SIGNIFICANCE OF APPLIED IRRIGATION AND FERTILIZATION SYSTEMS FOR IMPROVING TOMATO PRODUCTIVITY AND ITS FRUIT QUALITY IN A NEWLY RECLAIMED CALCAREOUS SOIL

Nader R. Habashy, Mohsen A.M. El Bassiouny and Mohamed S.A. Ewees*
Soils, Water and Environ. Res. Inst., Agric. Res. Center, Giza, Egypt
*Soils and Water Depart., Fac. of Agric., El Fayoum University, Egypt

ABSTRACT:

A field experiment was carried out on a newly reclaimed calcareous soil with sandy loam texture class at a Private Farm adjacent to Alexandria road (km 52), and cultivated with tomato plants (*Lycopersicon esculentum*) under two irrigation systems (furrow and drip) during growing season of 2005. Fertilization methods were carried out as soil and fertigation applications. The used fertilizers were urea (46% N) and mono-potassium phosphate (15% P_20_5 and 38% K_2O), with rates of 100 kg N fed^{-1}, 40 kg P_2O_5 fed^{-1} and 48 kg K_2O fed^{-1}. This work aims to study the effects of irrigation and fertilization methods on tomato yield and fruit quality, with special reference to NPK fertilizers use efficiency.

At the elongation stage (60 days after transplanting), some selected plants were taken to determine some vegetative growth parameters, i.e., plant height, dry weight, leaf area index, number of flowers per plant and the chlorophyll concentration (a and b) as well as N, P and K uptake by plants. Soil samples were also taken at different depths (0-15, 15-30, 30-45 and 45-60 cm) to determine available N, P and K. In addition, at harvest (90 days after transplanting) tomato yield and the fruit quality parameters (firmness, total soluble solids, titrable acidity, vitamin C and total sugar) were identified.

The obtained results reveal that experimental soil is classified as Typic Haplocalcids, coarse loamy, mixed, thermic. According to a parametric evaluation system, it could be evaluated as moderately suitable (S2S1S3S4), with an intensity degree for each of soil texture, $CaCO_3$ and gypsum, as soil limitations, lies in the range of slight-moderate (rating = 90-75). In addition, the used irrigation water source (underground water) lies in the first category of C1S1, where ECiw and SAR values lay within the range of < 0.75 dS/m and < 6.00, respectively.

Moreover, the obtained data show that the abovementioned vegetative growth parameters recorded the highest increases at fertigation system followed by NPK fertilization as soil application under drip and furrow irrigation ones. Also, available N and K contents in soil behaved the same abovementioned trend of irrigation and fertilization systems, with superiority for fertigation NPK one in soil surface (0-15 cm), may be due to their lesser by leaching. As for available phosphorus, it was prone to fix at the point of application (soil surface). The aforementioned trend was positively reflected on NPK uptake by plants and tomato yield, where fertigation NPK exhibited relatively higher N, P and K uptake as compared to NPK fertilization under drip and furrow irrigation systems. The relative increases in tomato fruit yields reached 36.68 and 16.80% for fertigation and drip over the furrow irrigation system, respectively. Fertigation NPK exhibited significantly higher fruit number per plant (as an average of 56.9) followed by drip (50.4) and furrow (43.7) irrigation systems.

The NPK fertilizers-use efficiency was reached a maximum value at fertigation NPK (205.9 kg fruit kg^{-1} NPK), followed by NPK fertilization as soil application under drip (175.9 kg fruit kg^{-1} NPK) and furrow (150.6 kg fruit kg^{-1} NPK) irrigation systems. Thus, it could be concluded that applying fertigation NPK system resulted in a pronounced improvement of vegetative growth parameters, and in turn increasing tomato yield and its fruit quality.

Key words: Calcareous soil, tomato, fertigation NPK, furrow and drip irrigation systems.

INTRODUCTION:

Tomato is one of the most popular and widely grown vegetable crops in the world. It responds well to the application of fertilizers and is reported to be a heavy feeder of N, P and K. Efficient use of fertilizer and water is highly critical to sustained agricultural production. In general, utilized fertilizers applied under traditional methods are not efficiently by the crops. In fertigation system, nutrients are applied through emitters directly into the zone of maximum root activity, and consequently fertilizer-use efficiency can be improved over conventional method of fertilizer application.

Bar Yosef and Sagiv (1982) reported fertilizer saving and increase in tomato yield due to fertigation. Generally, crop response to fertilizer application through drip irrigation has been excellent and frequent nutrient applications have improved the fertilizer-use efficiency **(Malik *et al*., 1994). Habashy (1992 and 2005)** revealed that dry matter of tomato shoots, fruit yield and its quality parameters gave the highest values in the case of urea phosphate treatment under drip irrigation.

Hebbar *et al*., (2004) stated that fertigation with normal fertilizers gave significantly lower yield as compared with fertigation with water-soluble fertilizers. This attributed to complete solubility and availability of water-soluble fertilizers as compared with normal fertilizers.

The purpose of this work was to evaluate both irrigation and fertilization systems [i.e., furrow or drip and NPK as soil application or nutrients mixed with water through a drip irrigation system (fertigation)] on yield and fruit quality of tomato in a newly reclaimed calcareous soil, with special reference to identify the role of applied treatments for NPK fertilizers-use efficiency.

MATERIALS AND METHODS:

A field experiment was carried out on a newly reclaimed calcareous soil surveyed as non-saline and non-sodic sandy loam soil at a Private Farm adjacent to Alexandria road (km 52) under two irrigation systems (furrow and drip) during growing season of 2005. Some physical and chemical properties of the experimental soil were determined according to the methods of **Jackson (1973) and Page *et al.* (1982),** and the obtained data are presented in Table (1).

Table (1): Some physical and chemical properties of the experimental soil.

Soil characteristics	Value	Soil characteristics	Value
Particle size distribution %:		*Soluble cations (soil paste, meq/l)*:	
Sand	60.65	Ca^{2+}	4.47
Silt	22.23	Mg^{2+}	2.10
Clay	17.12	Na^{+}	4.90
Textural class	Sandy loam	K^{+}	0.73
Soil chemical properties:		*Soluble anoions (soil paste, meq/l)*:	
pH (1.25 soil water suspension)	8.25	CO_3^{2-}	0.00
$CaCO_3$ %	23.10	HCO_3^{-}	2.85
Organic matter %	0.78	Cl^{-}	6.00
ECe (dS/m, soil paste extract).	1.20	SO_4^{2-}	3.35
Soil physical properties:		*Available macronutrients (mg/kg)*:	
Bulk density g cm^{-2}	1.32	N	23.18
Available water %	16.87	P	5.60
Hydraulic conductivity cm h^{-1}	6.45	K	301.40

Twenty eight day old seedlings of tomato (*Lycopersicon esculentum*) were transplanted to the experimental field at a space of 90cm between both two lines and 30cm between the plants on a row (12000 plants fed^{-1}). The experiment was laid out in a randomized complete block design, with a plot area of 10.8 m x 9.6 m, with three replicates. The irrigation water was added through two systems, as follows:

a) Furrow irrigation and b) Drip irrigation.

Furrow irrigation treatment was applied at 6 days interval, with cumulating 18 irrigations for the current experiment, whereas, drip irrigation treatment was applied daily through in-line drippers (12000 emitters fed^{-1} and discharge of 4 L h^{-1} per each emitter). The quantity of applied irrigation water at furrow irrigation was measured using Parshall Flume, while flow meter was used for drip irrigation. It is worthy to mention that the water quantity used for all the applied two irrigation systems were equal amounts.

The applied fertilizers were added as soil application and fertigation system. The later one is represented by nutrients mixed with water through drip irrigation system. The used fertilizers were urea (46% N) and mono-potassium phosphate (15% P_20_5 and 48% K_2O), with rates of 100 kg N fed^{-1}, 40 kg P_2O_5 fed^{-1} and 48 kg K_2O fed^{-1}. These fertilizers were received entire P and K as soil application at transplanting of tomato, while N was added in two equal splits (28 and 56 days after transplanting). As for fertigation NPK, fertilizers were injected in weekly intervals through the in-line drippers. At elongation stage (60 days after transplanting), some selected plants were taken to determine some vegetative growth parameters, i.e., plant height, dry weight, leaf area index and the chlorophyll (a and b) concentration **(Hiscox and Isrealstam, 1979).** The selected youngest fully expanded leaves were taken from each plot for determining N, P and K contents according to **Van Schouwenberg (1968).**

Soil samples were also taken at different depths (0-15, 15-30, 30-45 and 45-60 cm) to determine soil available N, P and K contents according to **Jackson (1973).** At harvest, 90 days after transplanting, where tomato fruit reached 'color breaker stage', tomato yield was determined as well as the fruit quality parameters (i.e., firmness using fruit pressure tester with a probe diameter of 0.8 cm and values expressed in pounds, total soluble solids using hand held Brix meter, titrable acidity, vitamin C and total sugar) were evaluated using the methods undertaken by Association of Official Analytical Chemistry **(AOAC, 1990).** NPK fertilizers use efficiency was worked out as a factor of economic (total tomato yield in kg per one kg of NPK). The obtained data were subjected to analysis of variance (ANOVA) using SAS program.

RESULTS AND DISCUSSION

1. A general view on the experimental soil and irrigation water:

It is worthy to mention that the experimental soil represents one of the scattered private farms that are mainly encompassing the Miocence limestone as a parent material, and occupying the desert zone between the Nile alluvium and Alexandria Desert Road on km 52. It is developed under climatic conditions of long hot rainless summer and short mild winter, with scare amounts of rainfall. Due to the prevailing calcareous in nature through a medium soil media, it is surveyed as non-saline and non-sodic calcareous sandy loam soil under dry climate (Table, 1).

Taxonomic unit of the current experimental soil is identified and named on the basis of soil morphological and physio-chemical characteristics at the family level according to **Soil Survey Staff (1999)** as Typic Haplocalcids, coarse loamy, mixed, thermic. Also, according to a parametric system undertaken by **Sys and Verheye (1978),** the intensity degrees of soil limitations and suitability categories for the studied soil were calculated and presented in Table (2).

Table (2): Soil limitations and rating indices for evaluating the studied soil at the current experiment.

Topography (t)	Wetness (w)	S				Soil salinity/ alkalinity (n)	Rating (Ci)	Suitability class	Suitability subclass
		Soil texture (s1)	Soil depth (s2)	$CaCO_3$ (s3)	Gypsum (s4)				
100	100	75	100	90	90	100	60.75	S2	$S2_{s1s3s4}$

It is cleared from data obtained that soil texture (s_1), $CaCO_3$ (s_3) and gypsum (s_4) are the most effective limitations for soil productivity, respectively. The relative coarse texture (s_1) and high $CaCO_3$ content (s_3) have direct adverse effects on soil moisture retained and restrictive of nutrients availability. Also, the experimental soil could be evaluated as a moderately suitable ($S2_{s1s3s4}$), with an intensity degree for each of soil texture, $CaCO_3$ and gypsum (s_4) as soil limitations lies in the range of slight-moderate (rating = 90-75).

Usage of the underground water is one of the most additional developments, which have saved the fresh Nile water, accelerated the direction towards agricultural utilization projects at the newly reclaimed desert areas of Egypt through the National Economic Policy of Local Government. This is more related to the fact that agriculture utilization can be grown as a supplemental aspect to decrease the gap between the import and local production of human consumption and animal feeding in Egypt.

Table (3): Water characteristics of the used irrigation source (underground water).

Water characteristics	Value
pH	7.23
ECiw (dS/m)	0.57
Total dissolved salts (mg/l)	364.80
Soluble ions (me/l):	
Ca^{++}	1.90
Mg^{++}	0.83
Na^{+}	2.80
K^{+}	0.25
CO_3^{--}	0.00
HCO_{3-}	1.95
Cl^{-}	2.60
SO_4^{--}	1.23
Sodium adsorption ratio (SAR)	2.40
Residual sodium carbonate (RSC)	0.00
Irrigation water suitability degree	C1S1

According to the water salinity and sodicity classes undertaken by **Ayers and Westcot (1985),** data in Table (3) indicate that the used irrigation water (underground water) lies in the first category of C1S1, where ECiw and SAR values lay within the range of < 0.75 dS/m and < 6.00, respectively.

2. Vegetative parameters:

Economic input is a part of the total biological yield of any vegetable crop, and hence the vegetative growth parameters of the investigated crop (tomato) represent the important determinant of the economic yield. Data obtained from the different applied irrigation and fertilization systems illustrated in Table (4), and show that the plant height, leaf area index, total dry matter accumulation and number of flower per plant were significantly increased at the treatment of fertigation NPK followed by NPK fertilization as soil application under drip and furrow irrigation systems. The correspond relative increases in the aforementioned parameters for fertigation NPK & NPK fertilization as soil application under drip irrigation were 14.80 & 18.03%, 48.40 & 64.80%, 26.67 & 56.53% and 21.95 & 29.39%, respectively, as compared to furrow irrigation system.

Table (4): Vegetative growth parameters of tomato as influenced by the different irrigation and fertilization systems.

Treatments	Plant height (cm)	No. of flower per plant	Leaf area index (LAI)	Dry weight (g/plant)	Chlorophyll (a and b) (mg/g fresh weight)
Furrow irrigation	78.20	29.60	2.50	375	0.80
Drip irrigation	89.80	36.10	3.71	475	0.88
Fertigation NPK	92.30	38.30	4.12	587	1.44
L.S.D. at 0.05	3.20	1.02	--	157	0.06

It is noteworthy that impact of the applied treatments on the dry matter productions was more related to the leaf area index. This is due to the obtained increases in the total dry matter accumulations can be interpreted on the fact that higher LAI contributed to more photosynthesis and better carbohydrates yield. These findings are in harmony with those obtained by **Duncan (1971)** who obviously cleared the importance of canopy structure in light interception, crop growth and yield. Also, a higher leaf area index was more related to drip irrigation than furrow irrigation, this finding is in agreement with it has been reported by **Chawla and Narda (2000).**

Chlorophyll (a and b) concentration was significantly higher at fertigation treatment, followed by NPK soil application with drip and furrow irrigation. This is testimony for the longer source activity in fertigation, where nutrients were applied through 9-12 split doses to match the uptake by crop. This enhanced the current photosynthesis for developing vegetative growth parameters that leading to the development of dry matter production per plant in fertigation treatment as compared to the soil application treatments either with drip or furrow irrigation system (Table 4). These findings are in harmony with results obtained by **(Hebbar *et al*., 2004).**

3. Available NPK distribution in soil:

It was observed that the maximum values of applied NPK fertilizers, as easily soluble ones, were at soil depth of 15-30 cm for drip irrigation system, whereas their contents entirely soil application treatment at furrow irrigation tended to increase with soil depth up to the deepest layer of 45-60 cm (Table, 5). The later case was due to a higher leaching fraction of NPK fertilizers applied as compared to NPK fertilization as soil application under drip irrigation and fertigation NPK. **Alva and Mozzafari (1995)** confirmed these findings as they reported that fertigation or drip irrigation treatments maintained high concentrations of NO_3-N and K at shallow depth of soil.

Table (5): Available N, P and K contents (mg kg^{-1}) in different soil layers as influenced by the different application irrigation systems.

Treatments	Soil layers in cm			
	0-15	15-30	30-45	45-60
NO_3-N				
Furrow irrigation	27.08	39.92	33.00	45.45
Drip irrigation	33.09	42.63	32.66	26.62
Fertigation NPK	43.91	50.46	38.90	28.75
L.S.D. at 0.05	2.45	1.99	0.92	2.10
P				
Furrow irrigation	7.50	6.66	5.71	5.20
Drip irrigation	9.58	7.58	6.00	5.50
Fertigation NPK	10.40	8.91	6.41	5.95
L.S.D. at 0.05	1.32	0.96	0.25	0.52
K				
Furrow irrigation	365.41	373.80	385.41	399.16
Drip irrigation	386.25	406.66	393.33	380.58
Fertigation NPK	393.75	439.58	398.58	389.58
L.S.D. at 0.05	36.12	52.51	33.73	12.30

Available P distribution in soil layers reached a maximum value in topsoil, where it is prone to fix at the point of application (Table, 5). The accumulation of P at 0-15 cm was significantly higher, especially in fertigation system because of complete solubility of mono potassium phosphate and frequent of small application rate as compared to soil application. That means phosphorous fertilizer tends to fix at the point of application, mainly due to the relatively higher values of soil pH and $CaCO_3$ content, which restrict P availability.

4. NPK contents and uptake by plants:

Fertigation NPK and drip irrigation with NPK soil application had a significantly higher N, P and K contents and uptake by tomato plants over furrow irrigation (Table, 6). These increases in NPK uptake were due to the frequent application of these nutrients in better availability in root zone coupled with better root activity. Further, it was also due to the reduced loss of these nutrients primarily because of leaching in fertigation system as compared to NPK as soil application under furrow irrigation. Similar observations reported by **Van Sane *et al*. (1996).**

Table (6): N, P and K contents and uptake by tomato plants as influenced by different irrigation and fertilization systems.

Treatments	Content %			Uptake (kg fed^{-1})		
	N	P	K	N	P	K
Furrow irrigation	2.75	0.28	2.50	12.3	1.26	11.25
Drip irrigation	3.99	0.54	3.43	22.7	2.90	19.55
Fertigation NPK	4.51	0.69	4.13	31.79	4.86	29.11
L.S.D. at 0.05	0.57	0.15	0.22	2.54	0.92	2.33

This means that the fertigation NPK plays an important role for increasing the supplying power of soil capacity against nutrient deficiencies. Also, these beneficial effects were positively reflected on the vegetative growth and plant contents of NPK. These finding are in agreement with those obtained by **Habashy (2005)** who reported that fertigation NPK increased dry matter of plant and NPK contents or uptake.

5. Yield and fruit quality:

a. Tomato fruit yield:

Nitrogen, phosphorus and potassium nutrients either mixed with water through drip irrigation (fertigation system) or added as soil application under drip irrigation system registered significantly higher yields over that obtained from NPK as soil application under furrow irrigation one. The corresponding relative increases were 16.81 and 36.69%, respectively, as compared with furrow irrigation (Table, 7). These relative increases could be attributed to significantly higher increases in dry weights and number of flowers per plant, and in turn the increments in number of fruit and yield per plant, which took a similar trend to the aforementioned treatments. The distinctive tomato yield advantage reflected in drip system over furrow irrigation is further amplified by the fertigation system which was attributed to maintenance of a favorable available soil water and nutrients status in the root zone. Also, drip irrigation system with NPK soil application helped the plants to utilize moisture as well as nutrients more efficiently for the limited wetted area **(Phene and Beale, 1976).** Similar results of the improved tomato yield have been reported by **Ibrahim (1992); Habashy (1992) and Lava *et al*. (1996).**

Table (7): Tomato yield parameters as influenced by the different irrigation and fertilization systems.

Treatments	No. of fruit per plant	Mean fruit weight (g)	Fruit yield (kg per plant)	Fruit yield (ton fed^{-1})	FUE* (Kg fruit kg^{-1} NPK)
Furrow irrigation	43.7	54.2	2.36	28.32	150.6
Drip irrigation	50.4	54.7	2.75	33.08	175.9
Fertigation NPK	56.9	56.7	3.23	38.71	205.9
L.S.D. at 0.05	2.34	0.56	0.12	2.43	--

* Fertilizer-use efficiency

b) NPK fertilizers-use efficiency (FUE):

NPK fertilizers-use efficiency was significantly superior at fertigation system (205.9 kg kg^{-1} NPK) followed by drip irrigation with NPK soil application (175.9 kg kg^{-1} NPK) as compared to NPK as soil application under furrow irrigation (150.6 kg kg^{-1} NPK), Table (7). This was due to better soil media for available moisture and nutrients throughout the growth and flowering stages at fertigation NPK and drip irrigation with NPK soil application, which leading to better NPK uptake and production of tomato fruits.

c. Tomato fruit quality:

Tomato fruit quality can be controlled by different parameters, i.e. total soluble solids, fruit firmness, titrable acidity, vitamin C and total sugar, which showed significant differences in titrable acidity and ascorbic acid concentration while others remained equal for all the applied treatments. The corresponding relative increases at fertigation & drip irrigation were 2.50 & 15.0% and 4.02 & 15.9% of titrable acidity and ascorbic acid, respectively, as compared to NPK as soil application under furrow irrigation (Table, 8).

Table (8): Tomato fruit quality parameters as influenced by the different irrigation and fertilization systems.

Treatments	TSS*	Fruit firmness (Ibs)	Titrable acidity (%, as citric acid)	Ascorbic acid (mg 100^{-1} fresh weight)	Total sugar (%)
Furrow irrigation	3.95	7.35	0.40	16.00	1.10
Drip irrigation	4.12	7.43	0.41	16.67	1.31
Fertigation NPK	4.22	8.98	0.46	19.33	1.90
L.S.D. at 0.05	1.01	0.97	0.02	1.16	0.51

* Total soluble solids

It is noticed that applied K fertilizer had a positive impact on ascorbic acid concentration, may be due to its better availability to the plant. This is in harmony with the research finding of **Anac and Colcoglu (1995) and Habashy (2005)** who found that K increased the ascorbic acid concentration in tomato fruit. Therefore, it can be concluded that availability of nutrients evenly with fertigation NPK was responsible for the improvement of ascorbic acid concentration and titrable acidity in tomato fruits.

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أهميه أنظمة الري و التسميد المستخدمه في تحسين إنتاجيه محصول الطماطم وجودة ثماره في أرض جيرية مستصلحة حديثا

نادر رمزى حبشى محسن عبد الحميد محمد البسيونى محمد صابر على عويس*

معهد بحوث الأراضى والمياه والبيئة – مركز البحوث الزراعية – جيزة – مصر
***قسم الأراضى والمياه – كلية الزراعة – جامعة الفيوم – مصر**

أجريت تجربة حقلية علي أرض جيرية ذات قوام طميى رملى مستصلحة حديثا بمزرعة خاصة، تقع بمحازاة الطريق الصحراوي القاهرة - اسكندرية (كيلو ٥٢)، منزرعه بنباتات الطماطم *(Lycopersicon esculentum)* تحت نظامي ري سطحي، ري بالتنقيط. ولدراسة تأثير إضافة الأسمدة المعدنية لبعض المغذيات الكبرى (NPK) من خلال نظامي التسميد الأرضي والتسميد مع مياه الري بالتنقيط وذلك علي كمية محصول الطماطم وجودة ثماره، مع إعطاء أهمية خاصة لدور تلك المعاملات علي كفاءة أستخدام أسمدة NPK المضافة سواء أرضيا أو مع مياه الرى بالتنقيط. وكانت الأسمدة المستخدمة هي اليوريا (46%N) وفوسفات البوتاسيوم الأحادية (38% K_2O and 15% P_2O_5)، بمعدل إضافة ١٠٠ كجم N/فدان، ٤٠ كجم P_2O_5/فدان، ٤٨ كجم K_2O/فدان كإضافة أرضية أو التسميد مع مياه الري بالتنقيط.

بعد ٦٠ يوم من بداية الشتل تم أختيار بعض النباتات لتقدير قياسات النمو الخضري (طول النبات، الوزن الجاف، دليل مساحة الورقة،عدد الأزهار/نبات، ومحتوي الأوراق من الكلوروفيل بنوعيه a and b)، بالأضافة إلي محتوي النبات من عناصر النتروجين والفسفور والبوتاسيوم. وفى نفس الفترة تم أيضا أخذ عينات من التربة علي أعماق مختلفة (٠- ١٥، ١٥-٣٠، ٣٠-٤٥، ٤٥-٦٠ سم) لتقدير المحتوي الميسر فى التربة من عناصر النتروجين والفسفور والبوتاسيوم بعد ٩٠ يوم من الزراعة (مرحله النضج)، تم جمع محصول الطماطم لتقدير وزن الثمار علي إمتداد فترات طرح وجمع الثمار، مع تقدير جوده صفات الثمار من خلال تحديد قدرة التحمل ومحتواها من المواد الصلبه الذائبه وحمض الستريك وفيتامين ج والسكريات الكليه.

وتشير النتائج المتحصل عليها إلى أن أرض التجربة تنتمى إلى الوحدة التقسيمية التالية:

Typic Haplocalcids, coarse loamy, mixed, thermic، كما تنتمى إلى رتبة الأراضى المتوسطة الصلاحية للزراعة (Moderately suitable, S2s1s3s4)، كما يسود بها بعض المحددات لإنتاجية التربة ممثلة فى قوام التربة، $CaCO_3$ ، الجبس والتى تقع فى مدى بسيط-متوسط (Rating = 75-90)، كما وأن المياه المستخدمة فى الرى (مياه آبار جوفية) تعتبر جيدة الصلاحية للرى حيث تنتمى إلى الدرجة الأولى First category of C1S1 ، كما تشير النتائج إلى أن كل قياسات النمو الخضري المشار إليها سابقا قد سجلت زيادة معنوية كنتيجة للمعاملات تحت الدراسة مع تفوق معاملة التسميد خلال ماء الري بالتنقيط (Fertigation)، يليها الإضافة الأرضية مع كل من الري بالتنقيط والري السطحي. وبالنسبة للمحتوي الميسر من عناصر النيتروجين والفسفور والبوتاسيوم فى التربة، فقد أظهرت النتائج أن هناك زيادة معنوية في كل من عنصري النيتروجين والبوتاسيوم في الطبقة السطحية (صفر – ١٥) للتربة عند معاملة التسميد من خلال الري بالتنقيط وذلك ربما يرجع إلى إنخفاض معدل الفقد بالغسيل، بينما عنصر الفسفور فقد وجد أنه يظل في صورة غير متحركة في الطبقة السطحية. كما أظهرت النتائج زياده نسبية في تركيزات عناصر النيتروجين والفسفور والبوتاسيوم كمحتوى وكميات ممتصة بواسطة

النباتات كنتيجة لتلك المعاملات مع تفوق لمعاملة التسميد من خلال ماء الري بالتنقيط ويليها الأضافة الأرضية مع الري بالتنقيط مقارنة بمعاملة التسميد الأرضي تحت نظام الري السطحي.

وقد حققت المعاملات تحت الدراسة أفضل القيم لمحصول الطماطم بزياده قدرها ٣٦.٦٨، ١٦.٨٠٪ لكل من معاملات التسميد من خلال الري بالتنقيط والإضافة الأرضية مع الري بالتنقيط مقارنة بطريقة التسميد الأرضي مع الري السطحي. بالأضافة إلي ذلك فقد كان هناك زيادة معنوية لعدد الثمار لكل نبات وصلت إلي ٥٦.٩ كمتوسط في حالة التسميد من خلال ماء الري بالتنقيط، ٥٠.٤ في حالة الإضافة الأرضية مع الري بالتنقيط، ٤٣.٧ مع التسميد الأرضى تحت نظام الري السطحي. أما من حيث دراسة كفاءة أستخدام تلك الأسمدة، فقد سجلت أعلي قيمة لها عند أستخدامها من خلال الري بالتنقيط (٢٠٥.٩ كجم ثمار/ كجم NPK)، يليها الأضافة الأرضية مع الري بالتنقيط (١٧٥.٩ كجم ثمار/ كجم NPK) ثم الإضافة الأرضية مع الري السطحي (١٥٠.٦ كجم ثمار/كجم NPK). ولذا فإنه يوصى بإجراء عملية التسميد بعناصر NPK من خلال أذابتها في مياه الري بالتنقيط (Fertigation) خاصة فى مثل تلك الأراضى ذات المحتوى المرتفع نسبيا من $CaCO_3$ ، حيث أن تلك المعاملة قد أدت إلي تحسن ملحوظ في قياسات النمو الخضري و من ثم زيادة محصول الطماطم وجودة ثماره.