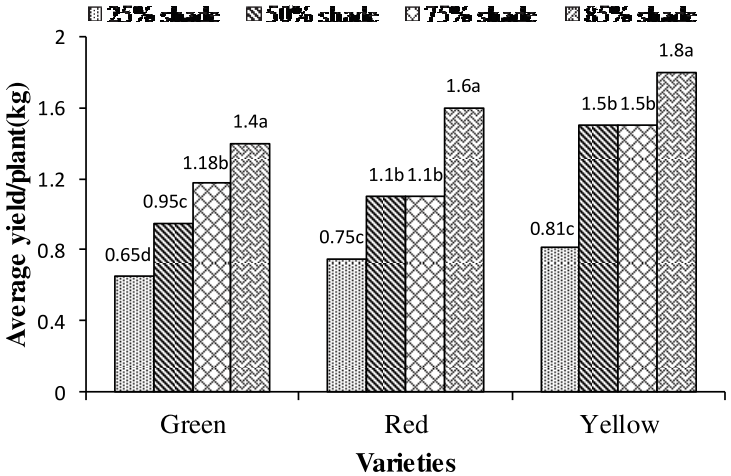

Figure 10: Average Yield per Plant in Different Varieties of Bell Pepper among the Shade Levels. Mean with the same letter within a given variety are not significantly different at p=0.05

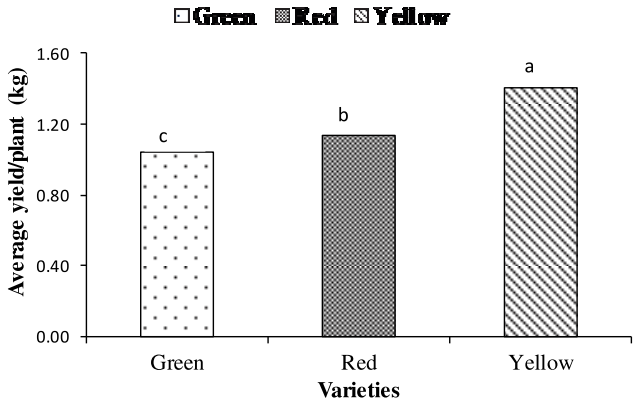

Figure 11: Average Yield per Plant in Different Varieties of Bell Pepper.Mean with the same letter between the varieties are not significantly different at *p=0.05*

25 % Shade50 % Shade75 % Shade 85 % Shade

Plate 1: Fruit Size of Yellow Bell Pepper under Different Shade Levels

According to results of experiment using the different shade levels and yield parameters tested, the 85% shade level was found to be the most suitable for cultivation of bell pepper (Plate 1) and among the varieties tested, the yellow variety was found to be the most suitable variety for the Kilinochchi district.

Conclusions

Bell pepper varieties can be grown successfully in Kilinochchi district under different shade levels. Among the shade levels, 85% shade level was more suitable to grow bell pepper to obtain the highest yield. Among the varieties, even though the number of fruits were highest in red variety, yellow variety performed well by producing other desirable characters such as large size fruits with the highest individual fruit weight. Therefore, yellow variety bell pepper and 85% shade level combination can be recommended for Kilinochchi district to grow bell pepper.

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