Minufiya J.Agric.Res.Vol.35 No. 4(2):1521-1531(2010)"http://agri.menofia.edu.eg/megla.html"

EFFECT OF SHADING AND CALCIUM LEVELS ON GROWTH AND YIELD OF SOME SWEET PEPPER CULTIVARS DURING SUMMER SEASON

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(Received: Apr. 28 , 2010)

ABSTRACT: *Two field experiments were carried out in Technogreen Company- Ismailia location- Egypt, in 2006 and 2007 summer seasons to investigate the response of three sweet pepper cultivars; namely, Mazurka, Paramo and Carmen to plastic net shading, i.e. white screen (25 % shading) or white and black (50 % shading for 30 days and 25 % afterwards) and calcium treatments (25, 50 and 75 ppm) as compared with the control.*

Data indicated that increased shading to 50 % shading for 30 days and 25 % afterwards significantly increased plant height, leaf area, early yield, marketable yield and total yield, whereas non-marketable yield was decreased as compared with the control.

Data also showed that calcium treatment at 75 ppm Ca increased leaf area, early yield, marketable yield and total yield, but it decreased non-marketable yield. On the other hand, 50 ppm Ca treatment recorded the highest plants.

Carmen and Paramo cultivars recorded higher values ,of plant height, early yield, marketable yield, total yield and the lowest non-marketable yield as compared to Mazurka cultivar, whereas, Carmen and Mazurka cultivars recorded larger leaf area than Paramo cultivar. The highest marketable -fruits was obtained in Carmen and Paramo cultivars treated with 75 ppm calcium under the condition of 50 % shading for 30 days followed by 25 % shading up to the end of harvesting season as compared with the other treatments.

Key words : *shading, Calcium, Capsicum annum, sweet pepper*

INTRODUCTION

Sweet pepper crop *(Capsicum annum* L.) is one of the most important vegetable crops in Egypt. In Europe, Spain is rated number one in production of sweet pepper in the Dutch greenhouses, reaching the highest average yield in the world (28 kg/m^2), followed by Italy, Bulgaria and the Netherlands Abd-Elmawgoud, (2002). In Egypt, sweet pepper production suffers from several physiological problems, such as fruit disorders Blossom End Rot (BER), Color Spots (SP), Cracking and sun scald. Such problems that occur in summer season are due to the high temperature, high light intensity, high relative humidity (Rh) and some problems in calcium absorption. According to the results of many investigators, shading resulted in reducing many of these problems, which led to significant increases in marketable yield of different vegetable crops. Shading, for example, decreased fruit disorders

(non-marketable yield), sunscald and BER in pepper fruits Haim *et al.*, (1985). Shading also improved the quality of tomato fruits Hamer *et al.*, 2004, Gent, 2007 and Riga *et al.*, (2008) and increased the marketable yield of cucumber Lorenzo *et al.*, (2006). Shading at an early stage of plant development increased cell division and volume in leaves, and also positively affected fruit growth and yield of pepper Schoch, (1972).

The results of several investigators indicated that when light intensity decreased, plant height and leaf area increased in pepper Rylski and Spiglman, (1986) and tomato El-Gizawy *et al.*, (1992a), Sharma and Tiwari, (1993), Zheng Qin and Li-xia, (1998) and Adam *et al.*, (2002). Shading with black net provides 30 % reduction in solar radiation almost doubled total fruit yield of tomato El-Aidy *et al.*, (1983) and El-Gizawy *et al.*, (1992b).On the other hand, shading reduced the percentage of unevenly colored tomato fruits from 13 % to 6 % and increased shelf life from 4 to 6 days and star-shaped cracks was reduced as the degree of shading increased (Holsteijn *et al.*, 1990)

Calcium also plays an important role in the plant cell wall building, calcium is the key of element responsible for firmness of pepper fruits Fleming *et al.*, (1993).Calcium deficiency causes deformed tissues and death of the growing points including buds, blossom end rot and leaf tips John *et al.*, (2000) .It was found that 76 % of calcium goes to the leaves, 15 % for stems, 4 % for side shoots and 5 % only to the fruit in tomato plants Voogt, (1993).Additional foliar application of calcium chloride improved growth of pepper plants grown under sandy soil condition El-Tohamy *et al.*,(2006). Spraying Ca was the most effective factor for increasing pepper fruit yield Fathy, (2005) and Pereira *et al.*, (2002) .Calcium foliar application significantly increased early yield and total yield of lettuce plants under sandy soil conditions El-Sayed *et al.*, (2006).

The aim of this study was to investigate the effect of shading and calcium levels on the growth and yield of some sweet pepper cultivars during the summer seasons.

MATERIALS AND METHODS

This experiment was carried out in Techngreen Company Farm (Ismailia location) in 2006 and 2007 seasons in sandy soil texture to investigate the effect of shading and calcium levels on the growth, marketable yield and non-marketable yield of three sweet pepper cultivars. The screen green houses provided 25% shading through the growing season was the first treatment, additional black screen for the first 30 days was used to provide in total 50% shading and open field grown cultivars formed the control (unshaded treatment).

The experiment included 27 treatments (3 shading levels X 3 calcium levels X 3 cultivars) and was adapted in split- split plot design with three replicates. The shading treatments were assigned as main plots where the

calcium treatments were distributed as sub-plots and the three cultivars as sub-sub-plots.

The experimental treatments were as follows:-

1- Shading level treatments:-

a- Without shading (control).
b- Shading level 25 % (white screen), for the whole season
c- Shading level 50 % for 30 days and 25 % afterwards (white screen and black screen).

2- Calcium level treatments:-

a- Low level (25 ppm CaO).
b- Medium level (50 ppm CaO).
c- High level (75 ppm CaO).

3- Cultivar treatments:-

a- Mazurka cultivar (red).
b- Paramo cultivar (orange).
c- Carmen cultivar (yellow).

Pepper seedlings were transplanted on 12th and 21st of May in 2006 and 2007 seasons, respectively. Calcium nitrate (19% CaO) was used as a source of calcium and was applied through drip irrigation system.

There were three replications, each replicate of the main plot (shading treatment) consisted of 9 beds 18 rows (16m x 24 m) divided into 3 sub-plots, each was 8 m length x 16 m width. Each sub-plot divided into 3 sub-subplots, each consisted of two rows (8m x 1.6 m) containing a cultivar namely, Mazurka, Paramo and Carmen.

Thirty days after transplanting, a random sample of three plants from each replicate was taken to determine the vegetative growth characteristics, i.e., plant height and leaf area at flower node number 3(after 75 days from transplanting).

At harvest stage fruits were collected for early yield (the sum of the first 8 pickings), marketable yield, non-marketable yield and total yield as (kg /m^2)

Statistical analysis was done according to Snedcor and Cochran, (1972) and means were compared using the L.S.D. methods at 5 % level of significance.

RESULTS AND DISCUSSION

1- Effect of shading and calcium levels on plant growth of sweet pepper cultivars

a- Effect of shading

The response of pepper plants to shading is probably vary in different geographical areas, seasons and cultivars and from different agricultural

practices such as planting density, irrigation, fertilization and other factors Rylski and Spigelman, (1986).

Plant development in screen houses was entirely different from that in the open. Data recorded in Table (1) indicated that plant height was significantly increased as light intensity decreased. Therefore, the highest values of plant height in (both seasons) were recorded on plants grown under 50 % for 30 days(103.9 and 121.3 cm) and followed by those grown under 25% shading (97.2 and 115.5 cm) in the first and second season, respectively. The increase in plant height of shaded plants was a result of both internodes elongation and node number. These results agreed with those obtained by Rylski and Spigelman, (1986), El-Gizawy (1992a) and Adam *et al.*, (2002).

Table 1: Effect of shading and calcium levels on the plant height and leaf area (after 75 days) of some sweet pepper cultivars during 2006 and 2007 seasons.

Treatments		Plant height (cm)		Leaf area ($cm^{2)}$	
		2006	2007	2006	2007
Shading	0%	57.96	53.41	58.37	38.56
	25%	97.22	115.50	109.40	84.73
	50%-30days	103.90	121.40	115.10	120.90
L.S.D at 0.05		1.68	1.25	1.07	1.77
Calcium levels	25 ppm	81.85	92.52	89.59	79.25
	50 ppm	90.89	99.96	92.55	81.02
	75 ppm	86.33	97.82	100.70	83.87
L.S.D at 0.05		1.78	1.58	1.00	0.75
Cultivars	Mazurka	74.30	86.74	99.65	81.63
	Paramo	91.70	104.70	90.22	74.28
	Carmen	93.07	98.85	92.92	88.22
L.S.D at 0.05		1.06	1.84	0.82	0.71

Regarding the effect of shading on pepper leaf area, data also presented in Table (1) showed that, in shaded plants, the leaves were bigger than those in full sun light under the lowest light intensity (50% shading for 30 days) conditions, the total leaf area measured on the third flower node was about 97 % and 213 % greater than those grown in full sun light in both seasons, respectively. Because of low light intensity, leaves expanded more to receive more light for photosynthesis as was explained by Wilawan, (1998). These

results agreed with those obtained by Rylski and Spigelman, (1986) and El-Gizawy *et al.*, (1992a &b).

b- Effect of calcium

Regarding the effect of calcium treatments on plant growth, data also tabulated in Table (1) indicated that the medium calcium level(50ppm) enhanced plant height of sweet pepper plants (90.89 and 99.96 cm) as compared to the other calcium treatments in both seasons. These results may be due to the role of calcium in cell expansion and cell division John *et al.*, (2000). The obtained results agreed with Bar *et al.* (2003) and El-Tohamy *et al.*, (2006).

Concerning the effect of calcium levels on pepper leaf area, data also showed that pepper leaf area linearly increased with increasing calcium levels (12.4% and 5.8 %) in 2006 and 2007 seasons, respectively as compared to low calcium level.

c- Effect of cultivars

Data also presented in Table (1) clearly indicate that Carmen and Paramo cultivars recorded taller plants as compared with Mazurka cultivar in both seasons. The average plant height after 75 days was 74.3, 91.7, and 93.07 cm in the first season, and 86.74, 104.7 and 98.85 cm in the second season for Mazurka, Paramo and Carmen cultivars, respectively. In contrast Mazurka and Carmen leaf area was greater than Paramo.The highest leaf area was observed in the first season (2006) with significant differences between cultivars. Leaf area was 99.65, 92.92 and 90.22 cm^2 in Mazurka, Carmen and Paramo cultivars, respectively

2- Effect of shading and calcium levels on the early, marketable, non-marketable and total yield.

a- Effect of shading

Data recorded in Table (2) indicate that *early yield*, marketable yield and total yield were significantly increased due to shading compared with control. On the contrary, *non-marketable yield* was significantly decreased due to shading in both seasons. Data show that shading (50% shading for 30 days and 25 % afterwards) increased the *early yield* (87.3 %, 85.9 %), *marketable yield* (74.5 %, 83.4 %) and *total yield* (54.8, 68.8 %) over the control in 2006 and 2007 seasons, respectively. In contrast, *non-marketable yield* was about 49.5 % and 57.9 lower than that on plants grown in full sunlight. The greater fruit yield produced from shaded plants may be explained by the assumption that during summer, high temperature increases shedding of tomato flowers Abdalla and verberk, (1968) and reduces fruit set Levey *et al.* (1978). Moreover, tomato fruits produced under such conditions are smaller and this would also contribute to reduced yield

.These results are in accordance with those obtained by El-Gizawy *et al.*, (1992 b) and Adam *et al.*, (2002) on tomato under 40% and 51% shading, respectively and Haim *et al.*, (1985), Rylski and Spigelman, (1986) and Aloni *et al.*, (1994) on pepper.

Table 2: Effect of shading, calcium levels and cultivars on the yield of sweet pepper during 2006 and 2007 seasons.

Treatments		Early yield kg /m^2		Marketable yield kg /m^2		unmarketable yield %		Total yield kg /m^2	
		2006	2007	2006	2007	2006	2007	2006	2007
Shading	0%	1.65	1.91	3.69	3.92	18.85	25.23	4.54	4.90
	25%	2.78	2.61	5.20	6.03	14.73	14.96	5.83	6.87
	50%30days	3.09	3.55	6.44	7.19	9.52	10.62	7.03	8.27
L.S.D at 0.05		0.12	0.15	0.14	0.08	1.58	1.29	0.09	0.16
Calcium levels	25 ppm	2.14	2.34	4.60	5.05	17.75	24.34	5.52	6.03
	50 ppm	2.48	2.71	5.09	5.73	13.85	15.53	5.70	6.89
	75 ppm	2.89	3.03	5.63	6.37	11.47	10.93	6.20	7.13
L.S.D at 0.05		0.08	0.07	0.11	0.10	0.63	0.96	0.13	0.10
Cultivars	Mazurka	2.18	2.22	4.72	4.94	18.84	20.13	5.73	5.82
	Paramo	2.46	2.62	5.05	5.87	11.28	18.79	5.47	7.15
	Carmen	2.87	3.24	5.55	6.34	12.98	11.89	6.21	7.07
L.S.D at 0.05		0.06	0.09	0.06	0.17	0.58	0.63	0.09	0.19

b- Effect of calcium

Data illustrated in Table (2) also indicate that *early*, *marketable* and total yield significantly increased as a result of increasing calcium levels. The highest values were recorded on plants fertigated with 75 ppm of calcium, (2.89 and 3.03 kg/m^2) for the *early yield*, (5.63 and 6.37 kg/m^2) for *marketable yield* and (6.2 and 7.13 kg /m^2) for *total yield*, in 2006 and 2007 seasons, respectively. On the contrary, the lowest values were recorded on plants received 25 ppm calcium for the *early*, *marketable* and *total yield* in both seasons, respectively. These results are in accordance with those obtained by Periera *et al.*, (2002) and Fathy (2005), on pepper.

Concerning the effect of calcium levels on the *non-marketable yield*, data illustrated in Table (2) show that the highest calcium level (75ppm) clearly decreased the *non-marketable yield* from 17.75 % in the lower level of

calcium to 11.47 % in the first season and from 24.34 to 10.93% in the second season, respectively. These results agreed with those obtained by Fleming *et al.*, (1993) and Pereira et al., (2002) on pepper.

c- Effect of cultivars.

As shown also in Table 2, Carmen cv. recorded the highest values in the *early* and *marketable yield* (2.87 and 3.24 kg/m2) and (5.55 and 6.34 kg. /m^2), in 2006 and 2007 seasons, respectively, followed by Paramo cv. (2.46 and 2.62 kg/m^2) and (5.05 and 5.87 kg /m^2) for the *early* and *marketable yield* in both seasons, respectively. Data also show that Carmen cultivar recorded the highest *total yield* in 2006 season (6.21 kg/m^2), whereas Paramo recorded the highest *total yield* (7.15 kg/m^2) in the second season. Meanwhile, Mazurka cultivar recorded the highest percentage of *non-marketable yield* (18.84 and 20.13%) in both seasons, respectively.

3-Effect of the interaction between shading and calcium levels on sweet pepper yield.

The interaction effect between shading and calcium levels was significant on the *early yield* in the second season only (Table 3).Data indicated that plants grown under 50 % shading for 30 days followed by 25 % shading and fertigated with 75 ppm calcium recorded the highest value of early yield in the second season (3.79 kg/m^2), as well as, the highest values on the *marketable yield* in both seasons (7.35 and 7.83 kg/m^2), and the highest *total yield* in the first season only (7.76 kg/m^2) whereas, the treatment 50 % shading for 30 days treated with 50 ppm calcium recorded the highest value of the total yield in the second season (8.69 kg/m^2) followed by the treatment of 75 ppm (8.68 kg/m^2) without significant differences.

Non-marketable yield was decreased from 23.14% in the control to 8.33 % in 50 % shading for 30 days and 25 % afterwards and from 35.21% to 6.51 % in the first and second seasons, respectively. These results may be due to the role of shading and calcium in decreasing fruit disorders in pepper fruits. Haupt and Weisenseel (1976) suggested that phytochrome molecules located in the plasma membrane function as Ca^{2+} carriers and facilitate an increase in the Ca^{2+} when irradiated with red light. It is well known that calcium plays an important role in the plant cell wall building, it is the key of the element responsible for firmness of pepper fruits (Fleming *et al.*,1993).

Table 3: Effect of the interaction between shading and calcium levels on The yield of sweet pepper during 2006 and 2007 seasons.

Treatments		Early yield kg./m^2		Marketable yield kg./m^2		Non-marketable yield %		Total yield kg./m^2	
Shading	Calcium levels	2006	2007	2006	2007	2006	2007	2006	2007
0%	25 ppm	1.36	1.57	3.42	3.43	23.14	35.21	4.46	4.58
	50 ppm	1.61	1.88	3.69	3.91	17.80	23.22	4.48	4.90
	75 ppm	1.98	2.27	3.95	4.40	15.60	17.27	4.67	5.23
25%	25 ppm	2.34	2.11	4.76	5.17	19.42	21.68	5.55	6.08
	50 ppm	2.77	2.70	5.24	6.07	14.28	14.18	5.80	7.07
	75 ppm	3.23	3.03	5.59	6.87	10.49	9.02	6.16	7.47
50%-30 days	25 ppm	2.73	3.33	5.63	6.54	10.76	16.14	6.54	7.42
	50 ppm	3.05	3.53	6.33	7.20	9.47	9.20	6.80	8.69
	75 ppm	3.47	3.79	7.35	7.83	8.33	6.51	7.76	8.68
L.S.D at 0.05		N.S	0.11	0.19	0.17	1.08	1.67	0.23	0.17

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تاثير مستويات التظليل والكالسيوم على النمو والمحصول لبعض اصناف الفلفل الحلو خلال الموسم الصيفى

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الملخص العربي

أجريت تجربتان حقليتان فى مزرعة شركة تكنوجرين – موقع الاسماعيلية خلال الموسم الصيفى لعامى ٢٠٠٦و٢٠٠٧ لدراسة مدى استجابة ثلاثة اصناف الفلفل الحلو(مازوركا , بارامو و كارمن) لمعاملات التظليل بالشبك البلاستيك الابيض (٢٥ ٪ تظليل) او الابيض والاسود (٥٠٪ تظليل لمدة ٣٠ يوم ثم ٢٥ ٪ بعد ذلك) والكالسيوم (٢٥ , ٥٠ , ٧٥ جزء فى المليون) مقارنة بمعاملة الكنترول(صفر تظليل) .

أوضحت النتائج الاتى :-

- زيادة ارتفاع النباتات ومساحة الورقة بصورة معنوية فى معاملة التظليل بالشبك الابيض مع الاسود (٥٠٪ تظليل لمدة ٣٠ يوم ثم ٢٥ ٪ بعد ذلك) بالمقارنة بالكنترول.
- ادت كذلك المعاملة السابقة الى زيادة المحصول المبكر والمحصول الصالح للتسويق والمحصول الكلى. فى حين ادت نفس المعاملة الى انخفاض المحصول الغير صالح للتسويق مقارنة بالكنترول.
- وجد ان المعاملة بمستوى الكالسيوم ٧٥ جزء فى المليون ادت الى زيادة مساحة الورقة و المحصول المبكر والصالح للتسويق وكذلك المحصول الكلى. وعلى العكس من ذلك ادت المعاملة الى انخفاض المحصول الغير صالح للتسويق. فى حين سجلت المعاملة ٥٠ جزء فى المليون اعلى ارتفاع للنباتات مقارنة بالمعاملة ٢٥ جزء فى المليون .
- سجلت اصناف الكارمن والبارامو اعلى ارتفاع للنباتات , اكبر محصول مبكر وصالح للتسويق و محصول كلى واقل محصول غير صالح للتسويق مقارنة بصنف المازوركا , فى حين سجل صنفى الكارمن والمازوركا اكبر مساحة للورقة مقارنة بصنف البارامو.
- تم الحصول على اعلى محصول وافضل جودة ثمار من المعاملة٥٠٪ تظليل لمدة ٣٠ يوم ثم ٢٥٪ بعد ذلك مع التسميد بمستوى الكالسيوم ٧٥ جزء فى المليون على اصناف الكارمن والبارامو مقارنة بباقى المعاملات .