J. Agr. Sci. Tech. (2011) Vol. 13: 289-299

Soil Chemical Properties and Yield of Tomato as Influenced by Different Levels of Irrigation Water and Fertilizer

F. Al-Mohammadi[1]*, and Y. Al-Zu'bi[1]

ABSTRACT

This research was conducted under greenhouse conditions to evaluate the optimum combination of irrigation and fertilizer levels to attain the best yield and quality of tomato crop. The experiment was conducted by using a split-plot design with three replicates. Irrigation levels were applied to the main plots and fertilizer levels to the sub-plots. For each experimental unit, the irrigation levels were W1=8mm/day, W2=7mm/day, W3=6mm/day , and W4=5mm/day. Fertilizers treatments varied during the growing season. For the period after transplanting till flowering, the treatments consisted of weekly applications of F1= (N1, P1, K1, respectively, 9.8, 6.13, 7.35 g /plot), F2= (N2, P1, K1, respectively,14.7, 6.13 , 7.35g/plot), F3= (N2, P2, K1, respectively,14.7, 9.19, 7.35 g/plot), and F4=(N2, P2, K2, respectively, 14.7, 9.19, 11.0 g/plot). Fertilizer levels were increased as the plants developed during the growing season. Plant height and the number of flowers per tomato plant were measured during the growing season and at harvesting time. Random samples of tomato leaves and fruits were taken from each experimental plot to determine the percentage of dry matter, total nitrogen, phosphorus, and potassium contents of fruits and leaves. Total yield during harvesting period and average fruit weight were also measured. Results indicated that irrigation and fertilizer levels had significant effects on the number of flowers per plant and W1F2 combination was significantly the most effective treatment compared to the other treatments. Plant height was not affected significantly by any treatment. The total yield significantly increased in W3F1 treatment. Average fruit weight was significantly higher in W2F3 as compared to the other treatments .The percentage of dry matter was significantly affected by the treatment W3F3 in both leaves and fruits. Total leaf contests of nitrogen, phosphorus, and potassium significantly increased in W2F4 treatment. Total nitrogen content in tomato fruits did not show any significant difference among different treatments, whereas fruit phosphorus and potassium contents significantly increased in W2F3 and W4F4 treatments.

Keywords: Fertilization, Greenhouse, Irrigation levels, Tomato.

INTRODUCTION

The Hashemite Kingdom of Jordan is known to be one of the most water scarce countries in the world, where water shortages have become a permanent feature and meeting water demands is a challenge. Jordan is suffering from a serious water crisis: present water use already exceeds the renewable freshwater resources by more than 20% (Doaa, 2006). Jordan's renewable natural water resources are estimated to be in the magnitude of 780×10^6 m³ year^{-1}(MWI, 2006).

Regarding irrigation requirements, a satisfactory supply of water increases the total fresh weight of the plant and assists in increasing total seed yield (George, 1989).Water management during fruit sizing and ripening can affect yield and quality of drip-irrigated processing tomatoes (Cahn *et*

[1] Department of Plant Production and Protection, Faculty of Agricultural Technology, Al-Balqa' Applied University, Al-Salt, Jordan.
* Corresponding author, email: fadhil_almohammadi@yahoo.com

[DOR: 20.1001.1.16807073.2011.13.2.6.1]

al., 2001). The optimum water requirement for tomato production is around 75% of the ET_c. Based on these evidence, the recommended actual irrigation rate for tomato crops in tropical greenhouses is between 4.1-5.6 mm day^{-1} or equivalent to 0.3–0.4 l mm $plant^{-1}$ day^{-1} (Harmanto *et al*., 2005). The highest marketable yield that was obtained by supplying 100% ET_c amounted to 66.4 metric tons (MT ha^{-1}) as the average of three cultivars, while only 6.21 MT ha^{-1} was obtained in the unirrigated control. However, yield water use efficiency (YWUE) was highest in the treatment receiving 50% ET_c and amounted to1.09 kg m^{-3} (Perniola *et al*.,1994). Increasing rates of water supply had a significant influence on the main yield components, while the influence of nitrogen supply was generally weak (Dadomo *et al.,*1994).Increasing amounts of water resulted in decreased concentration of N, Ca, Mg, P, or K in the fruit, while it increased concentrations of P and Ca in other cases(Christo *et al*., 1994).Tüzel *et al.*(1994) indicated that increasing the irrigation rate resulted in an increase in yield, but tended to reduce the dry matter content of the fruits.Tomato plants should be fertilized with organic or chemical fertilizers to produce high yields.The common fertilizer application rates are 60-120 kg N ha^{-1}, 60-140 kg P_2O_5 ha^{-1}, and 60-120 kg K_2O ha^{-1} (Hanson *et al*., 2001). In their experiment, Mootemurro *et al*.(2007) pointed out that the treament with 100 kg N ha^{-1} seemed to allow a good balance among productivity, quality, plant nitrate utilization, and pollution risks. In comparing the fertilizer N applied rates with the conventional N management (870, 720, and 630 kg N ha^{-1} in the three seasons, respectively), site specific management reduced N fertilizer by, respectively, 62, 78, and 80% without significant impact on tomato yield (He *et al*., 2007). Tomato plants grown in a nutrient solution with a 12/2 NO_3/NH_4 mM ratio resulted in a higher yield (Flores *et al*., 2003). They also mentioned that increasing NH_4 in the nutrient solution increased fruit quality, but was associated with a decrease in yield. Rahman *et al*. (2007) showed that irrigation and N, alone and in combination, influenced the yield and yield contributing characters of tomato.The optimum N dose was recorded to be 163.3 kg ha^{-1}, which gave the optimum average fruit yield of 50.43 MT ha^{-1}. The greatest requirement of K, N, Ca, and P is just before the fruit begins to ripen (Penalosa *et al*., 1988). Nitrogen requirement of tomato is moderate during foliage growth, until fruit development. Phosphorus is very important for vigorous growth and fruit production. Potassium is needed for fruit development and enlargement (Samuel *et al*., 1985). Tomato fruit contains 45-60% of the total N, 50-60% of the total P, and 55-70% of the total K absorbed by the plants, and the major proportion of the nutrients in the fruit is absorbed at flowering time (Terebayashi *et al*., 1991). In the study by Hegde (1997), the proportion of the nutrients in the fruits declined with an increase in nutrient applications. He also found a linear and highly significant relationship between the plant uptake of N, P, and K and the crop yield.

Hegde and Srinivas (1989) results show that, in tomatoes, dry matter accumulation during the initial 30 days after transplanting (DAT) is low and less than 5% of the total dry matter produced by the end of the growth cycle.They also found that the rate of dry matter accumulation in the stem and fruit continues to increase until the crop reaches full maturity and the proportion of dry matter distributed in fruits ranged from 51%, in crops without N fertilization, to 39%, in crops that had received 240 kg N ha^{-1}. Tomato yields did not increase with N rates above the recommended rate of 200 kg ha^{-1} (Clark et al., 1989). Leaf K concentrations at the time of the first flower and early fruit set were adequate with 274 kg ha^{-1} K_2O, but, at the same time, deficiency was detected with 183 kg ha^{-1} K_2O (Hochmuth *et al*., 1991). The increase in nitrogen supply resulted in an increase in concentrations of N and Ca and a decrease in P in tomato fruits (Christo *et al*., 1994).

[DOR: 20.1001.1.16807073.2011.13.2.6.1]

Close relationships were apparent between dry matter accumulation and nutrient uptake and between the partitioning of the dry matter among the tissues and the partitioning of nutrients.The dry matter increase occurred from flowering until early fruit growth stage and was a result of increasing leaf and stem growth (Fisher *et al*., 2002). In our region, there is limited published data on plant nutrient uptake under drought conditions. Since Jordan suffers from a water deficiency, the aims of this study are to determine:

1) The response of tomato plants to nutrients under low levels of irrigation.

2) The optimum combination of irrigation and fertilizer for the best growth and yield of tomato plant.

MATERIALS AND METHODS

This research was carried out during the winter of 2006/2007 using plants of tomato Galia cultivar. The research was conducted in a clay-loam soil of a plastic house(260m^2) in the experimental station of Al-Balqa' Applied University (Table 1), using a split plot design with three replicates. The main plots were assigned to the irrigation levels, which were 8, 7, 6, and 5 mm day^{-1}, and the sub- plots were allocated to the fertilizer levels as described in Table 2. Soil samples were collected from three sites representing the soil of the experimental area at 0-20, 20-40, and 40-60 cm depth. Soil analysis included textural class of soil using Boyoucos method (ICRDA,1996), available nitrogen using Kjeldhal method (Brenmer,1965), available phosphorus using Olsen method (Olsen and Dean,1965), available potassium using ammonium acetate extraction method (Pratt,1965), electrical conductivity using the conductivity bridge (Richards.1965), and soil pH was measured by using a pH meter (McKeague, 1978, and McLean, 1982). Inside the greenhouse, the soil was flooded with water, allowed to dry to field capacity, then plowed, rotivated, levelled and subdivided into beds. Each bed was 3.5m in length and contained two planting rows 50 cm apart. All beds were covered by plastic mulch. Tomato seedlings were transplanted in beds on 5 November, 2006 at 40 cm spacing within the row and 9 plants/row. The plants were irrigated manually immediately after transplanting and were trained and pruned weekly as recommended for protected tomato (Wittwer and Honmma, 1979). The greenhouse was sprayed with pesticides and weeds were controlled manually. Fruits were harvested at full-slip stage. Plants were manually irrigated at the same time each week and according to the treatments. Fertilizer was applied with irrigation water according to the growth stage (Table 2). Harvesting of mature fruits started on 20 March, 2007, and continued until the end of the growing season on 1 June, 2007. The parameters recorded were plant height at the time of flowering, number of flowers/plant**,** total yield, dry matter of leaves and fruits, and the average fruit weight. Chemical analysis included, nitrogen content by the Kjeldal

Table1. Monthly averages of some meteorological parameters during the growing season of 2006/2007 in AL-Balqa' Expiremental Sta tion.

Months	Max.Temp. (C^o)	Min.Temp. (C^o)	AverageTemp. (C^0)	R. H %	Sunshine (hr)
Nov., 2006	22.1	12.8	17.4	50.7	6.8
Dec., 2006	18.1	9.4	13.7	58.9	5.8
Jan. , 2007	16.5	8.4	12.4	66.9	5.4
Feb., 2007	17.5	9.6	13.5	68.9	4.7
Mar., 2007	19.5	10.0	14.7	69.4	6.2
Apr. ,2007	25.4	13.7	19.6	56.4	6.9
May ,2007	32.4	20.7	26.6	44.4	5.5

[DOR: 20.1001.1.16807073.2011.13.2.6.1]

Table 2. Amount of fertilizers applications rates in different treatments (g /plot / week).

Growing stages	Treatment	N [a]	P [b]	K [c]
From transplanting to the flowering stage.	F1	9.80	6.13	7.35
	F2	14.70	6.13	7.35
	F3	14.70	9.19	7.35
	F4	14.70	9.19	11.02
At flowering Of 1-3 flowers.	F1	19.60	6.13	27.00
	F2	29.40	6.13	27.00
	F3	29.40	9.19	27.00
	F4	29.40	9.19	40.50
At flowering of 4-6 flowers.	F1	22.10	9.80	36.75
	F2	33.15	9.80	36.75
	F3	33.15	14.70	36.75
	F4	33.15	14.70	55.12
At fruiting stage.	F1	27.00	12.25	49.00
	F2	40.50	12.25	49.00
	F3	40.50	18.37	49.00
	F4	40.50	18.37	73.50

[a] :As Ammonium Sulfate $(NH_4)_2SO_4$ (20 %N)
[b] : As Mono Ammonium Phosphate $NH_4H_2PO_4$ (44 % P_2O_5)
[c] : As Potassium Nitrate KNO_3 (44 % K_2O)

procedure(Chapman and Pratt.,1961), phosphorus content by using the spectrophotometer (U.V), and potassium content by using a flame photometer according to the procedure of Ryan *et al.* (2001).

Data were analyzed statistically using SAS program (SAS Institute Inc.1999) and Duncan's Multiple Range test at 0.05 significance level as outlined by Little and Hills (1978).

RESULTS AND DISCUSSION

Soil Chemical Properties

Addition of fertilizer did not affect soil pH due to the buffering capacity of the soil (Table 3). This result agrees with the findings of Ayoola (2006), who found that the different levels of fertilizer did not significantly affect the soil pH. Electrical conductivity (EC_e) of the soil saturation extract significantly increased after fertilizer application; however, this increase was not high enough to affect the plants growth or yield. According to Richards (1954), EC_e values of 0-2 dS. m^{-1} are considered safe for all crops and yields, while sensitive crops are affected when those values are between 2 to 4 dS.m^{-1}. EC values between 4 - 8 dS. m^{-1} are harmful to most crops. Nitrogen percentage in the soil decreased significantly, mainly due to N mineralization, which increases losses of nitrogen from the soil by leaching and volatilization. This result agrees with the finding of Ayoola (2006), who showed that the use of fertilizer N increases N mineralization due to the build-up of soil organic N. In addition, much of the organic N in Broadbalk topsoil was derived from fertilizer N, and the nitrogen decreased more under inorganic fertilizer alone because nutrients from this source were readily available compared with that from organic source.This might result in higher N uptake by crops.There was a significant difference in P content in the soil after the addition of fertilizer due to increase in the amounts of soluble organic matter (mainly organic acids), which increased the rate of desorption of phosphate and thus improved the available P content in the soil.The change in available P was generally low in

Table 3. Soil analysis before planting and after harvesting as affected by fertilizer applications.

Parameters	Depth (cm)	Measured values	
		Before Planting	After Harvesting
pH	0-20	7.60a	7.80a
	20-40	7.73a	7.50a
	40-60	7.73a	7.50a
Electrical conductivity (dS/m)	0-20	0.50a	1.70b
	20-40	0.55a	1.70b
	40-60	0.66a	1.59b
Sodium Adsorption Ratio (SAR)	0-20	1.80a	2.87b
	20-40	1.31a	2.16b
	40-60	1.16a	2.44b
Exchangeable Sodium Percentage (ESP)	0-20	0.33a	2.82b
	20-40	0.55a	1.84b
	40-60	0.45a	2.24b
Total Nitrogen N (%)	0-20	0.11a	0.03b
	20-40	0.10a	0.03b
	40-60	0.11a	0.03b
Phosphorus P (ppm)	0-20	7.86a	55.33b
	20-40	14.6a	58.66b
	40-60	12.3a	26.70b
Potassium K (meq/l)	0-20	5.34a	19.39b
	20-40	6.02a	19.11b
	40-60	6.02a	18.58b
Organic Matter OM (%)	0-20	2.32a	0.70 b
	20-40	3.01a	0.58 b
	40-60	2.22a	0.66 b

* For each separate effect, means within each row having different letters are significantly different according to Duncan's Multiple Range test at 0.05 significant level.

all depths because P is relatively immobile and strongly adsorbed by soil particles (Glendining *et al*., 1966). Although Jordanian soil is generally rich in potassium, application of fertilizer K to the soil had significant effect on potassium availability in different soil depths. Soil organic matter (OM) decreased after planting because of mineralization and availability of water that increased the decomposition rate of the organic matter. ESP and SAR increases in the soil after harvesting were propably due to calcium binding to P compounds and also calcium precipitation. (Table 3).

Vegetative Characteristics and Yield

There were no significant differences between the effects of irrigation and fertilizer levels on plant height of tomato (Table 4).The height of tomato plants at time of flowering ranged between 113 to132 cm. This means that although water or fertilizer levels decreased there was no significant effect on tomato plant height, which indicates that tomato plants grown under greenhouse conditions (experimental conditions) can produce vegetative growth either by using high or low levels of water and fertilizers. This finding is in line with the studies conducted by Ghebbi Si-Smail *et al*. (2003) who found that plant height of tomatoes was not affected by the amount of water supplied.

The highest number of flowers per plant was obtained in treatment W1F2, i.e. the first level of irrigation (W1) and the second levels of fertilizer (F2), while W4F4 had the lowest number (Table 4). Other interactive

[DOR: 20.1001.1.16807073.2011.13.2.6.1]

Table 4. Effect of irrigation and fertilizer levels on plant height, number of flowers/day/week, total yield, and average fruit weight of tomato crop grown under plastic house conditions.

Water levels	Fertilizer levels	Plant height (cm)	Number of flowers per day per week	Yield MT/ha	average fruit weight (gm)
W_1	F_1	120.10 * a	14.33 abcd	66.9 bcdef	91.40 cd
	F_2	132.60 a	21.67 a	63.1 efg	85.00 ef
	F_3	129.10 a	19.00 abc	61.9 fgh	93.50 c
	F_4	126.70 a	17.66 abc	53.9 k	77.30 gh
W_2	F_1	119.30 a	13.33 bcd	56.5 ijk	77.20 gh
	F_2	123.10 a	13.33 bcd	59.2 ghij	85.90 de
	F_3	115.00 a	14.00 abcd	57.2 hijk	112.20 a
	F_4	128.20 a	17.66 abc	71.5 ab	107.10 a
W_3	F_1	123.70 a	16.00 abc	76.4 a	100.70 b
	F_2	123.80 a	19.66 abc	55.7 jk	80.20 c
	F_3	120.50 a	15.66 abc	63.9 defgh	92.30 c
	F_4	123.70 a	21.33 ab	60.7 ghij	73.00 h
W_4	F_1	123.90 a	13.00 cd	68.0 bcde	80.10 fg
	F_2	113.30 a	13.00 cd	69.4 bc	96.00 bc
	F_3	121.10 a	13.00 cd	68.7 bc	94.70 c
	F_4	114.30 a	6.33 d	65.9 cdefg	91.20 cd

* Means within columns having different letters are significantly different according to Duncan's multiple range test at 5% significant level.

treatments had little significant differences among each other in this regard. This result was due to the effect of high levels of water. Conversely, when irrigation levels decreased, those had a significant effect on number of flowers, regardless of whether fertilizer was increased or not. This result agrees with the finding of Dumas *et a*l. (1994) and Dadomo *et al*.(1994), who found that the water had an important influence on vegetative characteristics, and the nitrogen factor has very little influence on the number of flowers.

The highest total yield was found for W3F1 interaction (76.4 MT ha^{-1}), which did not differ significantly from W2F4. The lowest total yield was recorded in W1F4 treatment, amounting to 53.9 MT ha^{-1}. (Table 4). This indicates that tomato plants grown under the conditions of this experiment did not respond significantly to the increase in water levels higher than W3, or, for fertilizer levels, higher than F1. Hence, both fertilizer and water can be saved when tomato is grown under greenhouse condition, as tomato plants can produce optimum yield when receiving water and fertilizer at optimum levels. This result was confirmed by Ulla Veit-Köhler *et al*. (2000), Harmanto *et al*.(2005), Cahn *et a*l.(2001), and Dadomo *et al*.(1994). They pointed out that the lower water supply gives high marketable yield with high fruit quality.Water level of W2 combined with a higher level of fertilizer (either F3 or F4) resulted in a higher average fruit weight compared with other interactive combinations. On the other hand, the interactive treatment W3F4 produced significantly smaller fruit weight (73g).

Leaves of tomato plants treated with the W3F3 had more dry matter (23.1%), although it does not significantly differ from W3F4 or W1F3. On the other hand, the lowest significant value of leaf dry matter content was recorded in treatments W2F3, W4F3, and W4F4. These results were consistent with the increased dry matter content of tomato fruit in W3*F3 treatment. The lowest accumulation of dry matter, however, was found in fruits grown in the combination of the W3*F1 treatment. This indicates that the leaves are considered as a source for dry matter content while fruits are a sink (Salisbury and Ross.1992).Increasing fertilizer levels from F1 to F3 or decreasing water levels from W4 to W3 resulted in a higher content of dry matter in both leaves and fruits of tomato. This result may be due to a pronounced effect of photosynthesis which resulted in a high accumulation of dry matter (Salisbury and Ross.1992).On the other hand, high level of irrigation promotes vegetative growth of plant which resulted in a low accumulation of dry matter. These results were in agreement with those of Fisher *et al*. (2002), de C. Carmello and Anti (2006), and Ghebbi Si-Smail *et al*. (2003), who found that the dry matter content decreased when irrigation, or fertilizer levels, increased.

Nutrient Contents

The highest nitrogen contents of tomato leaves were obtained from the combination of F4 level of fertilizer with either W2 or W3 levels of irrigation, while the lowest content was found in leaves of plants treated with W4 and F2 (Table 5).This means that nitrogen content of tomato leaves would significantly decrease if irrigation levels increase more than W2 or W3 and the fertilizer level more than F1. Other combination treatments show small differences among them. The interaction between the irrigation and fertilizer levels on nitrogen content of tomato fruit was not significantly affected by using any treatment (Table 6). Again, the result agreed with Tei *et al*. (2002) who clarified that nitrogen content decreased during the entire crop cycle, due to the fact that tomato plants require a large amount of nitrogen for vigorous vegetative growth, hence the remaining amount for fruit will be very small.

Irrigation and fertilizer levels or their interaction caused significant effect on phosphorus content of tomato leaves (Table 5).The highest phosphorus content in tomato leaves was in W2F4 treatment and the lowest one was obtained from W2F1 and W4F4. Comparison of the other combination treatments with each others showed significant differences among them. The interactive effect of irrigation and fertilizer levels gave little significant effect on the phosphorus content of the tomato fruits

Table 5. Effect of irrigation and fertilizer levels on leaves dry matter, nitrogen, phosphorous, and potassium contents of tomato grown under plastic house conditions.

Irrigation levels	Fertilizer levels	Dry matter %	N%	P %	K%
W_1	F_1	13.6* ab	1.74 ab	0.14 cd	0.79 b
	F_2	13.8 ab	1.52 bcd	0.16 bc	0.64 b
	F_3	19.2 a	1.38 cd	0.13 cd	0.72 b
	F_4	16.4 ab	1.45 bcd	0.13 cd	0.58 b
W_2	F_1	17.7 ab	1.55 abcd	0.01 d	0.68 b
	F_2	13.5 ab	1.73 ab	0.13 cd	0.82 b
	F_3	11.8 b	1.70 abc	0.14 cd	0.61 b
	F_4	13.8 ab	1.91 a	0.21 a	2.06 a
W_3	F_1	16.4 ab	1.60 abcd	0.13 cd	0.68 b
	F_2	16.8 ab	1.70 abc	0.12 cd	0.73 b
	F_3	23.1 a	1.63 abcd	0.13 cd	0.60 b
	F_4	19.0 a	1.92 a	0.12 cd	0.87 b
W_4	F_1	14.0 ab	1.63 abcd	0.13 cd	0.70 b
	F_2	17.5 ab	1.28 d	0.15 bc	1.14 b
	F_3	13.1 b	1.54 abcd	0.17 b	1.17 b
	F_4	12.8 b	1.47 bcd	0.11 b	1.08 b

* Means within columns having different letters are significantly different according to Duncan's multiple range test at 0.05 significant level.

Table 6. Effect of irrigation and fertilizer levels on fruits dry matter, nitrogen, phosphorous, and potassium contents of tomato grown under plastic house condition.

Irrigation levels	Fertilizer levels	Dry matter%		N%		P%		K%	
W_1	F_1	9.2*	ab	2.00	a	0.19	b	2.19	ab
	F_2	8.4	b	2.13	a	0.23	b	2.11	ab
	F_3	9.1	ab	1.97	a	0.22	b	2.10	ab
	F_4	9.3	ab	2.55	a	0.21	b	2.10	ab
W_2	F_1	9.0	ab	2.23	a	0.22	b	2.16	ab
	F_2	10.6	ab	2.49	a	0.21	b	2.18	ab
	F_3	9.2	ab	2.07	a	0.95	a	2.13	ab
	F_4	9.3	ab	2.11	a	0.24	b	2.24	ab
W_3	F_1	7.6	b	2.18	a	0.17	b	2.37	ab
	F_2	8.3	b	2.10	a	0.26	ab	2.11	ab
	F_3	11.9	a	2.10	a	0.23	b	2.05	b
	F_4	10.7	ab	2.09	a	0.22	b	2.16	ab
W_4	F_1	8.4	b	2.00	a	0.23	b	2.05	b
	F_2	9.8	ab	1.90	a	0.19	b	2.04	b
	F_3	9.0	ab	1.96	a	0.20	b	1.69	c
	F_4	10.1	ab	2.04	a	0.25	b	2.89	a

* Means within columns having different letters are significantly different according to Duncan's multiple range test at 0.05 significant level.

(Table 6). Significant difference in phosphorus content of the fruits was obtained in W2F3 compared with the other treatments. This result is consistent with former findings in which the highest phosphorus content of tomato leaves was obtained in W2F4. Christo *et al*. (1994) found that phosphorus content of plants increased as irrigation or fertilizer levels increased.

Interaction between irrigation and fertilizer levels showed small significant effect on potassium content in tomato leaves (Table 5). The only combination treatment that showed a significant difference from others was W2F4, in which potassium content was the highest (2.06%).These results are consistent with the results found for the nitrogen and phosphorus contents of tomato leaves. The other treatments did not differ significantly from each other. In contrast, the added fertilizer, or the increased irrigation level, did not affect potassium content in the tomato fruits, except that the content decreased significantly when the plants were exposed to water stress (Table 6), (Hochmuth *et al*., 1991; and Fisher *et al*., 2002).

CONCLUSION

Results show that the highest total yield was obtained by using 6 mm/day of water and 27, 12.5, and 49 g/plot/week of, respectively, N, P, and K fertilizers. The highest percentages of dry matter in both leaves and fruits were obtained by application of 6mm/day of water and 40.5, 18.37, 49g/plot/week of, respectively, N, P, and K fertilizer. Comparing with the control, growers should realize that using lower water and fertilizer levels can still have an economical yield with a good quality. Further research and studies are recommended to substantiate these results under plastic conditions in similar geographical areas.

ACKNOWLEDGEMENT

This research was financially supported by Al-Balqa' Applied University, Jordan (www.bau.edu.jo).

REFERENCES

1. Ayoola, O. T. 2006. Effects of Fertilizer Treatments on Soil Chemical Properties and Crop Yields in a Cassava-based Cropping System. *J. Appl. Sci. Res*., **2**: 1112-1116.
2. Brenmer, I. M. 1965. Total Nitrogen. In: "*Methods of Soil Analysis",* .Part 2., Agronomy Series#9, American Society of Agronomy, Inc., Madison.
3. Cahn, M. D., Herrero, E. V., Snyder, R. L. and Hanson, B. R. 2001. Water Management Strategies for Improving Fruit Quality of Drip-Irrigated Processing Tomatoes. *Acta Hort.,* **542**: 111-116.
4. Chapman, H. D. and Pratt, P. F. 1961. Method of Analysis for Soil, Plant and Water. Publisher University of California .University of California, Berkeley, CA, USA.
5. Christo, M., Leoni, S., Cornillon, P., Gainze, A., Dumas, Y., Rodriguez, A., and Dimirkou, A. 1994. Influence of Water and Nitrogen Availability on Elemental Composition of Processing Tomato Fruit in EU. Countries. *Acta Hort.*, **376**: 279-284.
6. Clark, G. A, Hochmuth G. J., Hanlon, E. A., Stanley, C. D., Maynard D. N, and Haman, D. Z. 1989. Water and Fertilizer Management of Micro-irrigated Tomato Production on Sandy Soils in Southwest Florida. Southwest Fla. *Water Manage. Dist*., *Final Report*.
7. Dadomo, M., Macua, J. I., Gainza, A. M., Christou, M., Dumas, Y., Branthôme, X. and Bussières, P. 1994. Influence of Water and Nitrogen Availability on Yield Components of Processing Tomato in the European Union Countries. *Acta Hort.,* **376**: 271-274.
8. de C. Carmello, Q. A., and Anti, G. R. 2006. Accumulation of Nutrients and Growth of Processing Tomato. *Acta Hort.,* **724**: 85-90.
9. Doaa, A. 2006. Environmental and Natural Resource Management. *The International Development Research Center*.
10. Dumas, Y., Leoni, C., Portas, C. A. M., and Bièche, B. 1994. Influence of Water and Nitrogen Availability on Yield and Quality of Processing Tomato in The European Union Countries. *Acta Hort.,* **376**: 185-192.
11. Fisher, K. J., Johnstone, P. R., and Nichols, M. A. 2002. Nutrition of Processing Tomatoes. *Acta Hort.,* **571**: 45-49.
12. Flores P., Navarro J. M., Carvajal M., Cerda A. and Martinez V. 2003. Tomato Yield and Quality as Affected by Nitrogen Source and Salinity. *Agron. J*. **23** :249-256.
13. George, R. A. T. 1989. Vegetable Seed Production. John wiely and sons Inc. Third Avene, New York., Pp 605.
14. Ghebbi Si-Smail, K., Benamara, A., and Dumas, Y. 2003. Effect of Potassium Fertilization on the Behaviour of Three Processing Tomato Cultivars under Various Watering Levels. *Acta Hort.,* **613**: 169-172.
15. Glendining, M. J., Polwlson. S, Poulation P. R., Bradury N. J., Palazzp, D. 1966. The Effects of Long-term Applications of Inorganic Nitrogen Fertilizer on Soil Nitrogen in the Broadbalk.Wheat Experiment. *J. Agric. Sci.,* **127**: 347-363.
16. Hanson, P., Chen, J. T., Kuo, C. G., Morris, R., and Opena. R. T. 2001. Tomato Production. *Asian Vegetable Research and Development Center (VRDC).*
17. Harmanto, V. M., Salokhe, M. S., Babel, and Tantau, H. J. 2005. Water Requirement of Drip Irrigated Tomatoes Grown in Greenhouse in Tropical Environment, *Agric. Water Mang.,***17(3)**: 225-242.
18. He, F., Chen, Q., Jiang, R., Chen, X., Zhang, F. 2007. Yield and Nitrogen Balance of Greenhouse Tomato (*Lycopersicon esculentum Mill*). with Conventional and Site-Specific Nitrogen Management in Northern China. *Nutr. Cycling Agroecosyst.*, **77(1)**:1-14.
19. Hegde, D. M., and Srinivas, K. 1989. Growth and Yield Analysis of Tomato in Relation to Soil Matric Potential and Nitrogen Fertilization. *Ind. J. Agro*n.,**34**: 417-425.
20. Hegde, D. M. 1997. Nutrient Requirements of Solanaceous Vegetable Crops**.** Food and Fertilizer the Technology Center for Asian and Pacific Region.
21. Hochmuth, G., D., Maynard, C., Vavrina, and Hanlon, E. 1991. Plant Tissue Analysis and Interpretation for Vegetable crops in Florida**.** *Fla. Coop. Ext. Serv. Spec. Ser. SS-VEC*-42.
22. International Center for Agriculture Research in the Dry Areas (ICARDA). 1996. *Soil and Plants Analysis Manual Adapted for the West Asia and North Africa Region*, International Center for Agricultural Research in the Dry Areas. Syria.

[DOR: 20.1001.1.16807073.2011.13.2.6.1]

23. Little, T. M. and Hills T. 1978. *Agricultural Experimentation. Design and Analysis*. John Wiley and Sons, New York.
24. McKeague, J. A. 1978. *Manual on Soil Sampling and Methods of Analysis*. Canadian Society of Soil Science, pp 66-68.
25. McLean, E. O. 1982. Soil pH and Lime Requirement., pp 199-224. In: *Methods of Soil Analysis*, Part 2**:** Agronomy Series #9. Chemical and Microbiological Methods.
26. Ministry of Water and Irrigation (MWI). 2006. Annual Report, Amman. Jordan.
27. Mootemurro, F., Maiorana, M., Lacertosa, G. 2007. Plant and Soil Nitrogen Indicators and Performance of Tomato Grown at different Nitrogen Fertilization levels. *J. Food Agric. Environ.*, **5(2)** :143-148.
28. Olsen, S. R., and Dean, L. A. 1965. Phosphorus pp1035-1049. In: *Methods of Soil Analysis*. Part 2.Agronomy series #9, American Society of Agronomy, Inc., Madison.
29. Penalosa, J. M., Carpena, O., and Zornoza, P. 1988. A Study of the Nutrient uptake by Tomato Plants in Sand Culture. *Soilless Culture*. **4**: 41-50.
30. Perniola, M., Rivelli, A. R., and Candido, V. 1994. Yield Response to Water and Stress Indexes on Tomato. *Acta Hort.,* **376**: 215-226.
31. Prrat, P. F. 1965. Potassium. pp1022-1030. In: *Methods of Soil Analysis*. Part 2. Agronomy series#9, American Society of Agronomy, Inc., Madison.
32. Rahman, M. J., Mondol, A. T. M. A. I., Rahman, M. N., Begum, R. A. and Alam, M. K. 2007. Effect of Irrigation and nitrogen on Tomato Yield in The Grey Terrace Soil of Bangladesh. *J. Soil Nature*. : 1-4.
33. Richards, L. A. 1954. *Diagnosis and Improvement of Saline and Alkali Soils.* Hand Book#60, USDA .Washington.
34. Richards, L. A. 1965. Physical Condition of Water in Soil. In: *Methods of Soil Analysis* .Part 1. Agronomy Series #9, American Society of Agronomy, Inc., Madison.
35. Ryan, G, Estefan, G, and Rashid, A. 2001. *Soil and Plant Analysis Laboratory Manual*. International Center for Agricultural Research in the Dry Areas. (ICARDA). Aleppo, Syria.
36. Salisbury, F. B., and Ross. C. 1992. *Plant Physiology*. Amazon. Com. UK.
37. Samuel, L., Werner, L., and James, D. 1985. *Soil Fertility and Fertilizer*. Collier Macuillan Publisher., London.
38. SAS Institute Inc. 1999. SAS System for Windows, Version 8. SAS Institute. Cary, NC.
39. Tei, F., Benincasa, P. and Guiducci, M. 2002. Effect of N Availability on Growth, N uptake, Light Interception and Photosynthetic Activity in Processing Tomato. *Acta Hort.,* **571**: 209-216.
40. Terebayashi, S., Takii, K., and Namiki, T. 1991. Variation in Diurnal uptake of Water and Nutrients by Tomato Plants of Different Growth Stages Grown in Water Culture*. J. Jap. Soc. Hort. Sci***. 59**: 751-755.
41. Tüzel, I. H., Ul, M. A. and Tüzel, Y. 1994. Effect of Different Irrigation Interval and Rates on Spring – Season Glasshouse Tomato Production: I. Yiled and Plant Growth. *Acta Hort.* **366**:381-388.
42. Ulla, V-K, Krumbein, A., Kosegarten, K. 2000. Effect of Different Water Supply on Plant Growth and Fruit Quality of *Lycopersicon esculentum*. *J .Plant Nutr. Soil Sci*., **126**:583 – 588.
43. Wittwer, S. H., and Honmma, S. 1979. *Greenhouse Tomatoes, Lettuce and Cucmbers*. Michigan Stat University Press.

تاثیر سطوح مختلف آبیاری و کود شیمیایی بر خصوصیات شیمیایی خاک و تولید گوجه فرنگی

ف. المحمدی و ی. الزوبی

چکیده

این تحقیق در شرایط گلخانه‌ای بمنظور ارزیابی ترکیب مناسب سطوح مختلف آبیاری و مصرف کود شیمیایی برای بدست آوردن بهترین تولید و کیفیت محصول گوجه‌فرنگی بمرحله اجرا درآمد. آزمایش در قالب طرح کرت های خرد شده در سه تکرار انجام شد. سطوح آبیاری در کرتهای اصلی و سطوح کودی در کرتهای فرعی پیاده گردید. در هر واحد آزمایشی سطوح آبیاری در هر روز W1=8mm، W2= Vmm، W3=6mm، W4=5mm و سطوح کودی در هر هفته بصورت F1= (N1, P1, K1, 9.8, 6.13, 7.35 g), F2= (N2, P1, K1, 14.7, 6.13 , 7.35g/plot), F3= (N2, P2, K1, 14.7, 9.19, 7.35 g/plot), and F4=(N2, P2, K2, 14.7, 9.19, 11.0 g/plot) به مرحله اجرا درآمد. از طرف دیگر سطوح مختلف کودی با رشد گیاه در دوره رشد و زمان برداشت محصول افزایش یافت. ارتفاع و تعداد گل در هر گیاه در دوره رشد و در زمان برداشت محصول اندازه‌گیری شد. نمونه آزمایشی از برگ و میوه در دوره رشد و زمان برداشت محصول افزایش یلفت. ارتفاع و تعداد گل درهر گیاه در دوره رشد و در زمان برداشت محصول اندازه‌گیری شد. نمونه آزمایشی از برگ و میوه در دوره رشد و زمان برداشت محصول برای اندازه گیری ماده خشک، میزان کل نیتروژن، فسفر و میزان مختلف پتاسیم در برگ و میوه برداشت گردید.همچنین کل محصول و متوسط وزن میوه در هنگام برداشت اندازه گیری شد. نتایج نشان داد که سطح آبیاری و کود شیمیایی تاثیر معنی داری روی تعداد گلها دارد و ترکیب W1F2 بیشترین تاثیر در بین تیمارها مختلف دارد در حالیکه ارتفاع گیاه بطور معنی‌داری تحت تاثیر تیمارهای مختلف قرار نگرفت. تولید کل بطور معنی داری با تیمار W3F1 افزایش یافت. متوسط وزن میوه بصورت معنی داری با تیمار W2F3 در مقایسه با سایر تیمارها افزایش یافت و درصد ماده خشک در برگ و میوه بطور معنی داری تحت تاثیر تیمار W3F3 قرار گرفت. میزان کل نیتروژن، فسفر و پتاسیم در برگ بطور معنی داری تحت تاثیر تیمار W2F4 افزایش یافت. میزان کل نیتروژن در میوه گوجه فرنگی تفاوت معنی داری در بین تیمارها نشان نداد ولی میزان فسفر و پتاسیم در میوه بصورت معنی داری با تیمارهای W2F3 و W4F4 افزایش نشان داد.

[DOR: 20.1001.1.16807073.2011.13.2.6.1]