Impact Of Emission Uniformity On Nutrients Uptake And Water And Fertilizers Use Efficiency By Drip Irrigated 15 Years Old Washington Novel Orange Trees Grown On A Newly Reclaimed Sandy Area.

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Abstract A two successive years (2008- 2009) completely randomized field experiment with four replications on ≈ 15 years old Washington novel orange trees was conducted in a drip irrigated newly reclaimed sandy area at Wadi El- Mollak, Ismailia governorate. Field emission uniformity (Eu) and absolute field emission uniformity (Eua) were determined for the area under study to be 85.6% for Eu and 86.8% for Eua. The irrigation system at the studied area could be considered as good. Although the uniformity of irrigation at the area under sandy has exceeded 85%, great differences were estimated between the discharge of the drippers that adversely affected the uniformity of growth, nutrients uptake, yield and both water and fertilizers use efficiency by the trees. With this respect, differences among the annual amounts of irrigation water received by the trees and consequently fertilizers dissolved in it have reached 43.1%. accordingly, significant variations were calculated to be 27.8% for leaf area, 26.7% for the dry weight of the leaves and 40.6% for obtained yield. Content of nutrients in the leaves of trees that received the maximum amount of irrigation water were higher than those of trees that received the minimum amounts by 18.3, 22.0, 25.8, 18.4 and 30.4% for N, P, K, Ca and Mg, respectively. Consequently, relative uptake of these nutrient took the same trend. Positive differences in this parameter were 45.3, 49.0, 51.8, 46.6 and 56.4% for the aforementioned nutrients, respectively. Values of water and fertilizers use efficiency by the trees were also greatly affected by the uniformity of irrigation. Higher amounts of irrigation water and applied fertilizers adversely affected both parameters. Improving the uniformity of emission of the trickle irrigation system to be more than 90% will lead to uniform fertigation. Uniform production (quantity and quality of fruits for each tree) is expected. [Journal of American Science 2010; 6(7):113-119]. (ISSN: 1545-1003).

Key Words: Trickle irrigation, Field emission uniformity, Sandy soil, novel orange, Water use efficiency, Nutrients uptake, Fertilizers use efficiency.

1. Introduction

For any irrigation system, the uniformity and efficiency of using both water and fertilizers by growing plants are of the major importance. Ideally, the application of water throughout the system should be absolutely uniform. With trickle irrigation, each dripper should deliver exactly a predetermined amount of water (Vermeiren and Jobling, 1980). Actually, drip irrigation system is not completely uniform. The variation or non –uniformity of emitter discharge in such irrigation system is the result of number of factors. The most important of these factors are the hydraulic variation and emitter discharge variation, (Bucks et.al., 1982). The hydraulic variation along the lateral line and sub main manifold is a function of land slope, length and diameter of the pipe and emitter discharge relationships. Emitter discharge variation at a given operating pressure is caused by manufacturing variability, and emitter plugging either complete or partial (Abou Khaled, 1982 & 1991; Bralts & Kesner, 1983 and Bralts et.al., 1985).

In Egypt, most of the newly reclaimed areas are planted with fruit trees under drip irrigation. Due to the variation in the amounts of irrigation water received by the growing trees in the same sub unit, growth, nutrients uptake, fruit yield and consequently both water and fertilizers use efficiency by the trees varied also from one tree to another (Ibrahim, 1993; El-Sonbaty & El-Hady, 1993; El-Hady et.al., 1994; El-Hady, 2002 and El-Hady and Abd El-Kader, 2003).

The present work aims at studying the effect of emission uniformity on ~ 15 years old novel orange trees grown in a newly reclaimed sandy area. In this study, the actual amounts of water and consequently fertilizers received by the trees through drip irrigation system were estimated. Nutrients uptake, fruit yield and both water and fertilizers use efficiency by the trees were evaluated.

2. Material and Methods

A two consecutive years (2008 and 2009) completely randomized field experiment, with four replications for each treatment (Steel and Torrie, 1980) was conducted as follows:

Location: Station no 18, Wadi El- Mollak, Ismailia governorate.

Indicator plant: Fifteen years old Washington novel orange trees.

Soil:

A sandy soil (>80% sand). The main analytical data of the soil determined after Klute, 1986 and Page et.al., 1982 are presented in table 1.

Irrigation system:

Trickle irrigation, distance between laterals is 7m. distance between drippers is 3m. drippers discharge is ≈4 l/hr. number of drippers/ feddan (one fed.= 4200 m^2) are 400 i.e. 2 drippers for each tree.

Irrigation water:

El-Shabab canal water was used. Regarding its quality, it was classified as no problem water (Ayers and Westcot, 1976), Table 2.

Water requirements for the crop:

Water requirements for the crop determined after Doorenbos and Pruit (1977) and Vermeiren and Jobling (1980) are 6000 m^3/fed devided into 3750 hrs. table 3 presents the distribution of irrigation water during the growing season (National Campaign for improving Citrus productivity in Egypt, 2003).

Table 1: Analytical properties of Wadi El- Mollak soil.

1- Mechanical analysis

Depth cm	Sand: Course 2000 - 200 µ %	Sand: Fine 200-20 µ %	Silt 20 – 2 µ %	Clay ‹2 µ %	Soil texture
0-30	47.7	32.3	15.9	4.1	Loamy sand
30-60	52.5	35.0	9.6	2.9	sand

2- Chemical analysis

Depth cm	pH 1:2.5	EC dSm^{-1}	$CaCO_3$ %	OM %	CEC Cmole kg^{-1}	Macro – nutrients ($\mu g\ g^{-1}$) Total			Available		
						N	P	K	N	P	K
0-30	7.95	0.65	6.12	0.35	7.9	520	435	770	36	6	65
30-60	8.30	0.40	7.35	0.19	7.3	415	312	546	32	6	58

3- Hydrophysical analysis

Depth cm	Bulk density $Mg\ m^{-3}$	Total porosity %	Water holding capacity* %	Field capacity* %	Wilting percentage*	Hydraulic conductivity $m\ day^{-1}$	Mean diameter of soil pores µ
0-30	1.51	43.0	19.6	6.45	2.55	4.65	13.3
30-60	1.63	38.5	18.7	5.82	2.36	4.35	12.9

*On dry weight basis.

Table 2: Analysis of irrigation water used

Source	pH	EC dSm^{-1}	Soluble cations (meq/l) Na^+	K^+	Mg^{++}	Ca^{++}	Soluble anions(meq/l) CO_3^{--}	HCO_3^-	Cl-	$SO_4^=$
El-Shabab canal	6.89	0.35	1.91	0.18	2.40	9.0	-	2.2	4.9	6.39

*Adj.SAR = 1.6.

** Fe = traces (<3 $\mu g\ g^{-1}$)..

Uniformity of emission:

Irrigation uniformity was determined after Vermeirn and Jobling (1980). the lowest and the highest rate of discharge were 3.143 ± 0.029 and 4.663± 0.032 lh^{-1}, respectively with an average of 3.671± 0.132lh^{-1} (Fig.1). Calculated field emission uniformity (Eu) and absolute field emission uniformity (Eua) using Keller and Karmeli (1975) method were 85.6 and 86.8%, respectively. Talking into consideration that the general criteria for Eu values for systems which have been in operation for one or more seasons are greater than 90% excellent; between 80 and 90%, good; 70 to 80%, fair and less than 70%, poor (Merriam and Keller, 1978), the system could be considered good.

Table 3. Water requirements for 15 years old* trickle irrigated novel orange trees grown on a sandy soil at Wadi El- Mollak, Ismailia governorate.

Growth period	months	Average number of hours of daily irrigation	Gross irrigation requirements	
			l day^{-1}/tree	
management practices winter.	December January	6 6	48 48	≈ 30 m^3/tree /year
The beginning of vegetative growth (spring growth cycle), flowering and the beginning of fruit setting.	February March April	6 9 9	48 72 72	
growth of small fruits until the end of falling.	May June	12 15	96 120	
fruit growth.	July August	15 15	120 120	
Autumn growth cycle and the completion of fruit growth and maturity.	September October November	12 12 9	96 96 72	
Mean		10.5	84	

*Vegetative cover ≈ 70%.

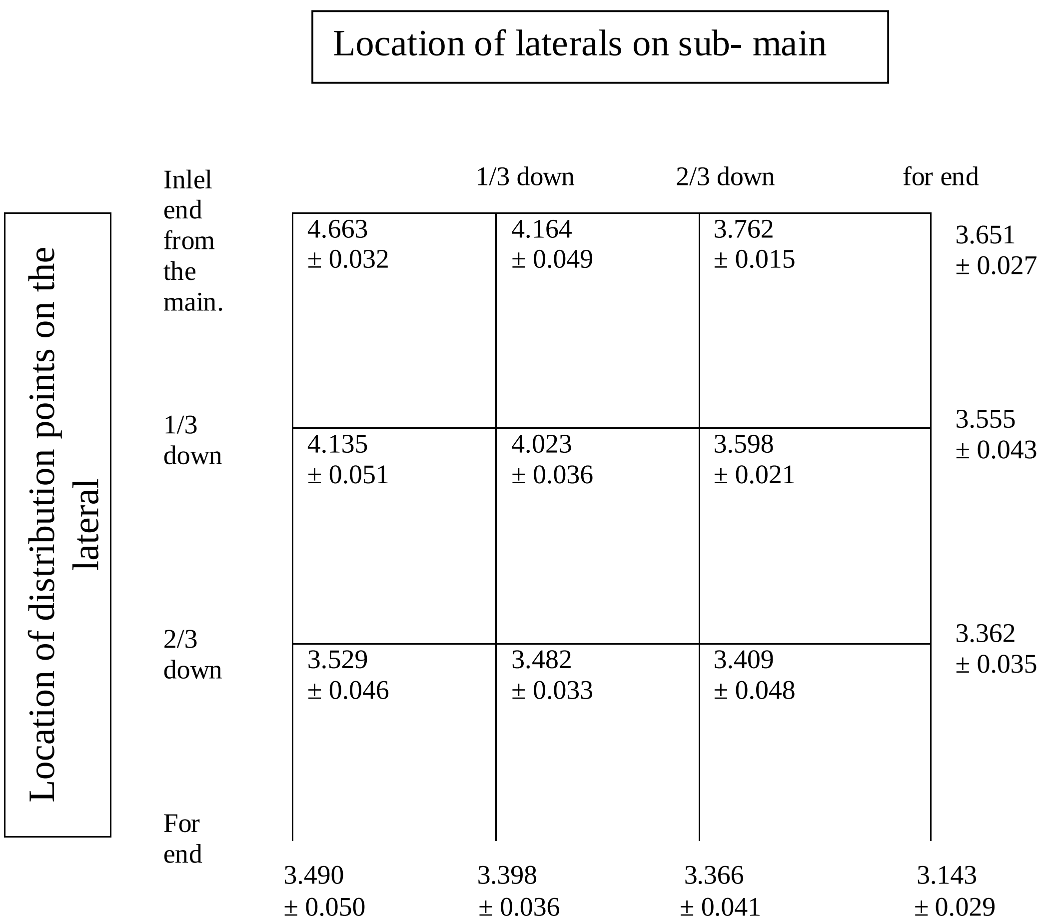

Fig.1. Discharge from selected distribution points (l/h) in the sub-main unit.

Field emission uniformity (Eu) = Minimum rate of discharge (l/hr) x 100/Average rate of discharge (l/h).

Absolute field emission uniformity (Eua) = 1/2[Average of lowest 1/4 of the field data emitter discharge (l/h) / Average of all the field data emitter discharge (l/h) + Average of all the field data emitter discharge (l/h) / Average of highest 1/8 of the field data emitter discharge (l/h)] x 100.

Fertilization:

1. Basal dose

Farmyard manure; superphosphate 15.5% P_2O_5, agricultural sulphur and potassium sulphate 48-52% K_2O at the rate of $20m^3$, 100kg, 100kg and 50kg /fed, respectively during January.

2. Fertigation

Ammonium nitrate 33.5% N, calcium nitrate 15.5% N, phosphoric acid 50% P_2O_5, potassium sulphate 48-52% K_2O and magnesium sulphate 33.3% MgO at the rate of 300, 150, 32, 200 and 20 kg/fed were distributed along the growing season beginning from 15th of February.

3. Foliar

Micro nutrients were sprayed thrice as chelates at the rate of 100, 100 and 200g of respectively, Mn (EDTA) 13% Mn, Zn (EDTA) 14% Zn and Fe (EDTHA) 6% Fe +1kg urea/600l just before flowering (February and March), after fruit setting (April) and during the period of fruit maturity (September), respectively.

Other agricultural practices:

The normal ones for novel orange

Choice of experimental units and treatments: Three sets of trees were chosen according to the amount of irrigation water received by the trees i.e. 6.286 ± 0.058, 7.342 ± 0.264 and 9.326 ± 0.064 l/h for sets no. 1, 2 and 3, respectively. These values correspond to the lowest, the average and the highest discharge of the emitters, in sequence. Each set consists of 24 trees divided into 4 replications. Accordingly, the annual amount of irrigation water received by the trees were 23.972, 28.259 and $36.142m^3$ for the three sets, respectively.

Studied parameters:

a) Some growth parameters that include: 1) Leaf area. 2) Average dry weight of leaves.

b) Content of N, P, K, Ca and Mg in the leaves (Cottenie et.al., 1982) and relative uptake of such nutrients. Leaf area and dry weight as well as leaf analyses were estimated for 6 months old leaves randomly sampled from each tree at the end of fertilization period i.e. 15th of October.

c) Number of fruits/ tree, average weight of fruit and obtained yield/ tree.

d) Water use efficiency by trees expressed as kg of the fruit yield produced by each m^3 of irrigation water used (Hillel, 1971).

e) Fertilizers use efficiency by trees expressed as kg of the fruit yield produced by each unit of fertilizers nutrient used (Barber, 1976).

Experimental design and statistical analysis:

The field experiment was designed in a completely randomized system. Results were statistically analyzed according to Snedecor and Cochran, (1980).

3. Results and Discussion

As the obtained results of both successive seasons were not significantly different, their average was taken into consideration.

Although the basal doses of fertilizers are the same for all trees of the studied area, variations in the amounts of irrigation water and consequently dissolved fertilizers received by trees greatly affect the nutrients uptake, yield and both water and fertilizers use efficiency by the trees. Table 4. presents the annual amounts of fertilizers received by trees through fertigation as affected by emission uniformity.

Table 4. Effect of irrigation uniformity on the amount of fertilizers received by the tree through fertigation (g/tree).

Set No.	N	P_2O_5	K_2O	CaO	MgO
Set 1	524.883	67.864	424.150	89.071	28.282
Set 2	618.750	80.000	500.000	105.000	33.340
Set 3	719.354	102.316	639.480	134.290	42.640

A. Emission uniformity and the nutrients uptake by the trees.

Content of N, P, K, Ca and Mg in the leaves as affected by the uniformity of irrigation are presented in table5. data show that the content of nutrients in the leaves of the trees of set 1 (that receive the minimum amounts of irrigation water) are lower than those of trees of set 2 (that receive the average amounts of irrigation water) by 8.2%% for N, 15.8% for P, 18.0% for K, 3.9% for Ca, and 21.1% for Mg. On the other hand, the content of nutrients in the leaves of trees of set 3 (that receive maximum amounts of irrigation water) are higher than those which receive the average amounts of irrigation water (trees of set 2) by 10.8, 8.4, 10.6, 14.6 and 13.0% for the aforementioned nutrients, respectively.

Taking the leaf area and the average of the dry weight of leaves as growth parameters, data in table 5 indicate that amounts of water delivered to the trees markedly affect such parameters. The higher amounts of irrigation water received by trees are the higher leaf area or average dry weight of leaf. Presented data show that the differences between the leaf area or average dry weight of leaves for set 1 and those of set 3 reached 30.8 or 32.6%.

Table 5. Effect of irrigation uniformity on the relative uptake of nutrients by the trees.

Set No	Average dry weight of leaf (mg)*	Leaf area (cm^2)**	Content %					Relative uptake				
			N	P	K	Ca	Mg	N	P	K	Ca	Mg
Set 1	221	18.01	2.320	0.165	1.670	2.300	0.380	0.513	0.036	0.369	0.508	0.084
Set 2	255	21.12	2.510	0.191	1.970	2.390	0.460	0.640	0.049	0.502	0.609	0.117
Set 3	289	23.89	2.780	0.207	2.178	2.740	0.520	0.803	0.060	0.629	0.792	0.150

* L.S.D. 0.05= 30 ** L.S.D. 0.05= 2.35.

According to the previous presentation of the data, relative uptake of nutrients are also shown in table 5. It is obvious that high quantities of irrigation water delivered to the trees coincide with high relative uptake of the nutrients under study. In other words, while the relative uptake of nutrients of set 1 was lower than those of set 2 by 24.8% for N, 36.1% for P, 36.0% for K, 19.9% for Ca and 39.3% for Mg, the relative uptake of nutrients by trees of set 3 that grown at the same sub- main unit was higher than those of trees of set 2 by 25.5, 22.4, 25.3, 30.0 and 28.2% for the aforementioned nutrients, in sequence.

B. Emission uniformity and yield.

Data of the fruit yield as affected by the uniformity of emission are presented in table 6. It is obvious that uniformity of emission markedly affected the number of fruits per tree and the average weight of the fruit. Consequently, the obtained fruit yields are significantly affected. The positive differences between the yield of the trees which receive the maximum amounts of irrigation water and that which receive the minimum amounts were 21.7, 24.4 and 51.5% for number of fruits per tree, the average weight of fruit and the fruit yield of the tree in kilograms, respectively.

Table 6. Effect of emission uniformity on the fruit yield and water use efficiency by the trees.

	Set 1	Set 2	Set 3	L.S.D 0.05
N	274.2	306.9	333.8	25.1
A	255	255	280	20.0
F	61.700	78.250	93.450	5.120
WUE	2.574	2.769	2.586	

N: Number of fruits/tree.
A: Average weight of fruit (g).
F: Fruit yield (kg/tree).
WUE: Water use efficiency by the tree (kgm^{-3}).

C. Emission uniformity and water use efficiency by the trees.

Values of water use efficiency by the trees expressed as kg of yield produced by each cubic meter of irrigation water used as affected by uniformity of emission are presented in table 6. Data show that the efficiency of water use by trees of set 1 (that received the minimum amounts of irrigation water) were the lowest. Values of water use efficiency by trees of set 1 are lower than those which receive the average amounts of irrigation water, i.e. trees of set 2 by 7.6%. on the other hand, water use efficiency by trees of set 3 (that received the maximum amounts of irrigation water) decreased. Value of water use efficiency by trees of this group (set 3) was 93.4% that of set 2. It seems that the amounts of water delivered to trees of set 3 are much more than that needed for growing the trees. Increments in the yield of this set is not correlated with the increment in delivered water to the trees.

D. Emission uniformity and fertilizers use efficiency by the trees.

Fertilizers use efficiency by the trees expressed as kg of yield produced by each one unit of N, P_2O_5, K_2O, CaO and MgO added through fertigation are presented in table 7. It is obvious that the amounts of water delivered to the trees and consequently fertilizers dissolved in it markedly affect the efficiency of using such fertilizers by the trees. The higher amounts of irrigation water received by trees are, the higher are the efficiency of using added fertilizers. This is true with only nitrogen fertilizers. Presented data (means of two subsequent seasons, 2008 and 2009) show that the negative difference between the value of N use efficiency by trees of set 1 and those of set 3 ≈ 10%. Regarding the other nutrients i.e. P, K, Ca and Mg and as previously mentioned with water use efficiency, high amounts of water delivered to trees of set 3 and consequently dissolved fertilizers in it negatively affected the efficiency of using these nutrients by the trees. With this respect, values of fertilizers use efficiency by trees of set 3 were lower than those of set 2 by ≈ 7%.

Table 7. Effect of emission uniformity on fertilizers use efficiency (g fruit yield/ g nutrient) by novel orange trees.

Fertilizer Nutrient	Set 1	Set 2	Set 3
Nitrogen	0.118	0.126	0.130
Phosphorus	0.909	0.978	0.913
Potassium	0.145	0.157	0.146
Calcium	0.693	0.745	0.696
Magnesium	2.182	2.347	2.192

Presented data indicate that uniformity of emission and consequently fertilizers application through trickle irrigation system greatly affect either the productivity or the nutritional status of the area. Although the uniformity of irrigation at the area under study has reached about 87%, great differences were estimated between the discharge of the drippers, that adversely affect the uniformity of growth, uptake of nutrients, obtained yield and water and fertilizers use efficiency by trees.

Various investigators have recommended that values of Eu of 94% or more are desirable and in no case should be below 90% (Abou Khaled, 1991, Vermeiren & Jobling, 1980, El- Sonbaty & El-Hady, 1993, El-Hady et.al., 1994, El-Hady, 2000 and El-Hady and Abd El- Kader, 2003). Therefore, care of irrigation system for raising the uniformity of emission to the aforementioned percentage is a must. This will lead to an uniform growth and uptake of nutrients during the growing season and at the same time will raise either the yield (quantity and quality) or both water and fertilizers use efficiency by growing trees.

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