Effect of water regime, pruning system and potassium silicate on dry mass production of sweet pepper plants grown in calcareous soil under greenhouse

Kotb H.M.- Hegazi H.H.- Ghoneim I.M.And M.N. Feleafel
Dep. of vegetable crops, Faculty of Agriculture
Alexandria University.

BSTRACT

Two greenhouse experiments were carried out at Army Farm, at El-Amria region, Alexandria, Egypt, during the two seasons of 2016-2017 and 2017-2018, as an attempt to rationalize of irrigation water through studying the effect of three water regimes, three pruning systems and four potassium silicate rates on the dry mass accumulation in the various plant organs of sweet pepper. Results showed that application of the lower amount of irrigation water (30% depletion ratio) with repeat its addition achieved the highest significant mean values of roots, stems, leaves and whole plant dry mass at one, three and nine months after transplanting (MAT), as well as fruits dry mass after three and nine MFT, in the two seasons. Furthermore, the results indicated that un-pruned sweet pepper plants achieved significant higher mean values of roots, stems and whole plant dry mass, at three and nine MAT, in both seasons, as well as fruits dry mass at nine MAT only , in both seasons. The addition of, foliar application of potassium silicate up to 500 or 1000 mg l^{-1}, significantly, accumulated higher dry weight in roots, branches, leaves, fruits and whole plant of sweet pepper plants after one, three and nine MAT, compared with that unsprayed, in the two seasons. Likewise, sweet pepper plants that un-pruned or pruned up to 3 branches $plant^{-1}$ and irrigated with the lower amount of irrigation water (30% depletion ratio) achieved the highest values of the dry mass of branches, leaves, fruits and whole plant at one, three and nine MAT compared with that pruned on two branches plant-1. However, the highest dry mass value of roots, branches, leaves, fruits and whole plant of pepper were obtained from the treatment combination included the lower amount of water (30 % water depletion ratio) and spray 1000 mg l^{-1} of potassium silicate, in both seasons, after one, three and nine MAT. Interactions between pruning systems and potassium silicate concentrations indicated that the highest values of the dry mass of roots, branches and whole plant of sweet pepper plants were achieved from treatment combinations containing un-pruned plants and sprayed the plants with 1000 mg l^{-1} of potassium silicate, in both seasons.

Key word: Sweet pepper, Water, Regime, Pruning system,potassium Silicate, Dry mass

INTRODUCTION

Sweet pepper (*Capsicum annum* L.) is one of the important *Solanaceious* vegetable crops that grown under greenhouses of worldwide. In Egypt, greenhouse pepper production is based on nine-month cycle (El- Sayed *et al.*, 2015), thus, it is a high-value cash crop that either for domestic market are for export.

The whole cycle of a sweet pepper plants divided into a vegetative and generative phases (Nielsen and Veierskov, 1988). In the vegetative growth stage, until 60 days after transplanting, the dry matter is oriented to the roots and leaves (Fernand, *et al.,* 2004). While in the generative stage, it consumes in formation the flowers, stems, leaves, and fruits. Therefore, the challenge facing greenhouse sweet pepper producers is to establish a strong vegetative growth and production of extra-large-sized fruits for export. However, pepper plants have a relatively a small root system where does not exceed 19.4-8.6% of the plant dry mass in both of the vegetative and reproductive growth stages, orderly (Fernand *et al*., 2004). Consequently, it is important to know how to achieve a balance between the growth of both roots and formation of the stems, leaves, flowers, and fruits of the pepper plant, through the redistribution of dry matter among various plant organs by improving pruning system and foliar application of potassium silicate under water stress conditions.

Total water requirements of sweet pepper are 1250 mm for long growing seasons and several pickings (FAO, 2015), i.e. 5000 m^3 fed^{-1}. For high yields, an adequate water supply and relatively moist soils are required during the growing period. The period at the beginning of the flowering is most sensitive to water shortage and soil water depletion in the root zone during this period should not exceed 25 % (FAO, 2015). Water shortage just prior to and during early flowering reduces the number of fruit (Katerji *et al*., 1993 and FAO, 2015). Therefore, controlled irrigation is essential for high yields because the crop is sensitive to both over and under irrigation (FAO, 2015). Where, Hedge (1987) found that bell pepper yields in India were similar when irrigated at 40% and 60% of available soil moisture, but yields were reduced when irrigation was applied at either 20% or 80% of available soil moisture.

Pruning system of sweet pepper plant is a tool to control of fruits development through restricting the branching pattern to 2 or 3 or 4 main stems. In this context, the limitation of shoot numbers achieved the heavier fruits (Cebula, 1995, Jovicich, *et al.*, 1999, Maboko *et al.*, 2012 and Alsadon *et al.*, 2013). Whereas, decreasing the number of shoots of pepper reduced the number of leaves on the plants, while the surface of a single leaf was extended (Dasgan and Abak, 2003), therefore this leads to a balance between vegetative and reproductive growth in order to maximize plant growth and fruit production. Where, pruning system contributes to facilitate the light penetration of the leaves, improve fruit set, early fruit ripening, and high yield of large-sized fruits (Resh, 1996, Jovicich, *et al.*, 1999 and Zende, 2008). Moreover, it achieves saving in the amount of water irrigation through reducing plant leaf area and canopy (Hipps *et al.*, 2014). Awalin *et al.* (2017) found that shoot pruning of pepper achieved the greatest number of marketable fruits per plant (8.70), maximum fruit setting (39.32%) and highest yield (26.60 t/ha).

Silicon (Si) foliar application, as potassium silicates, is a relatively new technique of feeding the plants. Where, Si has many roles in the plant physiology; regulation of the uptake of other ions and increase tolerance plants to various biotic and abiotic stresses (Zhu *et al*., 2004) as well as alleviate water stress through reduce transpiration rate (Hattori *et al*., 2005) by reduction the diameter of stomatal pores (Efimova and Dokynchan, 1986). Si is stimulating the growth and development of many plant species by correcting the levels of endogenous growth hormones, i.e., auxins, gibberellins and cytokinins under stress conditions (Hanafy Ahmed *et al*., 2008). Moreover, the adequate nutrition with Si interferes in the plant architecture; by enhancing rigidity, strengthening and elasticity of cell wall (Hanafy Ahmed *et al*., 2008) as well as improving erecting of leaves, increasing solar radiation interception and photosynthetic efficiency (Pereira *et al*., 2003; Al-Aghabary *et al*., 2004).

The current research was carried out as an attempt to achieve a balance between both the vegetative growth and fruits production by studying the influence of three-irrigation water regime, three pruning systems and four potassium silicate rates as well as its interactions on the dry mass production of sweet pepper plants (Gavotte F1 cv.) grown in calcareous soils under greenhouse.

MATERIALS AND METHODS

Two greenhouse experiments were carried out at the Army Farm, in El-Amria region, Alexandria, Egypt, during the two seasons of 2016-2017 and 2017-2018, as an attempt to rationalize of irrigation water through following up the distribution of dry mass in the various plant organs of sweet pepper, as affected by three-irrigation water regime, three pruning systems and four potassium silicate rates. Each experiment was conducted in nine greenhouses; the area of each greenhouse was 360 m^2 (6 rows × 1.5 m width × 40 m long).

One week before pepper transplanting, 4 m^3 of cattle manure + 2 m^3 of chicken manure + 20 kg sulfur + 50 kg calcium super phosphate 15.5 % was incorporated into the soil of the six rows, in each greenhouse, at 15-20 cm depth.

Preceding the initiation of each experiment, in both seasons, soil samples were collected from nine greenhouses, at 15-30 cm depth, and analyzed in Nobariya Lab. of agricultural analyses, for some soil's physical and chemical properties according to the published procedures (Page *et al*., 1982), the results of this analyses are listed in Table (1).

In each greenhouse, the drip irrigation network consisted of lateral's GR of 16 mm in diameter, with emitters at 0.5 m distance, with allocating two laterals for each row. The emitters had a discharge rate 4 l h^{-1}. For good plant establishment, before transplanting, 5 m^3 of irrigation water was applied to each greenhouse, and then the transplants of sweet pepper (Gavotte F1 cv., Rijk Zwaan Co., Netherlands) were sown, on August 5th, in both seasons of 2016 and 2017, in two lines on each row. The row spacing was 50 cm between the transplants and 25 cm between the two lines.

Treatments:

1-Water Regime

Three water regime (based on depletion ratio) treatments were executed, in the two experiments; 30, 50 and 70% from the available soil water (ASW) in the root zone. Therefore, net irrigation application depth to sandy loam soil was calculated to maintain the available soil water in the root zone (up to 30 cm depth) at 30, 50 and 70% in accordance with a depletion ratio 70, 50 and 30%, according to a formula that reported by Qassim and Ashcroft (2002).

Net irrigation application depth (mm) =
Root depth (m) × depletion fraction × total available water (mm m-1)

Table 1: some growing seasons physical and chemical properties of the experimental soil in 2016-2017 and 2017-2018.

Seasons	Mechanical properties					Texture	Chemical properties														Physical properties		
	Sand %	Silt %	Clay %	Gravel %	SP %		EC dS m^{-1}	pH	Na^{+} mgl^{-1}	Ca^{++} mgl^{-1}	Mg^{++} mgl^{-1}	HCO_3^- mgl^{-1}	CL^- mgl^{-1}	CO_3 mgl^{-1}	SAR	Caco3 %	O.c %	OM %	P mgl^{-1}	K mgl^{-1}	Virtual Density g cm-3	Porosity %	Field Capacity %
2016-2017	44	34	22	1.2	37	Sandy loam	5.97	8.04	640	255.5	116.6	188	986.5	0	4.145	8.72	.75	1.20	1.7	12.9	1.45	39.5	11.92
2017-2018	43	35	22	1.3	38	Sandy loam	5.40	7.95	628	238.6	115.9	190	987	0	3.53	9.77	.79	1.36	1.8	12.7	1.59	41.13	12.39

However, the actual water use of the pepper (crop evapotranspiration; Etc.), under greenhouse at El-Amria region conditions, was calculated and adjusted at the beginning of each week throughout the growing season, about 43 weeks (From August until the end of May). It is calculated by multiplying reference evapotranspiration (ET_0) of El-Amria region, by a crop coefficient (K_C); ET_c (mm day^{-1}) $=ET_0\times K_c\times 0.73$, as indicated in Allen *et al*., 1998 and Razmi and Ghaemi (2011), Table (2). Addition, irrigation frequency (irrigation period) was calculated by dividing the net irrigation application depth (mm) by ET_c (mm day^{-1}).

$$\textit{Irrigation period (day)} = \frac{\text{net irrigation application depth(mm)}}{\text{ETC(mm day-1)}}$$

2. Pruning systems

Three pruning systems were executed on the sweet pepper plants that grown under greenhouse, where after 30 days from transplanting, the first crown flower and lateral shoots, just above the cotyledonary node, were removed. Based on the number of branches, which left on each plant of sweet pepper, the pruning treatments were; control without pruning (Spanish pruning), left 2 and 3 main branches plant^{-1}(Holland pruning).

3. Potassium Silicate

Potassium silicate (K_2SIO_3), in a powder form, contain 22.5% SiO_2 and 10.25% K_2O, were used as a foliar application at four concentrations; 0, 250, 500 and 1000 mg l^{-1}. Potassium silicate was sprayed four times, at 30, 60, 90, and 120 days after transplanting. Spreading agent (Super Film 1 ml l^{-1}), was used, with different potassium silicate concentrations. The untreated plants (control) were sprayed with tap water plus the same spreading agent only.

Experimental Design:

Each experiment included 36 treatments, which were the combinations of four potassium silicate concentrations (0, 250, 500 and 1000 mg l^{-1}) under three pruning systems (without pruning, left 2 and 3 main branches plant^{-1})under three water regimes (30, 50 and 70% from the available soil water). The experimental design used was the split-split-plot system in a Randomized Complete Blocks Design, with three replications. Each replicate contained three greenhouses (main plots). Three water regime treatments were, randomly, arranged in the main plots, while three pruning systems were, randomly, distributed within each greenhouse as the sub-plots. Each sub-plot contained two rows having an area of 120 m^2. Moreover, four potassium silicate concentrations were randomly distributed within each pruning system as sub-sub-plots. Each sub-sub-plot contained two rows having an area of 30 m^2.The average temperatures and relative air humidity inside the greenhouse were 24.6 ± 2.1°C and 50.2 ± 2% throughout sweet pepper growth stages, respectively.

Agricultural Practices

All sub-sub-plots received the same amounts of fertilizers, where received N, P and K fertilizers at the rates of 180-270-180 kg fed^{-1} as ammonium nitrate (33.5%N), nitric acid (55%), NPK compound fertilizer (19-19-19) and mono potassium phosphate (0-52-34), in both experiments. NPK fertilizers were injected directly into the irrigation water (fertigation) using a venture injector at two doses weekly, started in the 2nd week after transplanting and continued up to the 39th week. Other cultural practices such as pest control and cultivation were carried out, whenever; it was necessary and as applied to the greenhouse commercial sweet pepper production.

Data Recorded:

After one, three, and nine months from transplanting (MFT), five plants were randomly chosen, from each sub-sub-plot, then uprooted from the soil to determine the dry mass accumulation of the root, stem and leaves (g) per plant. Moreover, sweet pepper fruits were harvested at twice weekly starting from 90 days after transplanting, then at the end of the growing season; fruits yield per plant was recorded and the dry mass accumulation of fruits (g) per plant were determined (Ryan *et al.,*2007*)*.

Table 2: Length of the growth stages, crop coefficients (Kc), reference evapotranspiration (ET0) and water requirements (ETc) of pepper plants growing under the greenhouse, as average to both seasons of 2016-2017 and 2017-2018 growing seasons.

Growth stages	Vegetative	Flowering and fruits formation	End season
Number of days stage^{-1}	35	235	30
Average crop coefficients (K_C)	0.65	1.0	0.95
Average reference evapotranspiration (ET_0) mm day^{-1}	5.6	3.5	5.6
Water requirements of pepper crop (ET_c) mm day^{-1}	3.64	3.5	5.32
Total water requirements per growth stage	127.4	822.5	159.6

Statistical Analysis:

Data recorded during the study were subjected to analysis of variance techniques according to the design used by the CoSTAT statistics software program. The Revised LSD test at P<0.05 was used to compare differences among means of various treatment combinations as described by Gomez and Gomez (1983)..

Results and discussion

The results presented in Figures (1, 2 and 3) showed significant influences of water regime (depletion ratios; 30, 50 and 70 % of ASW), pruning systems (without pruning, left 2 and 3 branches plant^{-1}) and potassium silicate concentrations (0, 250, 500 and 1000 mg l^{-1}) on the dry mass accumulation of various plant organs of sweet pepper, through varied growth stages, i.e. after one, three and nine months after transplanting (MAT), in both seasons of 2016-2017 and 2017-2018.

Effect of Water Regime (depletion ratios)

Results in Figure 1 (B, C, E and F) illustrated that there were significant and gradual increases in dry mass accumulation of roots, branches, leaves, fruits, and whole plant through varied growth stages, i.e. at three and nine MAT, in both seasons, as a result of decreasing the water depletion ratio from 70 up to 30 % of ASW in the root zone. the, application of lower amount of irrigation water (30% depletion ratio) with repeat its addition achieved the highest significant mean values of roots, stems, leaves and whole plant dry mass at one, three and nine MAT, as well as fruits dry mass after three and nine MFT, in the two seasons of 2016-2017 and 2017-2018. Moreover, the results Figure 1 (A and D) showed that dry mass values of various plant organs of sweet pepper in the early growth stage (at one MAT) did not significantly differ with applying irrigation water at 50% and 70% of ASW. While, significant difference between 50% and 70% of ASW were detected of dry mass values of various plant organs of sweet pepper after three and nine MAT, in both seasons. Such results might be expected on base that increase the available soil water, with the application of the lower amount of irrigation water (30% depletion ratio) with repeat its addition, leads to growing sweet pepper plants with no exposure to any water stress. Accordingly, the increase in available soil water will led to an increase in available nutrients would allow for excessive rates of photosynthesis and the accumulation of stored food in the various plant organs of sweet pepper. The current results are in agreement to a great extent with those reported by Kirnak *et al*., (2001) who reported that plant growth is decreased when soil water availability is limited. Hedge (1987) found that bell pepper yields in India were similar when irrigated at 40% and 60% of available soil moisture, but yield was reduced when irrigation was applied at either 20% or 80% of available soil moisture. Moreover, Ezzo *et al.,* (2010) revealed that moderate (90 % ET_0) and medium (70 % ET_0) irrigation regimes were able to compete high irrigation levels (110 % of ET_0) regarding the dry weight of sweet pepper plants. Likewise, Smittle *et al.* (1994) found that yields and water use were greatest when irrigation was applied at 25 kPa than using 50, or 75 kPa (Pressure unit kilopascal) during growing pepper crop.

Concerning the dry mass accumulation in branches, under the lower rate of depletion ratio (30%), the results indicated that there were an increase in the dry weight of branches 15.60, 60.80 and 105.71 and 16.47, 56.52 and 101.65 g at one, three and nine MAT, in both seasons, respectively (Figure 1). Where, branches dry mass achieved 63.33 and 62.36 % after one month, 57.60 and 53.26 % after three months and 17.76 and 15.59 % after 9 MAT from that accumulated by the whole plant, in two seasons.

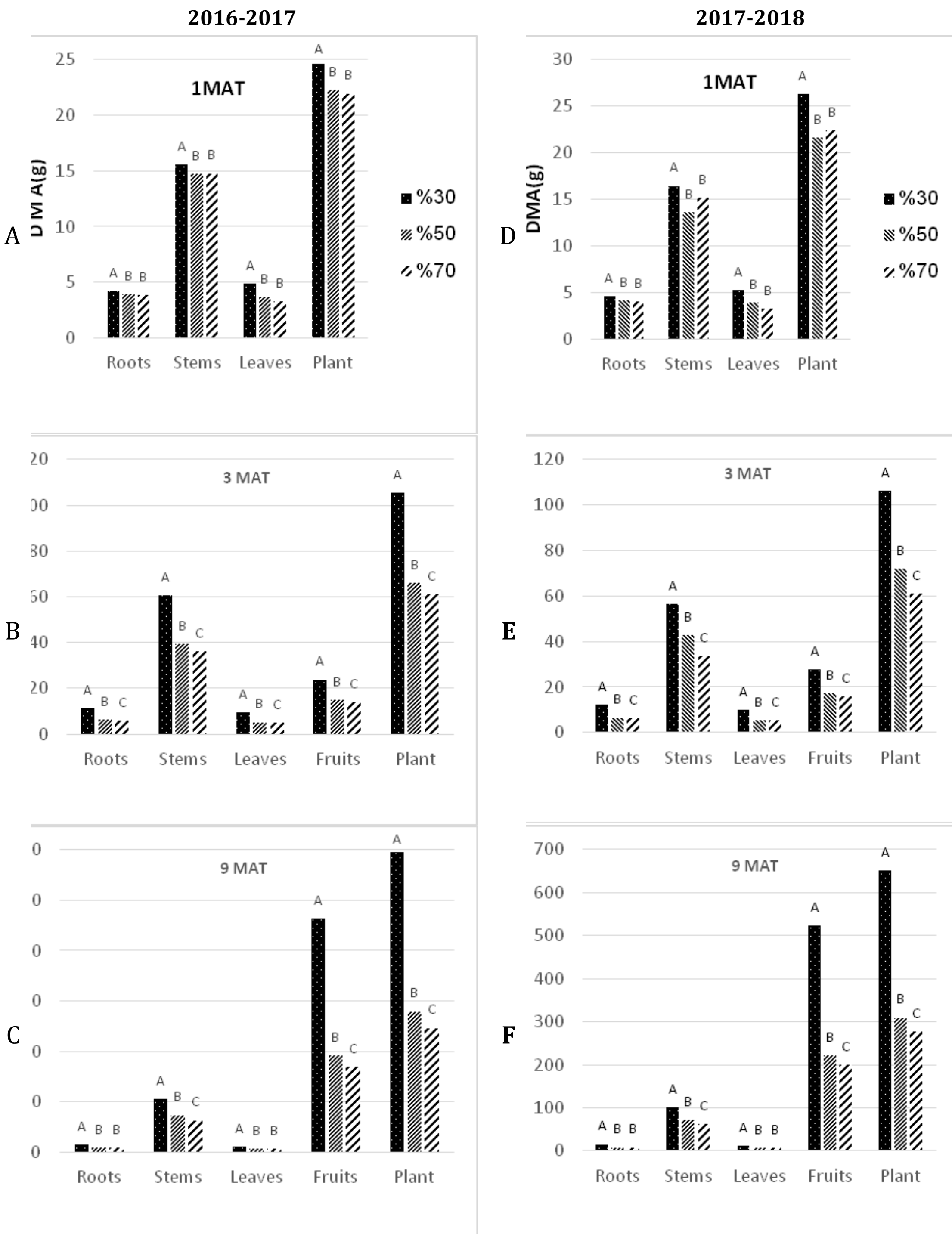

Fig. 1. Effects of water regime (depletion ratio %) on the dry mass accumulation (DMA) throughout the varied growth stages of sweet pepper plant, in both seasons of 2016-2017 and 2017-2018.

A, B, C = after 1, 3 and nine months after transplanting (MAT), in season of 2016-2017.

D, E, F = after 1, 3 and nine months after transplanting (MAT), in season of 2017-2018.

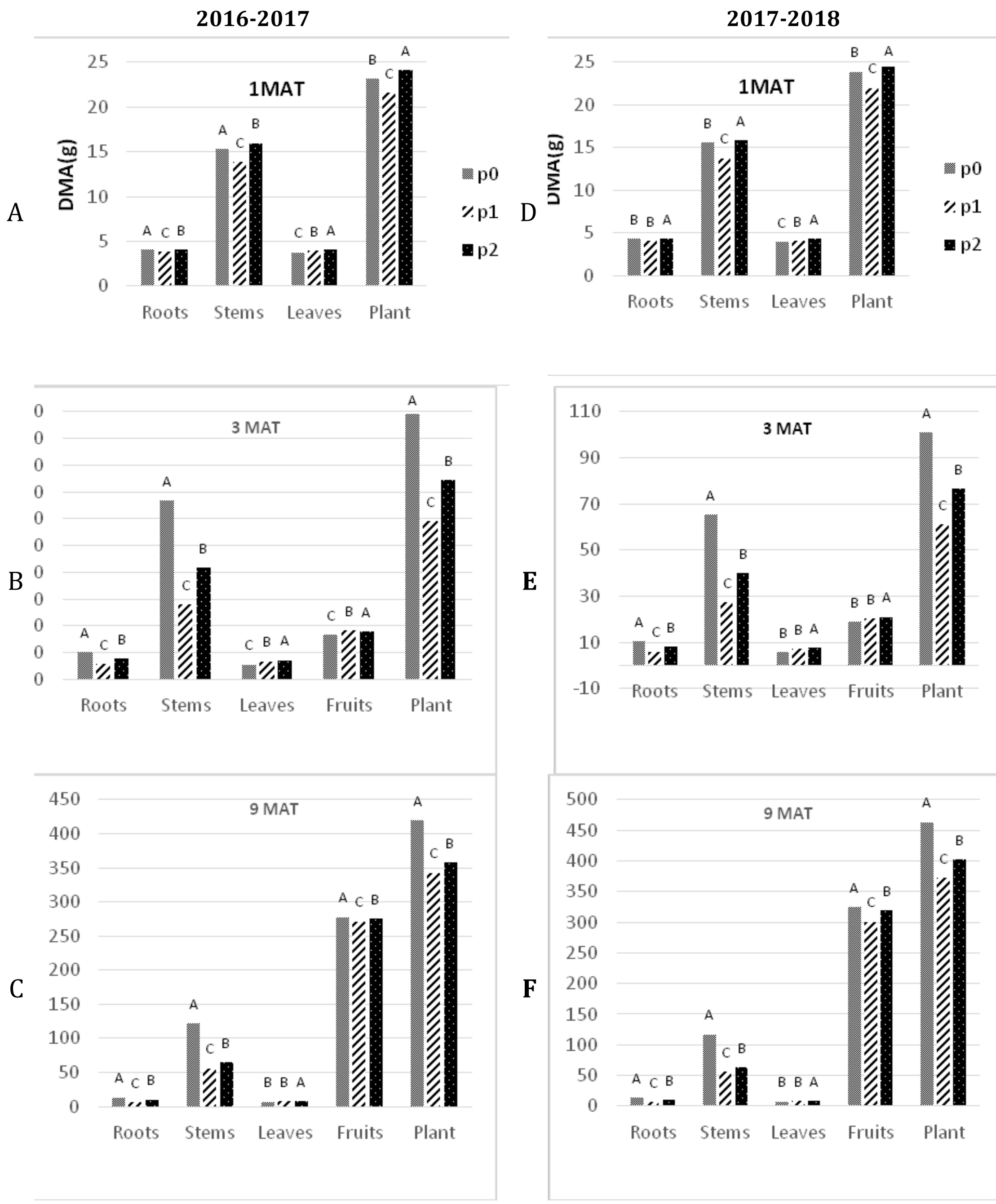

Fig. 2. Effects of pruning systems on the dry mass accumulation (DMA) throughout the varied growth stages of sweet pepper plant, in both seasons of 2016-2017 and 2017-2018.

A, B, C = after 1, 3 and nine months after transplanting (MAT), in season of 2016-2017.

D, E, F = after 1, 3 and nine months after transplanting (MAT), in season of 2017-2018.

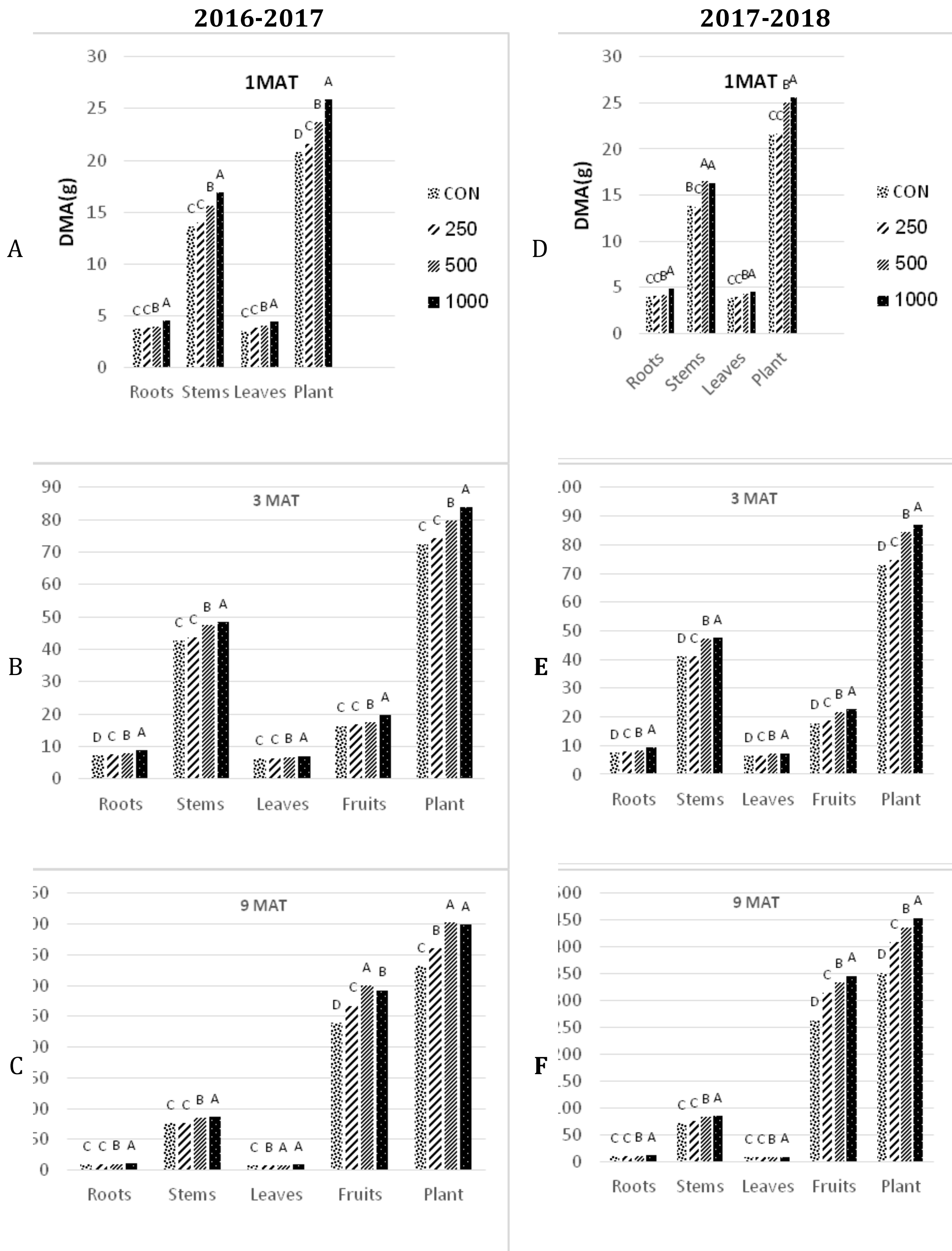

Fig. 3. Effects of potassium silicate (mg l^{-1}) on the dry mass accumulation (DMA) throughout the varied growth stages of sweet pepper plant, in both seasons of 2016-2017 and 2017-2018.

A, B, C = after 1, 3 and nine months after transplanting (MAT), in season of 2016-2017.
D, E, F = after 1, 3 and nine months after transplanting (MAT), in season of 2017-2018.

Regarding the fruits dry mass accumulation, the results in Figure (1) indicated that there were also, significant increase in the medium and late growth stages under the lowest depletion ratio (30%). Where, fruits dry mass was recorded 23.78 & 463.86 and 27.71 & 523.39 g after three and nine MAT, which obtained 22.53 & 26.08% after 3 MAT and 77.92 & 80.24 % after 9 MAT from the total dry mass accumulated by the whole plant under the same water depletion ratio in both seasons, respectively. These findings appeared to be in close agreement with results reported by Chatzoulakis and Drosos (1997) who indicated that application of 0.65 and 0.40 x ET_m (based on maximum evapotranspiration) which equivalent to 384 and 296 mm of water gave significant reduction in plant dry weight. However, results of Vamez *et al.,* (1992) reported that keeping the soil around field capacity (-0.03 MPa), the plant dry weight significantly higher than those in more dry treatments (keeping soil water potential at -0.1 or - 0.3 MPa).

Effect of Pruning Systems

Results in Figure 2 (A-F) indicated that there were a significant differences among pruning systems treatments on the dry mass accumulation of different sweet pepper plant organs at one, three and nine MAT, in both seasons. Spanish pruning system (un-pruned plants) for sweet pepper plants leads to accumulate more significant dry mass in the roots compared with Holland pruning system with 2 or 3 branches after one MAT, in the first season (Figure 2; D). Morovere, un-pruned sweet pepper plants achieved significant higher mean values of roots, stems and whole plant dry mass, at three and nine MAT, in both seasons (Figure 2; B,C,E and F), as well as fruits dry mass at nine MAT only , in both seasons(Figure 2; C and F). Generally, within the Holland pruning system, increasing the number of stems plant^{-1} from 2 to 3 branches, achieved the highest mean values of the roots, branches, leaves, fruits and whole plant dry mass at three and nine MAT, in the two growing seasons. Such a general positive response of dry mass accumulation of sweet pepper plants due to pruning system might be attributed to dry matter distribution is primarily regulated by the sink-strength of the various organs. Thakur *et al.,* (2018) stated that when the available assimilates equal or exceed the total sink strength of the plant, the growth rates of the vegetative parts and the individual fruit occur at the potential rates. However, when the amount of available assimilates is less than the total sink strength, the assimilates are distributed between roots, leaves, stem, and fruit according to their individual sink strengths relative to the total sink strength. Such results are in agreement with those obtained by Nielsen and Veierskov (1988) who mentioned that there is a balance development of the dry matter of roots and top, and a functional equilibrium seems to exist, but there seems to be an underlying control system of this balance. Jovicich, *et al.,* (1999) reported that number and dry weight of leaves and total plant dry weight were higher in four and two than in single-branche plants. Additionly, Maniutiu *et al.* (2010) reported that the shoot pruning is an important factor in proper utilization of production of sweet pepper. Furthermore, pruning of sweet pepper under greenhouse conditions facilitate light penetration throughout the leaf canopy for more efficient interception of light, which reflected on the increase the dry mass of the organs of sweet pepper plants (Jovicich, *et al.,* 1999). The previous findings indicated that the foliar structure of the plants pruned to three main branches was sufficiently large to allow for higher accumulation of dry matter when compared with to the two branches within the Holland pruning system.

Effect of Potassium Silicate

The different comparisons, Figure 3 (A-F), indicated that, in both seasons, dry mass of the roots, branches, leaves, fruits and whole plant of sweet pepper plants grown in calcareous soil under greenhouse conditions increased significantly and successively as the concentration of potassium silicate was increased up to 1000 mg l^{-1} after one, three and nine MAT. Application of potassium silicate at concentration of 1000 mg l^{-1} produced the highest dry weight accumulation for all studied plant organs, at all growth stages, in the two seasons. These significant increases might be attributed to the favorable effect of potassium silicate on the plant metabolism, and due to improve erecting of leaves, increase solar radiation interception and photosynthetic efficiency, which reflected on the increase dry mass of sweet pepper plant organs as mentioned by (Pereira *et al.*, 2003; Al-Aghabary *et al.*, 2004).

Interaction Effects Between Water regime (Depletion Ratios) and Pruning Systems

It is obvious from the data presented in Table (3) that the first order interaction between water depletion ratios and pruning systems had significant effects on dry weight accumulation of roots, branches, leaves, fruits and whole plant of sweet pepper plants after one, three and nine MAT, in both seasons. In general, the best treatment combination, which achieved the highest mean values of the dry mass accumulation of roots, was that involved un-pruned plants and irrigated with the lower amount of irrigation water (30% depletion ratio) with repeat its addition. Meanwhile, sweet pepper plants that un-pruned or pruned up to 3 branches plant^{-1} and irrigated with the lower amount of irrigation water (30% depletion ratio) achieved the highest values of dry mass of branches, leaves, fruits and whole plant at one, three and nine MAT compared with that pruned on two branches plant^{-1}. The increments in the dry mass of a pepper plants with combination between pruned pepper plants up to 3 branches and irrigated with the lowest amount of irrigation water (30% depletion ratio), might be due to that pruning system contributes to facilitate the light penetration of the leaves. In addition to, the increase in available soil water will be led to an increase in available nutrients for excessive rates of photosynthesis.

Interaction Effects Between Water regime (Depletion Ratios) and potassium silicate concentrations

The statistical comparisons listed in Table (4) illustrated the presence of some interaction effects, between water regime and potassium silicate concentrations, on the dry mass accumulation in varied organs of sweet pepper plants, at one, three and nine MAT, in both growing seasons. The results showed that the highest dry mass accumulation of varied plant organs and whole plant were obtained with application of the lowest amount of water (30 % depletion ratio) and sprayed the plants with 1000 mg l^{-1} of potassium silicate, in both seasons, after one, three and nine MAT. The obtained results may be attributed to the lower evapotranspiration caused as a result of spray sweet pepper plants with the highest concentration (1000 mg l^{-1}) of potassium silicate which increased the thickness of the leaves and protected plants from water loss.

Interaction Effects Between Pruning systems and potassium silicate concentrations

The comparisons among the means of the various treatment combinations, presented in Table (5), illustrated the presence of the interaction effects between the pruning systems and potassium silicate concentrations on the dry mas of varied organs of pepper plant through various growth stages, in both seasons.

The results showed that the highest values of the dry mass of branches, leaves and whole plant of sweet pepper plants after one MAT, were produced from treatment combinations involving pruned plants up to 3 branches and sprayed the plants with 1000 mg l^{-1} of potassium silicate, in both seasons. However, the highest values of the dry mass of roots at the same growth stage, was obtained from treatment combinations including pruned plants up to 2 branches and sprayed the plants with 1000 mg l^{-1}, in both seasons.

In The other growth stages; after three and nine months from transplanting, the results indicated that the highest values of the dry mass of roots, branches and whole plant of sweet pepper plants were achieved from treatment combinations containing un-pruned plants and sprayed the plants with 1000 mg l^{-1} of potassium silicate, in both seasons. Moreover, the highest values of dry mass of leaves and fruits obtained from treatment combinations including pruned plants up to 3 branches and sprayed the plants with 1000 mg l^{-1}. These significant increases might be due to the positive synergistic effect between the pruning systems and potassium silicate concentrations on the plant metabolism, improving erecting of leaves, increasing solar radiation interception and photosynthetic efficiency, which reflected on the increase dry mass of sweet pepper plant organs through various growth stages.

It is concluded that application of the lowest amount of water (30 % depletion ratio) with pruned pepper plants up to 3 branches plant^{-1} as well as spray the plants with 1000 mg l^{-1} of potassium silicate has led to increase the dry mass of the varied organs of sweet pepper plants through various growth stages. Therefore, the combination of water regime, pruning system and foliar application of potassium silicate have the potential to be used to increase the dry mass productivity of sweet pepper grown in calcareous soil under greenhouse, as a low input, safe, environmentally friendly agricultural practices and to save the irrigation water.

Table 3: First order interaction effect between water regime (Depletion ratio) and pruning systems on the dry weight of root, branches, leaves and whole plant and their of sweet pepper, grown in calcareous soil, under greenhouse conditions, after one, three, nine month from transplanting.

Depletion Ratio	Pruning	Dry weight (g)					Dry weight (g)				
		Roots	Branches	Leaves	Fruits	Whole Plant	Roots	Branches	Leaves	Fruits	Whole Plant
		2016-2017					2017-2018				
						One MAT					
30%	P_0[z]	4.27a	15.77 b	4.72b		24.76b	4.64 a	16.84 a	4.99c		26.47a
	P_1	4.20a	13.17e	4.73b		22.10e	4.61 b	14.02 c	5.25b		23.88bc
	P_2	4.11b	17.87 a	5.08a		27.06a	4.48 c	16.79 a	5.60a		26.87a
50%	P_0	3.97d	14.91 c	3.59de		22.47d	4.23 e	13.85 c	3.85f		21.93e
	P_1	3.72e	14.15 d	3.78c		21.65f	3.96 g	11.48 d	3.99d		19.43f
	P_2	4.04bc	15.15 c	3.69cd		22.88c	4.28 d	15.47 b	3.91e		23.66c
70%	P_0	4.00cd	15.16 c	3.08g		22.24de	4.19 f	16.05 b	3.12h		23.36bc
	P_1	3.54 f	14.24 d	3.32f		21.10g	3.73 h	15.80 b	3.16h		22.69d
	P_2	4.01c	14.97 c	3.55e		22.53d	4.20 f	15.45 b	3.44g		23.09b
						Three MAT					
30%	P_0	15.02a[y]	94.05 a	8.57 c	23.42b	141.06 a	15.89 a	86.72 a	8.96 c	27.30b	138.87a
	P_1	7.33 e	32.14 g	8.90 b	22.46 c	70.83e	7.85 d	34.35 e	9.13 b	26.84 c	78.17 d
	P_2	12.08 b	56.22 c	11.05a	25.46a	104.81b	12.79 b	48.50 c	11.47a	29.00 a	101.76b
50%	P_0	7.97 c	57.49 b	4.22 g	14.51 f	84.19 c	8.19 c	61.60 b	4.47 h	15.22h	89.48 c
	P_1	5.12 h	25.37 i	6.14 d	16.33 d	52.96 h	5.30 g	27.60 g	6.46d	17.99 e	57.35 h
	P_2	5.78 f	35.62 e	5.30 f	14.13 g	60.83 f	5.98 e	38.96 d	5.53g	18.68d	69.15 f
70%	P_0	7.50 d	48.95 d	4.20 g	12.03 h	72.68 d	7.87 d	47.73 c	4.47 h	14.89 i	74.96e
	P_1	4.93 i	26.83 h	5.55 e	15.94 e	53.25 h	5.15 g	20.50 h	5.89 e	16.70 f	48.24 i
	P_2	5.24 g	33.15 f	5.44 e	13.89 g	57.72 g	5.49 f	32.74 f	5.72 f	15.60g	59.55 g
						Nine MAT					
30%	P_0	19.74a[y]	169.00 a	10.33b	516.62 b	715.69a	20.91 a	159.31a	10.96b	520.89 b	712.07a
	P_1	8.71 e	65.85 e	10.21c	503.51 c	588.28c	9.23 e	70.30 e	10.84c	516.36 c	606.73c
	P_2	15.69 b	82.28 d	12.49a	521.81 a	632.27b	16.51 b	75.34 d	13.17a	532.91 a	637.93b
50%	P_0	9.85 d	91.00 c	5.81 h	231.81 d	338.47f	10.20 d	92.29 c	6.19 h	228.35 e	337.03g
	P_1	6.02 g	46.82 i	6.92 e	174.46 i	234.22h	6..39 g	41.34 i	7.41 e	171.85 i	226.99h
	P_2	7.28 f	51.35 h	6.78 f	199.29 h	264.70g	7.63 f	52.75 h	7.17 f	198.23 h	265.78g
70%	P_0	10.76 c	104.67b	5.29 i	228.82 e	349.54e	11.19 c	100.72b	5.52 i	229.11 d	346.54e
	P_1	5.85 g	55.50 g	7.27d	210.05 g	278.67d	6.08 h	55.41 g	7.55 d	210.50 g	279.54d
	P_2	7.40 f	59.64 f	6.26g	225.62 f	298.92f	7.59 f	62.54 f	6.44 g	226.45 f	303.02f

[Y.] Values marked with the same letter (s) are statistically similar using Revised LSD test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lower case letter(s) indicate differences within interaction of each character.

[Z] Pruning treatments: $\mathbf{P_0}$= without pruning (Spanish system) and $\mathbf{P_1}$= two stems and $\mathbf{P_2}$= three stems plant^{-1} (Holland system).

Table 4: First order interaction effects between water regime (Depletion ratio) and potassium silicate on the dry weight of root, branches, leaves and whole plant and their of sweet pepper, grown in calcareous soil, under greenhouse conditions, after one, three, nine month from transplanting.

Depletion Ratio	Potassium silicate mg l^{-1}	Dry weight (g)					Dry weight (g)				
		Roots	Branches	Leaves	Fruits	Whole Plant	Roots	Branches	Leaves	Fruits	Whole Plant
		2016-2017					2017-2018				
						One MAT					
30%	0	3.88d	14.24g	4.09 d		22.21 f	4.26 f	12.81 g	4.62 d		21.69 g
	250	3.93d	14.88f	4.39 c		23.20 e	4.32 e	13.51 f	4.71 c		22.54e
	500	4.32b	15.94d	5.27 b		25.53 b	4.69 c	17.16 c	5.70 b		27.55b
	1000	4.64a	17.36 a	5.62 a		27.62a	5.04 a	18.15 a	6.10 a		29.29a
50%	0	3.56 f	13.40 h	3.00 j		19.96 j	3.74 i	15.32 d	2.99 k		22.05fg
	250	3.71e	13.46h	3.41 h		20.58 h	3.92 g	14.79e	3.31 j		22.02fg
	500	3.55 f	15.45e	3.24 i		22.24f	3.72 i	17.64 b	3.28 j		20.92 d
	1000	4.60a	16.85 b	3.62 g		25.07c	4.79 b	17.21 c	3.38 i		25.38 c
70%	0	3.61 f	13.19 i	3.37 h		20.17 i	3.88 h	13.48 f	3.76 h		21.12h
	250	3.69e	13.59h	3.72 f		21.00 g	3.90 g	12.83 g	3.81 g		20.54 i
	500	4.01 c	15.59e	3.68 fg		23.28 e	4.27 f	14.64e	4.00 f		22.91 e
	1000	4.35b	16.57 c	3.96 e		24.88 d	4.58 d	13.45 f	4.09 e		22.12 f
						Three MAT					
30%	0	10.50 d[y]	55.81d	8.57 d	21.12 c	96.00 d	11.31 d	48.91 d	8.94 d	24.01 d	93.17 d
	250	11.16 c	57.35 c	8.94 c	21.38 c	98.83 c	11.86 c	49.76 c	9.09 c	24.95 c	95.66 c
	500	11.77 b	64.57 b	10.18b	25.76 b	112.28b	12.38 b	62.24 b	10.61b	30.46 b	115.69 b
	1000	12.46 a	65.49 a	10.35a	26.86 a	115.16a	13.16 a	65.18 a	10.77a	31.42 a	120.53 a
50%	0	5.78 i	37.16 h	5.17 g	14.70 e	62.81 h	5.94 i	40.40 g	5.48 g	15.65 h	67.47h
	250	5.87 h	37.03 h	5.14 g	14.51 e	62.55 h	6.09 h	40.11 g	5.41 h	16.61 g	68.22g
	500	5.76 i	42.26 e	5.23 fg	12.94 g	66.19 f	5.94 i	45.54 d	5.47 g	17.79 f	74.74f
	1000	7.75 e	41.51 f	5.34 ef	17.80 d	72.40 e	7.98 e	44.83 f	5.59 f	19.14 e	77.54 e
70%	0	5.38 k	34.90k	4.74 i	13.20 g	58.22 k	5.68 j	34.06 h	5.01 j	13.89 j	58.64 k
	250	5.65 j	36.49 i	5.18 g	14.51 e	61.83 i	5.90 i	33.68 i	5.51 g	14.80 i	59.89 j
	500	6.10 g	35.69 j	4.88 h	13.71 f	60.38 j	6.41 g	34.30 h	5.16 i	16.65 g	62.52 i
	1000	6.43 f	38.18 g	5.45 e	14.39 e	64.45 g	6.69 f	32.60 j	5.75 e	17.57 f	62.61 i
						Nine MAT					
30%	0	13.84d[y]	96.16 c	10.19 c	413.32d	533.51d	14.61 d	91.07 c	10.86d	419.76d	536.30d
	250	14.27 c	100.66 b	10.23 c	467.87c	593.03c	15.19 c	93.90 b	10.93c	483.62c	603.64c
	500	14.69 b	112.94 a	11.53 b	560.22b	699.38b	15.50 b	110.59 a	12.13b	566.65b	704.87b
	1000	16.06 a	113.08a	12.08 a	614.51a	755.73a	16.88 a	111.04 a	12.71a	623.51a	764.14a
50%	0	6.64 i	61.47 j	5.93 h	175.88j	249.92k	6.86 j	61.22 i	6.35 j	173.17l	247.60l
	250	7.13 h	58.03 k	6.17 g	229.90f	301.23g	7.47 i	60.87 i	6.53 h	227.35g	302.22h
	500	8.08 f	65.90 i	6.68 e	224.50g	305.16h	8.51 f	62.55 h	7.10 f	221.63h	299.79i
	1000	9.03 e	66.83 h	7.23 d	177.13j	260.22j	9.45 e	63.86 g	7.73 e	175.76k	256.80k
70%	0	7.47 g	70.50 f	6.16 g	196.09i	280.22i	7.67 h	61.20 i	6.38 ij	197.38j	272.63j
	250	7.49 g	69.37 g	6.15 g	236.83e	319.84f	7.73 h	72.01 f	6.41 i	233.85f	320.00g
	500	8.03 f	74.04 e	6.18 g	215.43h	303.68g	8.30 g	76.06 e	6.33 j	216.02i	306.71f
	1000	9.02 e	79.17 d	6.59 f	237.65e	332.43e	9.45 e	82.28 d	6.90 g	240.82e	339.45e

Y. Values marked with the same letter (s) are statistically similar using Revised LSD test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lower case letter(s) indicate differences within interaction of each character.

Table 5:First order interaction effect between pruning systems and potassium silicate on the dry weight of root, branches, leaves and whole plant and their of sweet pepper, grown in calcareous soil, under greenhouse conditions, after one, three, nine months from transplanting.

Pruning	Potassium silicate mg l^{-1}	Dry weight (g)					Dry weight (g)				
		Roots	Branches	Leaves	Fruits	Whole Plant	Roots	Branches	Leaves	Fruits	Whole Plant
		2016-2017					2017-2018				
One MAT											
P_0^{z}	0	3.82f	13.63 f	3.50 g		20.95 i	4.09 g	14.10 g	3.71 h		21.90ef
	250	3.88e	13.92 e	3.67 f		21.47h	4.15 f	14.57 e	3.82 g		22.54 d
	500	4.21d	16.37 b	3.94e		24.52e	4.47 e	17.02 c	4.17 e		25.66 b
	1000	4.42 c	17.20 a	4.07 d		25.69 b	4.71 c	16.62 d	4.25 d		25.58 b
P_1	0	3.63g	12.43 g	3.50 g		19.56 k	3.90 h	13.34 hi	3.84 fg		21.08 g
	250	3.63g	12.58 g	3.73 f		19.94 j	3.90 hi	13.03 i	3.86 f		20.79 g
	500	3.41h	14.06 e	4.08 d		21.55h	3.70 j	14.21efg	4.28 c		22.19de
	1000	4.62a	16.34 b	4.47 b		25.43 c	4.90 a	14.49 ef	4.56 b		23.95 c
P_2	0	3.61g	14.76 d	3.46 g		21.83 g	3.88 i	14.17 fg	3.82 g		21.87ef
	250	3.82 f	15.43 c	4.12cd		23.37f	4.09 g	13.53 h	4.15 e		21.77 f
	500	4.26d	16.55 b	4.18 c		24.99 d	4.51 d	18.22 a	4.54 b		27.27 a
	1000	4.5 b	17.24 a	4.66 a		26.45a	4.79 b	17.68 b	4.77 a		27.24a
Three MAT											
P_0	0	9.56 c^y	64.03 d	5.36 i	16.09 f	95.04d	10.06 c	62.39 b	5.68 k	16.97 k	95.10 c
	250	9.60 c	65.46 c	5.49 h	16.07 f	96.62 c	10.06 c	61.94 c	5.79 j	17.56 j	95.35 c
	500	10.34 b	68.36 b	5.74 g	16.79 e	101.23b	10.78 b	68.62 a	6.06 i	20.55 f	106.01b
	1000	11.16 a	69.47 a	6.07 f	17.66 d	104.36a	11.71 a	68.44 a	6.34 h	21.46 e	107.95a
P_1	0	5.03 j	25.49 k	6.62 e	16.20 f	53.34l	5.45 j	25.28k	6.94 f	18.22 i	55.89k
	250	5.60 i	26.91 j	6.79 d	18.10 c	57.40 k	5.90 i	26.29 j	6.95 f	19.19 h	58.33j
	500	5.61 i	29.84 i	6.81 d	17.17 e	59.43 j	5.86 i	29.42 h	7.15 e	21.69 d	64.12 i
	1000	6.94h	30.22 h	7.24 b	21.50 a	65.90 i	7.19 h	28.94 i	7.60 c	22.94 b	66.67 h
P_2	0	7.06 g	38.34 g	6.50 e	16.74 e	68.64 h	7.42 g	35.70 f	6.81 g	18.37 i	68.30 g
	250	7.50 f	38.50 g	6.99 c	16.23 f	69.22 g	7.90 f	35.31 g	7.27 d	19.62 g	70.10 f
	500	7.68 e	44.32 f	7.74 a	18.44 c	78.18 f	8.09 e	44.04 e	8.03 b	22.66 c	82.82 e
	1000	8.55 d	45.49 e	7.83a	19.89 b	81.76 e	8.93 d	45.22 d	8.17 a	23.73 a	86.05d
Nine MAT											
P_0	0	12.63c^y	114.20b	6.77 j	288.60 h	422.20h	13.11 d	102.20d	7.20 j	289.47i	411.98j
	250	12.65 c	113.67b	6.67 k	296.80 g	429.79g	13.30 c	112.97c	7.06 k	299.77h	433.10h
	500	13.51b	129.00a	7.45 i	356.03 a	505.99a	14.20 b	125.58b	7.89 i	359.22a	506.89a
	1000	14.99a	129.36a	7.68 g	344.10 b	496.13b	15.79 a	129.00a	8.09 h	349.97b	502.85b
P_1	0	6.16 k	53.06 i	7.91 e	239.39 j	306.52j	6.51 l	53.70 j	8.44 e	241.19k	309.84l
	250	6.44 j	54.19 h	7.77 f	306.91 f	375.31g	6.82 k	55.78 i	8.24 g	308.59g	379.43i
	500	6.71 i	57.05 g	7.92 e	326.46d	398.14d	7.05 j	56.01 i	8.30 f	324.58e	395.94d
	1000	8.15 h	59.92 f	8.92 c	328.74cd	405.73e	8.55 i	57.24 h	9.43 b	329.96d	405.18f
P_2	0	9.16 g	60.87 e	7.59 h	257.31 i	334.93i	9.53 h	57.59gh	7.95 i	259.65j	334.72k
	250	9.80 f	60.20 f	8.12 d	330.89 c	409.01e	10.27 g	58.03 g	8.57 d	336.47c	413.34e
	500	10.57e	66.83 d	9.02 b	317.65 e	404.07f	11.07 f	67.61 f	9.36 c	320.51f	408.55g
	1000	10.96d	69.80 c	9.30 a	356.45 a	446.51b	11.43 e	70.94 e	9.82 a	360.16a	452.35c

Y. Values marked with the same letter (s) are statistically similar using Revised LSD test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lowercase letter(s) indicate differences within interaction of each character.

Z Pruning treatments: **P_0**= without pruning (Spanish system) and **P_1**= two stems on each plant and **P_2**= three stems on each plant

References

AL-Aghabary, K.; Z. Zhu.; and Q. H. Shi. **2004**. Influence of silicon supply on chlorophyll content, chlorophyll fluorescence, and antioxidative enzyme activities in tomato plants under salt stress. Journal of plant nutrition 27: 2101-2115.

Allen, R.G; L. S, Pereira. D, Raes. and M, Smith. **1998**. Crop Evapotranspiration -Guidelines for Computing Crop Water Requirements, pp: 104−114. FAO Irrigation and drainage paper No. 56. FAO Rome, Italy.

Alsadon, A.; M.Wahb-Allah; H. Abdel-Razzak, and A.Ibrahim. **2013**. Effects of pruning systems on growth, fruit yield and quality traits of three greenhouse-grown bell pepper (*Capsicum annuum L.) cultivars*. AJCS 7(9):1309-1316.

Awalin, S., M. Shahjahan, A. Chandra Roy, A. Akter and M. Humayun Kabir.**2017**.Response of Bell Pepper (Capsicum annuum) to Foliar

Feeding with Micronutrients and Shoot Pruning. J. Agric. Eco. Res. Int.11(3): 1-8

Cebula, S. **1995**. Optimization of plant and shoot spacing in greenhouse production of sweet pepper. Acta Horticulturae 412: 321- 328.

Chatzoulakis, K. and N. Drosos. **1997**. Water requirements of greenhouse grown pepper under drip irrigation. Acta Hort. 449: 175 – 180.

Dasgan, H. Y. And K. Abak.**2003**. Effects of Plant Density and Number of Shoots on Yield and Fruit Characteristics of Peppers Grown in Glasshouses. Turk J Agric . 27: 29-35.

Efimova, G. V. and S. A. Dokynchan **1986**. Anatomo-morphological construction of epidermal tissue of rice leaves and increasing of its protection function under silicon effect. Agric. Biol., 3:57-61.

El-Sayed, .S. F.; H. A. Hassan and S. O. Mahmoud .**2015**.Effect of Some Soilless CultureTechniques on Sweet Pepper Growth, Production,Leaves Chemical Contents and Water Consumption under Greenhouse Conditions.Middle East Agric. Res. (4): 682-691

Ezzo, M.I., A.A. Glala, H.A.M. Habib and A.A. Helaly. **2010**. Response of sweet pepper grown in sandy and clay soil lysimeters to water regimes. American-Eurasian J. Agric. & Environ. Sci., 8 (1): 18-26, 2010.

FAO .(**2015**). land and water devision report crops water information : pepper .

Fernand, F.; N. Marcussi.; R, Lyra; V. Bôas.; L.J. G.de .Godoy and R. Goto.**2004**. Macronutrient accumulation and portioning in fertigated sweet pepper plants. Sci. Agric. (Piracicaba,Braz.). 61(1):62-68.

Gomez, C. A. and A. A. Gomez. **1983**. Statistical Procedures for Agricultural Research (2_{nd}) edition .An International Rice Research Institute Book.A wiley-Interscience.

Hanafy Ahmed ; A .H.,Harb ; E.E. Higazy M.A.,and H MorganSh. **2008**: Effect of silicon and boron foliar application on wheat plants grown under saline soil conditions. Int. J. Agri. Res. 3 (1): 1-26.

Hattori, T.; S. Inanaga.; H. Araki.; A.N P. S. Morita.; M. Luxova and A. Lux.**2005**. Application of silicon enhanced drought tolerance in *Sorghum bicolor*. Plant Physi123: 459-466.

Hedge, D.M., **1987**. Growth analysis of bell pepper (Capsicum annuum L.) in relation to soil moisture and nitrogen fertilization. Scient. Hort., 33: 179- 1 87.

Hipps, N.A. , M.J. Davies, J.M. Dunn, H. Griffiths, and C.J. Atkinson. **2014**.Effects of two contrasting canopy manipulations on growth and water use of London plane (Platanus x acerifolia) trees. Plant Soil, 382 , pp. 61-74.

Jovicich, E., D. J Cantliffe,. and G. J Hochmuth,. **1999**. Plant density and shoot pruning on yield and quality of a summer greenhouse sweet pepper crop in North central Florida. p. 184-190. In K.D. Batal (ed.) 28th National Agricultural Plastics Congress. Proc. Amer. Soc. Plasticulture, Tallahassee, FL, May 19- 22. ASP, State College, PA.

Katerji; M., M Mastrorilli, A Hamdy, **1993**. Effects of water stress at different growth stages on pepper yield. Acta Hort. 335, 165–171.

Kirnak H; C Kaya, Ismail TAS and D. Higgs.**2001**.The influence of water deficit on vegetative growth, physiology, fruit yield and quality in eggplants. Bulg. J. Plant Physiol., 27(3–4), 34–46.

Maboko ,.M. M.; C. P. Du Plooy and S. Chiloane.**2012**. Effect of plant population stem and flower pruning on hydroponically grown sweet pepper in a shade net structure. African Agric. Res. 7(11): 742-1748.

Maniutiu, D., R Sima., A. S Apahide., M Apahidean. and D Ficior. **2010**. The influence of plant density and shoot pruning on yield of bell pepper cultivated in plastic tunnel. Bull. UASVM Hort 67(1): 259-263

Nielsen, T.H. and B. Veierskov, **1988**. Distribution of dry matter in sweet pepper plants (*Capsicum annuum* L.) during the juvenile and generative growth phases. Sci. Hortic., 35: 179-187.

Page, A. L., R. H. Miller, and D. R. Keeney. **1982**. Methods of soil analysis, chemical and microbiological properties, part2, 2nd ed. ASA-SSSA, Madison, Wisc., USA.

Pereira, HS; G.C Vitti.and GH. Korndörfer.**2003**. Comportamento de diferentesfontes de silício no solo e nacultura do tomateiro. *RevistaBrasileira de Ciência de Solo* 27: 101-108.

Qassim, A. and B. Ashcroft, **2002**. Estimating Vegetable Crop Water use with Moisture-Accounting Method # AG1192, DPI Victoria. Available at: http://www.dpi.vic.gov.au/agriculture/horticulture/vegetables/vegetable-growing-and-management/estimating-vegetable-crop-water-use. (Accessed: October **2002**).

Razmi, Z. and A. A Ghaemi,. **2011**. Crop and soil water stress coefficients of tomato in the glass greenhouse conditions. J. Sci. Technol. Greenhouse Culture.2: 87.

Resh, H.M., **1996**. Hydroponic food production, 5th edn, Woodridge Press Publ. Co., Santa Barbara, Califonia.

Ryan, J.G., G. Estefan, A. Rashid .**2007**. Soil--Plant-Analysis Soil and Plant Analysis Laboratory Manual.Publisher: International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria.

Smittle, D. A.; W. L. Dickens and J. R. Stansel.**1994**. Irrigation Regimes Affect Yield and Water Use by Bell Pepper. J. AMER. SOC. HORT. SCI. 119(5):936–939.

Thakur, O.; V. Kumar and J. Singh .**2018**. A Review on Advances in Pruning to Vegetable Crops. Int.J.Curr.Microbiol.App.Sci 7(2): 3556-3565.

Vamez, C. E; A Alvino, V Magliulo, and Steduto, P., **1992**. Pepper response to mild conditions of combined soil water and salinity stress. Adv. Hort. Sci., 6:3-10.

Zende UM. Investigation on production techniques in capsicum under protected cultivation. M. Sc. degree. College of Agriculture, Dharwad, University of Agricultura Sciences Dharwad; **2008**.

Zhu Z.J.; G.Q. Wei.; J .Li. Q. Q .Qian; and J. Q. Yu. **2004**. Silicon alleviates salt stress and increases antioxidant enzymes activity in leaves of salt-stressed cucumber (*Cucumis sativus* L.). Plant Sci.167: 527-533.

الملخص العربي

تأثير الأجهاد المائي ونظام التقليم وسيليكات البوتاسيوم علي إنتاج الكتلة الجافة لنباتات الفلفل النامية في أرض جيرية تحت الصوب

حماده محمد قطب– حجازى حسن حجازى– إبراهيم محمد غنيم– مصطفى نبوي فليفيل
قسم الخضر– كلية الزراعة– جامعة الأسكندرية

أجريت تجربتان تحت الصوب البلاستيكية، بمزرعة المنطقة الشمالية العسكرية، بمنطقة العامرية بالإسكندرية، خلال موسمي ٢٠١٦– ٢٠١٧ ، ٢٠١٧ – ٢٠١٨، كمحاولة لترشيد مياه الري من خلال دراسة تأثير ثلاثة أنظمة للإجهاد المائي، وثلاثة نظم تقليم، وأربعة تركيزات من سيليكات البوتاسيوم على تراكم المادة الجافة في نباتات الفلفل، وقد أظهرت النتائج أن استخدام أقل كمية من مياه الري(نسبة استنفاد ٣٠٪) مع تكرارها، كانت قد حققت أعلى قيم معنوية من المادة الجافة في الجذور، والسيقان، والأوراق، والكتلة الجافة للنبات وذلك عند تقديرها بعد شهر، وثلاثة، وتسعة أشهر بعد الشتل، وكذلك المادة الجافة للثمار عند تقديرها بعد ثلاثة، وتسعة أشهر بعد الشتل ،وذلك في كلا الموسمين. علاوة على ذلك فقد أشارت النتائج إلى أن نباتات الفلفل التي لم تقلم كانت قد حققت أعلى القيم من المادة الجافة للجذور، والسيقان، والكتلة الجافة للنبات، وذلك عند تقديرها بعد شهر، وثلاثة، وتسعة أشهر بعد الشتل، في كلا الموسمين، وكذلك المادة الجافة للثمار، وذلك عند تقديرها بعد تسعة أشهر بعد الشتل فقط، في كلا الموسمين. بالإضافة إلى ذلك فإن الرش الورقي بسيليكات البوتاسيوم حتى ٥٠٠ أو ١٠٠٠ مليجرام للتر قد أدى الى تراكم أعلى وزن جاف للجذور، والفروع، والأوراق، والثمار، والنبات الكامل وذلك عند تقديرها بعد شهر، وثلاثة، وتسعة أشهر بعد الشتل.

أوضحت نتائج التأثير المتداخل بين معاملات الاجهاد المائي ونظم التقليم، أن نباتات الفلفل غير المقلمة، أو التي قلمت مع ترك ٣ أفرع على النبات، والتي رويت بأقل كمية من مياه الري (نسبة استنفاد ٣٠٪)، كانت قد حققت أعلى قيم للكتلة الجافة للأفرع، والأوراق، والثمار، والنبات وذلك عند تقديرها بعد شهر، وثلاثة، وتسعة أشهر بعد الشتل. أيضا أظهرت النتائج أن المعاملة التداخلية التي اشتملت على أضافة أقل كمية من مياه الري (نسبة استنفاد المياه ٣٠٪) مع الرش ب ١٠٠٠ مليجرام للتر من سيليكات البوتاسيوم كانت قد سجلت أعلى القيم للمادة الجافة في الجذور، والفروع، والأوراق، والثمار ولنبات الفلفل بأكمله، في كلا الموسمين، وذلك عند تقديرها بعد شهر، وثلاثة، وتسعة أشهر بعد الشتل. وكذلك تم الحصول على أعلى القيم من المادة الجافة للجذور، والفروع، والأوراق، والثمار، ونبات الفلفل بأكمله من المعاملة التوافقية التي شملت عدم تقليم النباتات مع رش النباتات ب ١٠٠٠ مليجرام للتر من البوتاسيوم سيليكات، في كلا الموسمين.