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EVALUATION OF SOME MULTINUTRIENT FERTILIZERS FOR TOMATO AND SQUASH ROTATION AND SOIL HEALTH UNDER DIFFERENT IRRIGATION SYSTEMS.

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ABSTRACT

Two field experiments (tomato and squash) in rotation were conducted at Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate, Egypt during the summer and the autumn seasons of 2008 and 2009 to evaluate the effects of some multinutrient fertilizers for long term cultivation under two irrigation systems on crop yield and soil quality. The experiments were carried out under wire proof green house conditions. Tomato (*Lycopersicon esculentum L*) seedlings under the local name of Alessa was planted . Two irrigation systems and nine fertilizer treatments were examined . Split plot design was used with four replicates. The main plots were assigned by two irrigation systems (surface furrow irrigation, and drip irrigation). The sub plots were randomly assigned by nine fertilizer treatments of :- 1-control (without fertilization), 2- recommended dose of N and P (200 kg N and 13.08 kg P fed^{-1}), 3- recommended dose of P and K (13.08 kg P and 41.5 kg K fed^{-1}), 4- recommended dose of N and K, 5- multinutrients 20 – 20 – 20 +1% Mg + micro nutrients, 6- multinutrient 20 – 20 – 20 + 1% Mg, 7- multinutrient 20 – 20 – 20 NPK as compound fertilizer (200 kg fed^{-1}), 8- commercial multinutrient 20 – 20 – 20 NPK as mixed fertilizer and 9- recommended dose of N. P and K (as urea, superphosphat and potassium sulphate). Squash was transplanted on the same design without fertilization depending on the previous fertilizer residuals. The obtained results can be summarized as :- surface irrigation gave higher tomato fruit yield of 32178.3 kg fed^{-1}, the highest dry fruit weight of 2413.37 kg fed^{-1}, higher P %, P content of the fruits (0.257% and6.2 kg fed^{-1}) respectively, higher values of K % in the shoot and fruits (0.9 and 2.7%) , NUE, PUE, KUE and the highest squash fruit yield of 10202.67 kg fed^{-1}. Drip irrigation produced the highest N % in the shoot and fruits of 0.602 and 0.912 % respectively. Surface irrigation generally decreased available N, K in the soil after squash while available P was increased compared to the values before planting. The highest tomato fruit yield of 31105.2 kg fed^{-1}, N% in tomato shoot of 0.677%, NUE155.5, PUE 814.0 and KUE 622.1 were obtained with T5. The highest K uptake 134.38, NUR% 27.42, PUR% 27.63 and KUR% 195.50 were obtained with T9.

Keywords: Multinutrient, fertilizers, irrigation, tomato, squash yield, soil health

INTRODUCTION

In arid or semi-arid areas crop growth is mainly dependent on irrigation. Irrigation methods and management are of importance to soil water status, and thus to plant water status. According to population increase in Egypt, there is a shortage of irrigation water, thus there are urgent needs to optimizing irrigation water. Shawky and Sallam (1996) concluded that improving water management in irrigated agriculture areas cannot attain sustained optimum land productivity conditions unless proper soil-crop-water relations are used. Drip irrigation systems, water can be applied directly to the crop at the root zone, having positive effects on yield and water savings and increasing the irrigation performance. Salts can accumulate near the root zone as a result of inadequate flushing at the wetting front (Dasberg and Or, 1999). Balanced fertilization is a best way for increasing crop production and fertilizes efficiency. Cabrera *et al.*, (2007) studied the unbalanced soil nutrition and its effect on tomato and cucumber yield under protected cultivation conditions, both species yield were lower than the expected ones, as a result of a nutritional unbalance determined by inadequate internutrient relations enhanced by fertigation.

The use of the stick fertilizer N:P:K (20:10:20) greatly increased the production of many new fine roots from the tomato plants compared to the unfertilized control, root length and root length density in the stick fertilizer treatment increased by 3.6 – 6.7 fold (Tian and Saigusa, 2005).

Tomato crop positively responded to the simultaneous of water and fertilizer under a drip system of irrigation in comparison with conventional application of fertilizer (Cukaliev *et al.*, 2008). Squash is similar in root distribution as tomato, it is widely grown all the year. The some significant and steady increases on number of fruits number and its various components corresponded to the progressive raising in the applied N levels up to 120 kg N fed^{-1}. However, the highest two N levels (80 and 120 kg N fed^{-1}) did not significantly differ in their effects on the average fruit weight $plant^{-1}$(Saad Radiya. 2002).

The objective of the present study is to evaluate the effect of irrigation systems, single, multintrients and mixed fertilizers on tomato and squash rotation yields and soil health.

MATERIALS AND METHODS

Two field experiments in rotation were conducted at Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate, Egypt during summer and autumn seasons of 2008 and 2009 (tomato and squash) in rotation to study effect of the long term cultivation under two irrigation systems and different fertilization treatments on crops production and soil quality. The two experiments were carried out under wire proof green house conditions. The latitude and longitude of the experimental site were 31° 05′ N and 30° 56′ E, respectively. Composite soil sample was collected from the experimental site before transplanting, prepared by air drying, crushing, sieving to pass through a 2 mm screen and analysied .

Some physical and chemical soil characteristics were determined according to Black *et al.*, (1965) and are shown in Table 1.

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

Parical size analysis (%)			Texture	Bulk density (kg m^3)	pH*	ECe (dSm^{-1})	Available nutrients (mg kg^{-1})		
Sand	Silt	Clay					N	P	K
5.62	31.59	62.79	Clayey	1.37	7.09	2.15	37.0	5.0	266.8

*** 1:2.5 soil : water suspension**

Tomato (*Lycopersicon esculentum*) seedlings under the local name of Alessa was used. One nursery plant (age 30 days) of tomato was transplanted under the drip irrigation 50 cm between the dripers and one meter between the laterals, (120 plant x 70 raws = 8400 plant fed.-1), the same number was conducted under the surface irrigation. Tomato was transplant on 15 April 2008. The plot area was $4.5m^2$. Split plot design was used with four replicates. The main plots were assigned by two irrigation systems of 1- Surface furrow irrigation, and 2- Drip irrigation. The sub plots were randomly assigned by nine fertilizer treatments of :- 1- Control (without fertilization), 2- Recommended dose of N and P (200 kg N and 13.08 kg P fed^{-1}), 3- Recommended dose of P and K (13.08 kg P and 41.5 kg K fed^{-1}), 4- Recommended dose of N and K, 5- Multinutrients 20 – 20 – 20 +1% Mg + micronutrients, 6- Multinutrients 20 – 20 – 20 + 1% Mg, 7- Multinutrients 20 – 20 – 20 NPK as compound fertilizer (200 kg fed^{-1}), 8- Commercial multinutrients 20 – 20 – 20 NPK as mixed fertilizer and 9- Recommended dose of N. P and K (as urea, superphosphat and potassium sulphate).

Nitrogen was applied of the single application as urea 46.5% N before the first, third and fivth irrigation in the furrow surface irrigation system and three times weekly in the drip irrigation during the growth period. Phosphorus was applied as single superphosphate 6.758 % P with the first irrigation after transplanting in the surface furrow irrigation and as monoammonium phosphate 26.59% P one dose weekly during the growth period in the drip irrigation system (the nitrogen in the monoammonium phosphate was considered). Potassium was applied as potassium sulphate 39.84% K in both irrigation systems with the nitrogen doses. Maltinutrients were added as the nitrogen application in both irrigation systems. In treatments of 5, 6, 7 and 8 N and K rates completed by the soluble single fertilizers.

For the second experiment squash was planted as a rotation after the end of tomato crop on the same place without any tillage. Under two irrigation systems of surface furrow irrigation and drip irrigation no fertilizers treatments were added depending on the residual fertilizer of the previous crop (tomato). Squash (*Cucurbita pepo*) seedlings were transplanted on 18 September, 2008, 8400 seedlings were planted per feddan. Plant samples (leaves and fruits) were taken after harvest stage, dried and wet digested in concentrated $HClO_4$ + H_2SO_4. In the digestive extract, total nitrogen was determined by kjeldahl method according to Jackson, (1958); phosphorus was determined colorimetrically using spectrophotometer according to the method described by Snell and Snell (1976), and potassium was determined using flame photometer according to the method described by Jackson (1958).

N, P and K uptake: were calculated by the following equation:

$$\text{Element uptake (kg fed}^{-1}) = \frac{\text{element (\%)} \times \text{dry yield (kg fed}^{-1})}{100}$$

-Utilization rate (UR) of N, P K fertilizer: was calculated according to Finck, (1982) as the following formula:

$$UR\% = \frac{\text{Total removal* - removed from soil reserves**}}{\text{Nutrient amount of applied fertilizer***}}$$

Where: * plant uptake. (kg fed^{-1}).
** The uptake of control treatment. (kg fed^{-1})
*** Quantity of nutrient in applied fertilizer. (kg fed^{-1})

Utilization efficiency: was calculated by the following equation:-

$$UE = \frac{\text{Total fruit yield (kg } fed^{-1}\text{)}}{\text{Utilization rate for the treatment x element applied}}$$

Fertilizer use efficiency: was calculated according to the following equation:-

$$FUE = \frac{\text{Fruits yield (kg} fed^{-1}\text{)}}{\text{Fertilizer applied}}$$

All data were statistically analysed using analysis of variance technique by means of MSTATC computer program according to Snedecor and Cochran, (1980).

RESULTS AND DISCUSSION

Data in Table 2 reveal that the average of fruit weight was affected high significantly by the irrigation systems. The highest average of fruit weight 32178.3 kg fed^{-1} was resulted from the surface irrigation. Increases of fruit weight which obtained from surface irrigation compared to drip irrigation may be due to increasing irrigation water in the surface irrigation led to decreasing soil electrical conductivity which enhance tomato growth and fruit setting (Table 1). These results could be enhanced with those obtained by Chung and Jun (2002), they reported that fruit weight was significantly decreased as the soil EC became higher than 1.5 dSm^{-1} .

Data listed in Table 2 indicate that the tomato fruit weight was significantly affected by the NPK fertilizer treatments. The highest value of tomato fruit yield (31105.2 kg fed^{-1}) was obtained with T5 (NPK20:20:20 + 1% Mg +micro) whereas, the lowest value of tomato fruit weight was (10558.8 kg fed^{-1}), resulted from control treatment. These results may be attributed to the effect of the balanced fertilizer and its contents of magnesium and micronutrients which enhance plant growth and yield, in addition to its effects on EC elevates. These results could be confirmed with those obtained by Abd El-Rahman (2001), Abdel-Aziz (2008), Soumya *et al.*, (2009) and Sima *et al.*, (2009).

Data in Table 2 indicate that N concentration in shoot and fruits of tomato plants was significantly affected by irrigation systems, the highest N concentration values were (0.60% and 0.91%) in shoot and fruits respectively, which obtained with the drip irrigation. This due to presence of available nutrients in the root zone for long term, which led to great absorption. These results are harmony with the obtained by Cukaliev *et al.*, (2008), badr and Talaab (2008) and Badr *et al.*, (2010).

It is quit obvious from the data presented in Table 2 the irrigation systems clearly affected N content of tomato shoots and fruits as well as the N uptake. The highest N content of (42.8 and 21.3 kg N fed^{-1}) of the shoots and fruits, respectively were obtained with the drip and surface irrigation, respectively. While the highest nitrogen uptake of (52.6 kg N fed^{-1}) was observed with the drip irrigation. The increases in the N uptake which recorded with the drip irrigation may be due to the increases of the available nitrogen in the root zone for the long time during the growth period. These results could be enhanced by those reported by El-Araby and Feleafel, (2003) and Zotarelli *et al.*, (2007).

Table 2: Effect of irrigation systems and fertilization treatments on weights of tomato fruits and shoots and their nitrogen composition at harvest (2008 season).

Irrigation and fertilizer	Total fruit weight (kg fed^{-1})	Dry shoot (kg fed^{-1})	%N in shoot	N content in shoot (kg fed^{-1})	Dry fruit (kg fed^{-1})	%N in fruits	N content in fruit (kg fed^{-1})	Total N uptake by shoot+ fruit (kgfed^{-1})
Drip	14313.6	7114.8	0.60	42.80	1073.36	0.91	9.80	52.60
Surface	32178.3	4890.9	0.49	23.80	2413.37	0.88	21.30	45.10
F test	**		*			*		
T1	10558.8	3324.7	0.38	12.50	791.7	0.68	5.34	17.84
T2	24307.5	7375.2	0.54	40.04	1822.8	0.90	16.50	56.54
T3	17747.1	6266.4	0.53	33.40	1331.4	0.74	9.80	43.20
T4	20283.9	6120.2	0.50	30.42	1520.4	0.98	14.90	45.32
T5	31105.2	5490.2	0.68	37.17	2333.1	0.88	20.40	57.57
T6	28186.2	4628.4	0.62	28.79	2113.9	0.96	20.20	48.99
T7	26197.5	4922.4	0.56	27.57	1963.5	0.94	18.30	45.87
T8	26405.4	5434.8	0.49	26.52	1980.3	0.91	17.90	44.42
T9	24420.9	10466.4	0.51	53.17	1831.2	1.07	19.50	72.67
F test	**	N.S	**	N.S	N.S	**-	N.S	N.S
LSD 0.05	2952.5	N.S	0.09	N.S	N.S	0.13	N.S	N.S

T1: Control (without fertilization),
T2: Recommended dose of N and P (200 kg N and 13.08kg P fed^{-1}),
T3: Recommended dose of P and K (13.08 kg P and 41.5 kg K fed^{-1}),
T4: Recommended dose of N and K,
T5: Multinutrients 20 – 20 – 20 +1% Mg + micronutrients,
T6: Multinutrients 20 – 20 – 20 + 1% Mg,
T7: Multinutrients 20 – 20 – 20 NPK (200 kg fed^{-1}),
T8: Commercial multinutrients 20 – 20 – 20 NPK,
T9: Recommended dose of N. P and K (as urea, superphosphat and potassium sulphate
N.S : not significant

Data presented in Table 2 reveal that N concentration in tomato shoots and fruits were high significantly affected by the fertilizer treatments. The highest value of N% in shoot was (0.68%) obtained from T5 (NPK 20:20:20 +1%Mg +micro), while the highest value of N% in fruits was (1.07%) from T9 (recommended dose of NPK as a single fertilizers). Also, the highest value of N uptake was (72.67 kg N fed^{-1}) obtained with T9 followed by (57.57 kg N fed^{-1}) with T5. The lowest N uptake value of (17.84 kg N fed^{-1}) was recorded with T1 (without fertilizer). The increment of N content and N uptake by tomato plants may be due to higher availability of the nutrients with increase N fertilizer, which final resulted in better root growth and increased physiological activity of root to absorb the nutrients. These results could be confirmed with those obtained by Han *et al.*, (2005) and Badr *et al.*, (2010).

Data in Table 3 reveal that no significant differences between the irrigation systems on P% in the dry shoot. While, these was a significant difference in the dry shoot between the two irrigation systems which affected the phosphorus content. The higher value (6.69 kg fed^{-1}) was obtained with the drip irrigation. On the contrary, the surface irrigation had higher dry fruit yield (2413.37 kg fed^{-1}) with higher P% of (0.257%) which produced higher P content of the fruits (6.2 kg fed^{-1}). Thus there was a negligible difference between P uptake values due to the two irrigation systems of (9.15 and 9,92 kg fed^{-1}) with the drip and surface irrigation, respectively. This may be due to the phosphorus less in their mobility in the soil, less in leaches which make the irrigation systems less effect in the uptake. These results could be enhanced by those obtained by El-Atawy (2003), Hebbar *et al.*, (2004), and Kadam *et al.*, (2005b).

Data presented in Table 3 reveal that the highest values of P concentration (0.115 and 0.315%) in shoot and fruit were obtained with T5 NPK (20:20:20 + 1%Mg +micro.) and T6 NPK (20:20:20 +1%Mg), respectively. The highest value of P uptake (13.48 kg fed^{-1}) was resulted from tomato plants treated with the recommended dose of NPK. While the lowest value of P uptake (5.19 kg fed^{-1}) was resulted from tomato plants without fertilizer (control). The obtained results may be due to T9 and T5 contain balanced nutrients N, P and K, in addition to the nutrients as impurities in the superphosphate and N, P, K, Mg, Fe, Mn and Zn in T5 which enhance plant uptake. These results could be supported with those obtained by Tian and Saigusa (2005) and Badr *et al.*, (2010).

Data in Table 3 indicate that the highest values of K% in shoot and fruits were (0.90 and 2.7%) resulted from the surface irrigation, hence the highest value of K uptake (109.18 kg fed^{-1}) was obtained with the surface irrigation. From these results it can be mentioned that the increase of K% and uptake by tomato plants my be attributed to the availability and K content in the soil depend on large extent on soil moisture conditions. The experimental soil had high electrical conductivity (salt affected soil) review and the dominant cation in the region is the sodium, the surface irrigation leached some sodium cation which led to increase potassium uptake. These results could be enhanced with those reported by El-Atawy (2007) and Badr *et al.*, (2010).

Table 3: Effect of irrigation systems and fertilization treatments on P and K composition of tomato fruits and shoots at harvest stage of 2008 season.

Irrigation and fertilizer	P in shoot (%)	P content In shoot (kgfed-1)	P in fruits (%)	P content in fruit (kgfed-1)	Total P uptake shoot+ fruit (kgfed-1)	K in shoot (%)	K content shoot (kgfed-1)	K in fruits (%)	K content fruit (kgfed-1)	Total K uptake shoot +fruit (kgfed-1)
Drip	0.094	6.69	0.230	2.46	9.15	0.80	56.92	2.40	25.76	82.68
Surface	0.076	3.72	0.257	6.20	9.92	0.90	44.02	2.70	65.16	109.18
F test	N.S		**			**		*		
T1	0.103	3.42	0.223	1.77	5.19	0.84	27.92	1.10	8.71	36.63
T2	0.094	6.93	0.250	4.55	11.48	0.88	64.90	2.90	52.86	117.76
T3	0.082	5.14	0.226	3.01	8.15	0.86	53.89	2.60	34.62	88.51
T4	0.082	5.01	0.152	1.31	7.32	0.75	45.90	2.80	42.57	88.47
T5	0.115	6.31	0.273	6.37	12.68	0.93	51.06	2.50	58.33	109.39
T6	0.096	4.44	0.315	6.66	11.10	0.99	45.82	3.00	63.42	109.24
T7	0.090	4.43	0.215	4.22	8.65	0.82	40.36	2.70	53.01	93.37
T8	0.075	4.08	0.220	4.36	8.44	0.87	47.01	3.20	63.37	110.38
T9	0.074	7.75	0.313	5.73	13.48	0.86	90.43	2.40	43.95	134.38
F test	N.S		**			N.S		**		
LSD 0.05	N.S		0.06			N.S		0.61		

Data presented in Table 3 reveal that K concentration in shoot was non significant, while in the fruit it was high significantly affected by fertilization treatments. The highest value of K% in shoot (0.99%) resulted from plants fertilized with multi nutrients (20:20:20 +1%Mg). The lowest value of K% (0.75%) resulted from recommended dose of single N and K (T4). The highest value of K% in fruits (3.20%) was obtained with multi nutrient commercial (T8), while the lowest value of K% (1.1%) resulted from treatment without fertilizer (T1). On the other hand, The highest value of K uptake (134.38 kg fed^{-1}) resulted from the recommended dose of single NPK (T9), while the lowest value was (36.63 kg fed^{-1}) obtained from tomato plants without fertilizer treatment (T1). The increment of K content and K uptake by tomato plants may be due to higher availability of the nutrients with increase in the N fertilizer which final resulted in better root growth and increased physiological activity of roots to absorb the nutrients. These results could be enhanced with those obtained by El-Atawy (2007) and Badr *et al.*, (2010).

Data presented in Table 4 show the effect of fertilization treatments on N, P and K utilization rate by tomato plants. The highest value of UR% of N (27.42%) resulted from tomato plants fertilized with recommended dose of single NPK (T9), while, the lowest value of UR% of N (13.29%) obtained from tomato plants which fertilized with commercial multi nutrients (T8).The highest values of UR% of P and K% were (27.63 and 195.5%) resulted from recommended dose of single NPK (T9) respectively, while the lowest value of

UR% of P (9.87%) was obtained from tomato plants which fertilized with the recommended dose of single P and K and the lowest value of UR% of K (103.68%) resulted from tomato plants which fertilized with recommended dose of single fertilizer of N and K (T4). These results explain that presence of the balanced N, P and k increased the utilization rate of all the used treatments. Absent of one of the nutrients led to decrease the utilization rate of the other nutrients. These results could be supported with those obtained by Kadam *et al.*, (2005 a and b) and Badr *et al.*, (2010).

Table 4: Effect of fertilization treatments on N, P and K utilization rate and N, P and K utilization efficiency in tomato yield

Treatments	N utilization rate (%)	P utilization rate (%)	K utilization rate (%)	N utilization efficiency	P utilization efficiency	K utilization efficiency
T1	-	-	-	-	-	-
T2	19.35	20.97	-	628.1	3858.3	-
T3	-	9.87	103.76	-	3286.5	341.3
T4	13.74	-	103.68	724.4	-	390.1
T5	19.87	18.73	145.52	777.6	4152.9	426.1
T6	15.58	14.78	145.22	880.8	4769.2	388.1
T7	14.02	8.65	113.48	935.6	7571.5	463.7
T8	13.29	8.13	147.50	1015.6	8124.7	326.8
T9	27.42	27.63	195.50	452.2	2907.3	250.5

Data in Table 5 show that the highest values of nitrogen use efficiency (NUE), phosphorus use efficiency (PUE) and potassium use efficiency (KUE) were (160.80, 1072.60 and 643.50) obtained from tomato plants irrigated with surface irrigation, respectively. This may be due to the nutrient use efficiency depending on the yield quantity. The surface irrigation encourage the increase of crop yield by avoiding the effect of salinity in addition to increase the solubility and availability of the nutrients. These results could be cnfirmed with those reported by Kadam and Sahane (2002 a and b) and El-Atway, (2007).

Data listed in Table 5 prove that the highest values of NUE, PUE and KUE (155.50, 814.0 and 622.1) were obtained from tomato plants which fertilized with multi nutrients NPK 20:20:20 +1% Mg + micro.) T5 in N,K and with T9 of P while, the lowest values of NUE, PUE and KUE (101.4, 591.5 and 263.70) resulted from the recommended dose of single fertilizer of N and k (T4), recommended dose of single fertilizer of P and K (T3) and multi nutrients NPK 20:20:20 +1% Mg (T6), respectively. This due to the applied element increased tomato yield. Also, presence of Mg plus micronutrients enhanced plant production

Table 5: Effect of irrigation systems and fertilization treatments on N, P and K utilization use efficiency (kg fruit/ unit fertilizer)

Irrigation and fertilizer	N-use efficiency	P- use efficiency	K- use efficiency
Drip	71.50	477.10	286.20
Surface	160.80	1072.60	643.50
T1	-	-	-
T2	121.50	810.20	-
T3	-	591.50	354.90
T4	101.40	-	405.60
T5	155.50	777.63	622.10
T6	140.90	704.66	263.70
T7	130.90	654.9	523.90
T8	132.00	660.14	528.10
T9	122.10	814.00	488.40

Soil quality after tomato, squash rotation

Available Nitrogen

Data presented in Table 6 show that the irrigation methods and fertilization treatments clearly affected available-N in the soil. Under the control (without fertilization) available N decreased from 37 $mgkg^{-1}$ before transplanting to 16 and 5.0 $mgkg^{-1}$ after Tomato and Squash, respectively with the surface irrigation. While under drip irrigation the decreases were from 37 to 30 and 5.9 $mgkg^{-1}$ after tomato and squash, respectively. Under T2 available N was decreased from 37 to 27.71 and 11.44 $mgkg^{-1}$ after tomato and squash, respectively with surface irrigation. While under the drip irrigation available N increased from 37 to 70.77 $mgkg^{-1}$ after tomato and it was decreased to 9.99 mg kg^{-1} squash. Under T3 available N was decreased with the two irrigation method, but the decrease was low under the drip irrigation. Under T4, T5 and T6 available N was decreased with surface irrigation and on contrary it increased with drip irrigation after the tomato, while it had approximately the same values with surface and drip irrigation after squash. Under T7, T8 and T9 available N decreased after tomato with the surface irrigation while it was constant with the drip and the same values of drip and surface were detected after squash.

In general under the surface irrigation available N was decreased from 37 to average 22.64 $mgkg^{-1}$. While it was increased to the average 41.48 with the drip irrigation. This may be due to the losses by leaching with the surface irrigation. After squash available N had the same values with the two irrigation methods. This may be due to the needs of squash was rather than the residual. These results are confermed to those obtained by Lecompte *et al.* (2008).

Available phosphorus

Data presented in Table 6 show that no clear differences in the available Phosphorus between the used irrigation methods after tomato (8.08 and 8.39 $mgkg^{-1}$) and after squash (5.11 and 5.75 $mgkg^{-1}$) with surface and drip irrigation, respectively. Generally available P was increased after tomato from 5 to 8.08 and 8.39 $mgkg^{-1}$ and returned blew after squash. This due to phosphorus immobile in the soil (no losses by leaching) and the decreasing after squash due to plant absorption and phosphorus fixation by calcium in the soil of high pH. All the fertilizer treatments increased available phosphorus in the soil after tomato except T4, where no clear increase was observed. The highest increase of available phosphorus values after tomato were observed with T3 and T9 followed by T5 under both irrigation treatments. This due to phosphorus applied with the fertilizer and the less amount of the leached with the irrigation water. Similar results were reported by Ling *et al.* (2005) and Zhang *et al.* (2009).

Available potassium

Data presented in Table 6 reveal that irrigation method clearly affected available K in soil after tomato, squash rotation. Surface irrigation generally decreased available K after tomato from 266.8 to average 242.7 $mgkg^{-1}$. The decrease was increased after the squash. On the other hand available K was increased after tomato in the drip irrigation from 266.8 to average 351.8, whereas it decreased after squash to the primary value. This due to the losses in potassium by leaching under the surface irrigation and increasing K uptake in presence of moisture.

With regard to the effects of fertilization treatments on available K in the soil, all the fertilizer treatments led to decrease available K after tomato and squash in the surface irrigation except T3 and T4 they were increased available K. On the contrary all the fertilization treatments under the drip irrigation increased available K after tomato and still higher after squash.These results could be confirmed with those reported by Cabrera *et al.* (2007) and Zhang *et al.* (2009).

Table 6 : Available N,P and K ($mgkg^{-1}$) in soil after tomato, squash rotation.

Treatments.	N ($mgkg^{-1}$)				P ($mgkg^{-1}$)				K ($mgkg^{-1}$)			
	Surface irrigation		Drip irrigation		Surface irrigation		Drip irrigation		Surface irrigation		Drip irrigation	
	tomato	squash	tomato	squash	tomato	squash	tomato	squash	tomato	squash	tomato	squash
T1	16.8	5.00	30.00	5.90	5.00	2.40	5.00	4.16	200.14	164.30	207.80	199.80
T2	27.71	11.44	70.77	9.99	7.50	5.33	8.70	6.30	201.43	197.90	266.80	224.18
T3	18.20	10.31	25.30	6.98	10.80	8.33	10.00	7.50	321.10	270.20	329.60	270.00
T4	26.11	10.45	45.84	7.10	5.90	2.50	8.10	5.00	318.32	216.70	352.20	252.33
T5	19.01	5.77	41.25	12.15	9.17	6.30	9.17	5.00	252.13	205.70	408.30	276.17
T6	24.98	5.02	47.23	14.74	8.60	5.33	10.30	6.30	236.24	197.30	468.39	331.90
T7	26.20	12.77	34.43	7.86	8.80	5.83	8.33	5.00	228.60	228.60	450.34	231.90
T8	17.40	10.43	37.90	6.40	6.17	5.00	6.67	5.83	212.13	247.50	360.49	254.90
T9	27.39	10.72	30.59	11.5	10.80	5.00	10.25	6.66	214.50	204.20	322.76	282.00
Mean	22.64	9.10	41.48	9.18	8.08	5.11	8.39	5.75	242.70	214.70	351.80	258.10

Soil pH(1:2.5 soil : water suspention)

Data presented in Table 7 reveal that there was little effect due to irrigation methods on soil pH after tomato and squash rotation. There was negligible increase in the soil pH under the drip irrigation compared to the surface irrigation. The increases were from 7.15 to 7.19 after tomato and from 7.14 to 7.16 after squash. This due to the soil buffering capacity. No clear sequence of the effects due to fertilizers treatments on soil pH . This due to the soil buffering capacity. Similar results were reported by Yan *et al.* (2004) and Hebbar *et al.* (2005).

Soil EC dSm^{-1} (1:5 soil : water extract)

Data presented in Table 7 show that dramatic increase in the soil EC was detected after tomato and squash cultivation. Irrigation methods clearly affected soil EC in tomato squash rotation. Drip irrigation causes clear increase in the soil EC after tomato and squash compared to the surface irrigation. The average EC values were 2.46 and 1.78 dSm^{-1} under the drip irrigation after tomato and squash, respectively. While they were 1.34 and 0.72 dSm^{-1} under the surface irrigation. In respect to fertilization treatments, generally all the fertilization treatments increased soil EC. The highest EC mean values (drip, surface after tomato and squash) of 1.81, 1.77, 1.76 and 1.72 dSm^{-1} were recorded with the single fertilizers of PK (T3), NK(T4), NP(T2) and NPK (T9), while the lowest values were recorded with the multinutrients with the sequence from low to high values T7, T5, T6 and T8. This may be due to the differences in the solubility and salt index of the fertilizers. These results are in harmony with those reported by Hebbar *et al.*(2005).

Table 7 : pH and EC in soil after tomato, squash rotation.

Treatments	pH				EC dSm^{-1}				Mean
	Surface irrigation		Drip irrigation		Surface irrigation		Drip irrigation		
	tomato	squash	tomato	squash	tomato	squash	tomato	squash	
T1	7.07	7.04	7.15	7.09	0.33	0.32	0.52	0.82	0.49
T2	7.14	7.11	7.27	7.22	1.52	0.86	2.77	1.92	1.76
T3	7.17	7.16	7.22	7.19	1.60	0.88	2.81	1.96	1.81
T4	7.20	7.20	7.24	7.20	1.57	0.84	2.79	1.90	1.77
T5	7.14	7.12	7.24	7.20	1.35	0.69	2.70	1.85	1.64
T6	7.18	7.15	7.11	7.10	1.45	0.75	2.65	1.89	1.68
T7	7.19	7.18	7.17	7.14	1.37	0.65	2.55	1.88	1.61
T8	7.13	7.13	7.18	7.17	1.40	0.81	2.61	1.95	1.69
T9	7.18	7.18	7.18	7.18	1.50	0.70	2.75	1.93	1.72
Mean	7.15	7.14	7.19	7.16	1.34	0.72	2.46	1.78	

- pH in 1: 2.5 Soil : Water suspention
- EC dsm^{-1} in 1:5 Soil: Water extract

In conclusion this study shows that presence of the balanced N, P and k increased the utilization rate of all the used treatments ,where (T5: Multinutrients 20 – 20 – 20 +1% Mg + micronutrients,)has the superiority. Absent of one of the nutrients led to decrease the utilization rate of the other nutrients. Surface irrigation gave higher tomato fruit yield, dry fruit weight, higher P %, P content of the fruits, higher values of K % in the shoot and fruits, highest squash fruit yield. Drip irrigation produced the highest N % in the shoot and fruits. Surface irrigation generally decreased available N, K in the soil after squash while available P was increased compared to the values before planting. All the fertilization treatments increased soil EC, the highest EC mean values (drip, surface after tomato and squash) were recorded with the single fertilizers of PK (T3), NK(T4), NP(T2) and NPK (T9), while the lowest values were recorded with the multinutrients with the sequence from low to high values T7, T5, T6 and T8.

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تقييم بعض الأسمدة المركبة على تعاقب الطماطم والكوسة وجودة التربة تحت نظم الري المختلفة

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نفذت تجربتان حقليتان بمزرعة محطة البحوث الزراعية بسخا محافظة كفر الشيخ – مصر خلال الموسمين الصيفى والخريفى لعامى ٢٠٠٨ و٢٠٠٩ لدراسة اثر تعاقب الكوسة بعد الطماطم تحت نظم رى ومعاملات تسميد مختلفة على المحصول وكفاءة التسميد وجودة التربة. حيث نفذت التجارب تحت ظروف الصوبة السلكية واستخدم تصميم القطع المنشقة فى اربعة مكررات حيث شملت القطع الرئيسية على نظامين للرى وهما الرى السطحى والرى بالتنقيط، كما شملت القطع الشقية بتسعة معاملات تسميد وهى:- ١- كنترول (بدون تسميد)، ٢- المعدل الموصى به من الاسمدة النتروجينيه والفوسفاتية المفردة (٢٠٠ كج ن + ١٣.٠٨ كج فوللفدان) ، ٣- - المعدل الموصى به من الاسمدة الفوسفاتية والبوتاسية المفردة (١٣.٠٨ كج فو + ٤١.٥ كج بو للفدان)، ٤- المعدل الموصى به من الاسمدة النتروجينيه والبوتاسية المفردة ، ٥- اضافة السماد المركب ٢٠ - ٢٠ - ٢٠ ن - فو - بو + ١% ماغنيسيوم + عناصر صغرى حديد – منجنيز – زنك – نحاس، ٦- اضافة السماد المركب ٢٠ - ٢٠ - ٢٠ ن - فو - بو + ١% ماغنيسيوم، ٧- اضافة السماد المركب ٢٠-٢٠-٢٠ ن - فو - بو ، ٨- اضافة السماد المخلوط ٢٠ – ٢٠ – ٢٠ ن – فو – بو و ٩- اضافة المعدل الموصى به من ن – فو – بو اسمدة منفردة. وتم زراعة الكوسة على نفس التصميم بدون تسميد اعتمادا على التأثير المتبقى من السماد المضاف للطماطم. ويمكن تلخيص النتائج المتحصل عليها فيما يلى: ١- اعطى الرى السطحى اعلى محصول ثمار طازج للطماطم ٣٢١٧٨.٣ كج/فدان ، واعلى محصول جاف ٢٤١٣.٣٧ كج /فدان ، واعلى نسبه مؤية للفوسفور ومحتوى الفوسفور فى الثمار (٠.٢٥٧%، ٦.٢ كج /فدان على التوالى) واعلى نسبة مئويه للبوتاسيوم فى المجموع الخضرى والثمار (٠.٩ ، ٢.٧%) واعلى كفاءة استخدام السماد المضاف لكل من ،النتروجين (١٥٥.٥) والفوسفور(٨١٤.٠)والبوتاسيوم(٦٢٢.١). واعلى محصول لثمار الكوسة ١٠٢٠٢.٦٧ كج/فدان. ٢ - اعطى الرى بالتنقيط اعلى نسبه مؤية للنتروجين فى المجموع الخضرى والثمار للطماطم ٠.٦٠٢ ، ٠.٩١٢ % على التوالى. ٣- بصفة عامة الرى السطحى ادى الى نقص كل من النتروجين والبوتاسيوم الميسر فى التربة بعد زراعة الكوسة بينما زاد الفوسفور الميسر بالمقارنة قبل الزراعة. ٤- اعطت المعاملة رقم ٥ (اضافة السماد المركب ٢٠-٢٠-٢٠ ن - فو - بو + ١% ماغنيسيوم + عناصر صغرى حديد – منجنيز – زنك – نحاس) اعلى محصول ثمار طماطم ٣١١٠٥.٢ كج/فدان واعلى نسبة مؤية للنتروجين فى المجموع الخضرى ٠.٠٦٧٧% واعلى كفاءة لاستخدام السماد المضاف للنتروجين والفوسفور والبوتاسيوم.٥- اعطت المعاملة رقم ٩ (اضافة المعدل الموصى به من ن – فو – بو اسمدة منفردة) اعلى امتصاص للبوتاسيوم ١٣٤.٣٨ ومعدل امتصاص السماد للنتروجين (٢٧.٤٢) والفوسفور (٢٧.٦٣)والبوتاسيوم (١٩٥.٥).

قام بتحكيم البحث

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