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Effect of Partial Shade and Weeding Intervals on Growth and Yield Performance of Chilli (*Capsicum frutescens* L.) in Dry Zone of Sri Lanka

G. Asharp (Corresponding Author)

Department of Agronomy, Faculty of Agriculture, University of Jaffna, Sri Lanka

Tel: 0094772913367 E-mail: asharpsharmec9@gmail.com

S. Sivachandiran

Department of Agronomy, Faculty of Agriculture, University of Jaffna, Sri Lanka

E-mail: ssivamathy@yahoo.com

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Abstract

Chilli (*Capsicum frutescens* L.) is one of the most important cash crop cultivated in the Sri Lanka. Though, chilli cultivation has been tremendously influenced by the adverse climatic conditions and weed infestations. To solve these issues, a field experiment was conducted at Integrated Farm and Training Center, Faculty of Agriculture, University of Jaffna, Kanagarayankulam, during February 2017 to July 2017, to evaluate the impact of partial shade and effect of different weeding intervals on growth and yield performance of chilli. The treatments consisted of two shade levels (partial shade and full sun) and four weeding intervals (weeding at one week, two week, three week intervals and no weeding) in split plot arrangement with three replicates. Light intensity was statistically significant ($p < 0.05$) between shade levels. The lowest light intensity and the highest relative humidity were recorded in partially shaded treatment as 22.50 klux and 85.42 %, respectively at 8.00 a.m. Weed density was significantly ($p < 0.05$) differed by shade and weeding interval treatments. The lowest weed density was recorded in full sun (control) and weeding at one week interval treatment. Shade treatments and weeding interval treatments have shown a significant ($p < 0.05$) effect on plant height, leaf numbers, leaf length, fruit length, fruit fresh weight and total yields. Partial shade and weeding at one week interval have shown significantly higher growth and yield performance compared to the other levels of treatment. Therefore, these results can be recommended for adoption by the farmers to improve the performance of chilli.

Keywords: climatic conditions, chilli, dry zone, partial shade, weeding interval

1. Introduction

Chilli (*Capsicum frutescens* L.) has its unique place in Asian diet a spice as well as a vegetable. It is also a high value crop commercially grown in Sri Lanka (Gunawardena and De Silva, 2014). It occupies an important place in the human culture since pre-history in many countries. *Capsicum* is well known in the pre-historic Mexican culture such as Aztecs and Olmecas. *Capsicum* belongs to the family *Solanaceae* possessing 10 species (Sarkar *et al*., 2007). Chilli is consumed as fresh, dried or powder throughout the world. It is rich in proteins, lipids, carbohydrates, fibres, mineral salts (Ca, P, Fe) and in vitamins A, D_3, E, C, K, B_2 and B_{12} (Orobiyi *et al*., 2013).

Fluctuation of biotic and abiotic factors are critical challenges of climate change on good quality crop production (Easwaran *et al.*, 2015). Wheeler *et al* (2000) reported that the global production of annual crops would be affected by the increases in mean temperatures of 2 – 4 ^{0}C expected towards the end of the 21st century. Furthermore, Godawatte *et al* (2011) stated that the output of Sri Lanka's dry zone agricultural would be decreased significantly in the next 20 to 30 years because of reduced rainfall and increased temperature. The extreme climatic conditions had been experienced in Northern Province, represented by above average ambient temperatures and below average rainfalls. Moreover, its groundwater-based cropping systems with high utilization of irrigation water from shallow aquifers makes farming activities vulnerable to climate change (Easwaran *et al.*, 2016). Climate change will have greater negative impact on poor farm households in dry zone of Sri Lanka as they have a low adaptive capacity to climatic change. In spite of the technological advances made in improved crop management, irrigation, plant protection and fertilization, weather and climate remain the key factors of agricultural productivity in many countries. Whether farmers could use the innovative technology to adapt to the climate change, weed infestation and pest incidences is a crucial question (Dishani and De Silva, 2015).

The climate change will be the leading reason for recent changes observed throughout the world with in the weed spectrum in different cropping system, which leads to complex crop – weed interaction (Ramesh *et al*., 2017). The agro climatic conditions, biotic and abiotic factors influence the growth and photosynthetic efficiency of the crop. The translocation of assimilates to the economical important parts results in big size fruits with higher fruit weight. As *Capsicum is* profitable commercial crop with high nutritional value extensive research had been carried throughout the world to increase the yield under unfavorable conditions (Sarkar *et al*., 2007).

Based on these facts, this study was carried out to evaluate the effect of partial shade and different weeding intervals as a fraction of package of practices to green chilli cultivation in dry zone of Sri Lanka.

2. Materials and Methods

2.1 Site Description

A field study was conducted during February 2017 to July 2017 at Integrated Farm and Training Center, Faculty of Agriculture, University of Jaffna, Kanagarayankulam, which has a well-drained, clay loam soil. This study was initiated to evaluate the impact of partial shade and effect of different weeding intervals on growth and yield performance of chilli. The study area is located between 9^o 01' N latitude and 80^o 53' E longitudes at an elevation of 67 m above mean sea level. It consists of slightly sloppy topography and relatively flat land.

2.2 Experimental Design and Treatment

Experiment was carried out in a split plot design with three replications, shade treatments (partial shades, full sun) in main plots and weeding interval treatments (weeding at one week, two week and three week intervals and no weeding) in sub plot (Table 1). The dimension of each individual plot was 1.8 m × 1.4 m. Shade nets (70 % poly propylene black shade net) were supported with wooden posts forming a pyramidal structure with the highest point at 1.5 m along the center of the main plots and lowest point at 1 m along the edge of the main plots. Weeding treatments were executed by doing the weeding at one week, two week and three week intervals and no weeding (control). Manual weeding was practiced throughout the experiment.

Table 1. Treatment combinations

Main plot	Sub plot	Treatment code
Partial Shade	Weeding at one week interval	$S_1 W_1$
	Weeding at two week interval	$S_1 W_2$
	Weeding at three week interval	$S_1 W_3$
	No weeding	$S_1 W_4$
Full sun (Control)	Weeding at one week interval	$S_2 W_1$
	Weeding at two week interval	$S_2 W_2$
	Weeding at three week interval	$S_2 W_3$
	No weeding	$S_2 W_4$

2.3 Crop Establishment and Management

Mould board ploughing and land levelling were applied. Chilli was raised in a nursery and thirty-day-old chilli seedlings (Variety $MICH_3$) were transplanted in 60 cm × 45 cm spacing. Water was applied by basin irrigation throughout the crop growing season. Fertilizer was applied according to the Department of Agriculture recommendation. Two rows of border crop (*Sorghum* sp) was established with the spacing of 30 cm × 15 cm around the experimental site in order to reduce the pest and disease problems.

2.4 Measurements and Data Collection

Environmental measurements, growth measurements, weed density, weed dry matter and yield components were recorded during the vegetative, reproductive and maturity periods.

Minimum and maximum light intensity, relative humidity and atmospheric temperature were measured in every treatments during 8.00 a.m., 12.00 p.m. and 4.00 p.m. at two week interval. Meanwhile, two plants were selected at random and used to count the number of leaves and used to measure the plant height and leaf length at two week interval. Weed infestations (weed density and weed dry weight) were evaluated at one week interval by counting and weighing (oven dry weight) the weeds in a 25 cm × 25 cm quadrate per plot. Total yield, fruit length and average fruit fresh weight were calculated at the end of the experiment.

2.5 Data Analysis

The collected data were subjected to analysis of variance using the General Linear Model procedure of SAS (9.1.3). Different mean comparisons were carried out by Duncan multiple range test at 5% probability.

3. Results and Discussion

3.1 Environmental Variables

Light intensity of shaded chilli plant was significantly lower than those of chilli plants grown in direct sun light, whereas the relative humidity of the air of the shaded plants was significantly higher than of plants grown in full sun light except at 12.00 p.m. and 4.00 p.m. Atmospheric temperature did not differ significantly except at 8.00 a.m. (Figure 1). The lowest light intensity (16.57 klux) and atmospheric temperature (33.26 ^{0}C) were recorded in partially shaded treatment. Bote and Struik (2011) stated that the reduced air temperature was mainly due to the reduced direct incidence of solar radiation on the coffee canopy. Shading buffers the extreme temperature variations and provides a microclimate which attenuates extreme temperatures of air and soil and preserves surface soil humidity.

3.2 Weed Density and Weed Dry Weight

The emergence of weeds showed little difference among weeding interval treatments. The lowest weed density and weed dry weight were observed in weeding at one week interval treatment. Experiments tested without weeding showed comparatively higher weed density and weed dry weight as 284 number/m^2 and 1.22 g/m^2 respectively (Table 2 and 3). These results were similar to G/Mariam and Fufa (2016) who stated that there was an increase in weed population and biomass with an increase in weed-crop competition period. Increase in weed density and weed dry weight with prolonged competition period might be due to the extra time availed by weed to germinate, survive and continue growth. The interaction between the shade treatments and weeding interval treatments were insignificant.

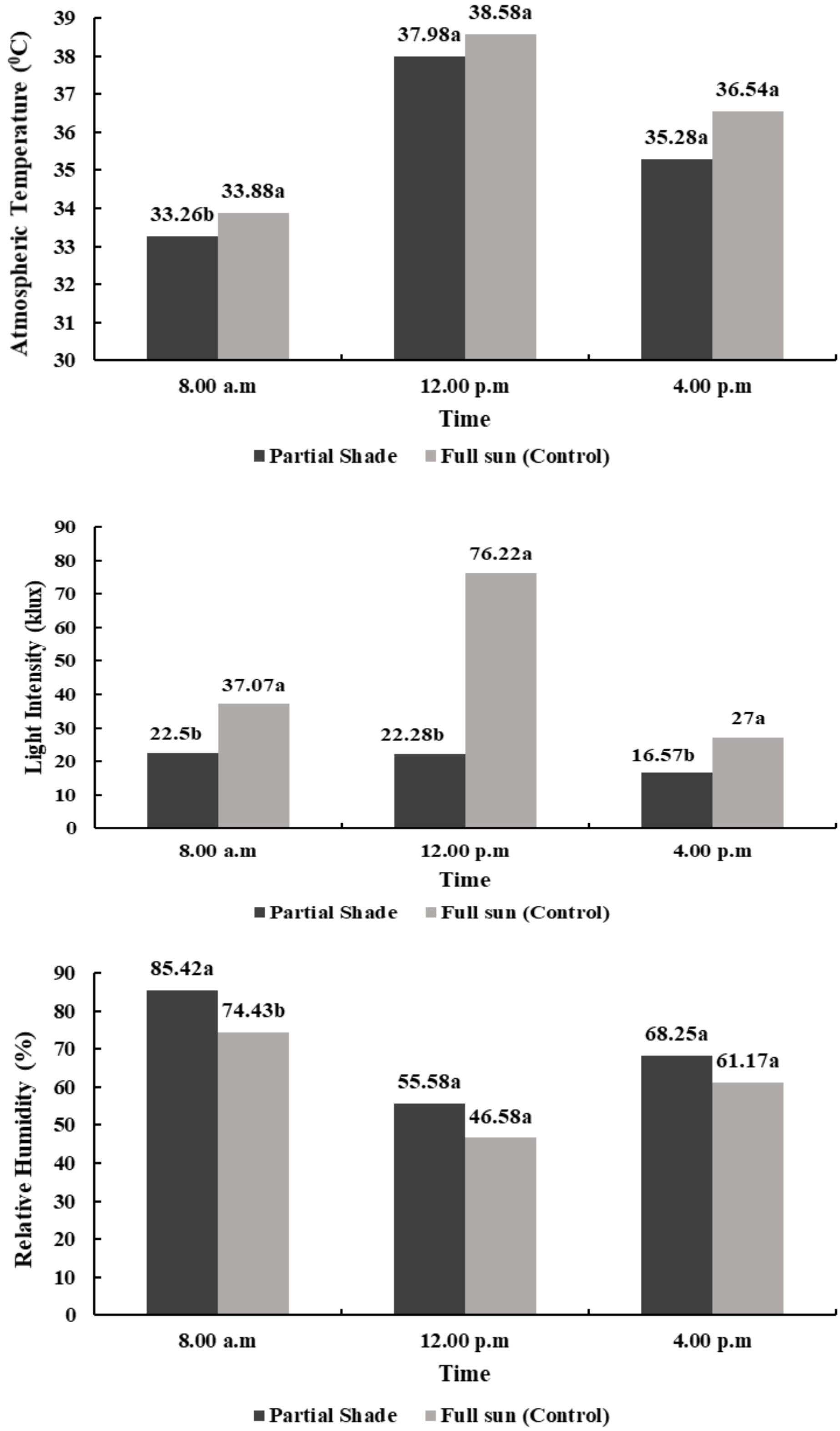

Figure 1. Relationships of atmospheric temperature (^{0}C), relative humidity (%) and light intensity (klux) with different time of the day

Table 2. Effect of shade treatments on weed density and weed dry weight

Shade Treatments (S)	Weed Density (Number/m^2)	Weed Dry Weight (g/m^2)
Partial Shade	199.67a	9.08a
Full sun (control)	158.33b	9.56a

Means with the same letter within a given treatment are not significantly different at p= 0.05

Table 3. Effect of weeding interval treatments on weed density and weed dry weight.

Weeding Interval Treatments (W)	Weed Density (Number/m^2)	Weed Dry Weight (g/m^2)
Weeding at one week interval	94d	1.22d
Weeding at two week interval	148c	5.66c
Weeding at three week interval	190b	8.98b
No weeding (Control)	284a	21.40a

Means with the same letter within a given treatment are not significantly different at p= 0.05

3.3 Plant Height

The results showed that the shade treatments differed significantly regarding plant height throughout the growth stages of chilli (Table 6). These results were comparable to Bibi *et al* (2012) who reported influence of partial shade on plant height of tomato crop in summer. The tested weeding interval treatments showed highly significant differences in plant height except three and five week after planting (3WAP and 5WAP). The interaction between the shade treatments and weeding interval treatments were insignificant.

3.4 Number of Leaves

In terms of the number of leaves, the lowest number at each growth stages was reported in full sun treatment (control) and no weeding treatment (control), showing comparatively poor growth, which resulted in lower plant height and fewer leaves. While the highest leaves were observed in partial shade treatment and one week weeding interval treatment at nine week after planting (9WAP) as 186.04 cm and 183.58 cm, respectively. A similar pattern was reported by Bibi *et al* (2012). The interaction between the shade treatments and weeding interval treatments were insignificant.

3.5 Leaf Length

A similar trend was observed in the leaf length resulting in the lowest value being in full sun treatment (control) and the highest in partial shade treatment. No effect of weeding interval treatment was observed but shade treatment showed a significant difference in all growth stages of chilli (Table 6 and 7). Morphological changes such as taller plants and thinner and larger leaves likely enhanced light capture under shaded conditions compared with unshaded plants in bell pepper (Carlos, 2013). The interaction between the shade treatments and weeding interval treatments were insignificant.

3.6 Yield Variables

Yield and yield attributes of chilli measured in the study were fruit length, single fruit weight and total yield. The data regarding fruit length are presented in Table 4 and 5. The analysis of variance (ANOVA) showed that the responses of shade treatment and weeding interval treatment had significant effect on fruit size. The interaction between the shade treatment and weeding interval treatment was also significant. The highest single fruit weight was obtained by partial shade treatment and weeding at one week interval treatment. On the other hand the lowest single fruit weight was recorded in full sun (control) and no weeding (control) treatments (Table 4 and 5). Because the adverse environment and weed competition with chilli might be reduce the single fruit weight. The interaction effect between the shade treatments and weeding interval treatments was non-significant. The ultimate aim in chilli cultivation is the economic yield. The data regarding total yield are given in Table 4 and 5. The ANOVA showed that total yield was significantly affected by shade treatments, weeding interval treatments and interaction between shade and weeding interval treatments. The maximum total yield was recorded in partial shade treatment (3.33 ton/ha) and weeding at one week interval treatment (3.44 ton/ha). The calculated difference in the total yield between partial shade and full sun (control) of 1.05 ton/ha showed the effect of shade and yield increase was 46.05 %. Meanwhile, 53.71 % of yield increase was recorded between weeding at one week interval and no weeding (control) treatments.

Table 4. Effect of shade treatments on average fruit length, single fruit weight and total yield

Shade Treatments (S)	**Average Fruit Length (cm)**	**Single Fruit Weight (g)**	**Total Yield (t/ha)**
Partial Shade	5.68a	2.26a	3.33a
Full sun (control)	4.67b	1.89b	2.28b

Means with the same letter within a given treatment are not significantly different at p= 0.05

Table 5. Effect of weeding interval treatments on average fruit length, single fruit weight and total yield

Weeding Interval Treatments (W)	Average Fruit Length (cm)	Single Fruit Weight (g)	Total Yield (t/ha)
Weeding at one week interval	5.64a	2.66a	3.44a
Weeding at two week interval	5.37b	2.10b	2.93b
Weeding at three week interval	5.13c	1.93bc	2.60c
No weeding (Control)	4.55d	1.62c	2.24d

Means with the same letter within a given treatment are not significantly different at p= 0.05

Table 6. Effect of shade treatments on average leaf length, average number of leaves and average plant height

Shade Treatments (S)	Average Leaf Length (cm)				Average Leaves Number per Plant				Average Plant Height (cm)			
	3WAP	5WAP	7WAP	9WAP	3WAP	5WAP	7WAP	9WAP	3WAP	5WAP	7WAP	9WAP
Partial Shade	6.18a	7.51a	10.76a	11.68a	41.63a	58.88a	118.83a	186.04a	35.67a	38.42a	44.38a	49.88a
Full sun (control)	5.03b	6.4b	6.75b	6.99b	25.33b	32.92b	86.08b	127.25b	24.03b	26.54b	33.38b	42.63b

Means with the same letter within a given treatment are not significantly different at p= 0.05
WAP indicates the Week After Planting

Table 7. Effect of weeding interval treatments on average leaf length, average number of leaves and average plant height.

Weeding Interval Treatments (W)	Average Leaf Length (cm)				Average Leaves Number per Plant				Average Plant Height (cm)			
	3WAP	5WAP	7WAP	9WAP	3WAP	5WAP	7WAP	9WAP	3WAP	5WAP	7WAP	9WAP
Weeding at one week interval	5.4a	6.63a	8.5a	9.07a	35.42a	51.33a	107.75a	183.58a	31.24a	33.88a	42.67a	51.5a
Weeding at two week interval	5.88a	7.25a	8.78a	9.55a	34.25a	46.5b	104.5a	165.83ab	30.75a	33.67a	39.42ab	47.5ab
Weeding at three week interval	5.55a	7.11a	9.1a	9.62a	34.83a	46.0b	99.83b	147.33bc	29.28a	31.71a	37.5ab	43.83bc
No weeding (Control)	5.60a	6.81a	8.63a	9.12a	29.42b	39.75c	97.75b	129.83c	28.13a	30.67a	35.92b	42.17c

Means with the same letter within a given treatment are not significantly different at p= 0.05
WAP indicates the Week After Planting

4. Conclusion

The present study confirmed the favorable benefits of the introduced adaptation package with partial shade and weeding at one week interval with the border crops in terms of improvement of growth, yield and environmental friendliness of chilli cultivation in the dry zone of Sri Lanka. Also, it has significantly enhanced the growth and production performances of chilli. Therefore, providing partial shade with one week interval weeding could be recommended for adoption by the farmers to improve the yield of chilli while promoting lower agro-chemical use, thereby having increased resilience to adverse climatic condition and weed infestation in enhanced environmental sustainability especially in the dry regions where chilli is cultivated.

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