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Impacts of deficit irrigation and humic acid application on growth, yield and fruit quality of Valencia orange trees

Hoda A. Khalil[*] and D.O. El-Ansary[**]
[*]Department of Pomology, and [**]Precision Agriculture Lab., Department of Pomology, Faculty of Agriculture, Alexandria University, Alexandria, Egypt.

THE PRESENT investigation was conducted during 2010 and 2011 growing seasons in order to study the effects of deficit irrigation (DI) and humic acid applications on the growth, yield and fruit quality of five-year-old Valencia orange trees (*Citrus sinensis* L.) grown under intensive cultivation conditions (1.5m x 4.5m) in raised beds of sandy soil in Mariot region located 45 Km at Alexandria Desert Road. Three irrigation regimes were imposed: (1) Standard practice irrigation (control): Re-irrigation immediately when soil moisture tension reached 15 kPa, (2) Moderate deficit irrigation (MDI): Re-irrigation 2 days after reaching a soil moisture tension of 15 kPa, and (3) Severe deficit irrigation (SDI): Re-irrigation 4 days after reaching a soil moisture tension of 15 kPa. Humic acid was applied as a soil conditioner (75 ml /tree/season) to test whether it can alleviate the negative impacts of irrigation water deficit. Irrigation deficit treatments significantly decreased shoot length, leaf area, fruit set, fruit weight and yield, but increased peel thickness, total soluble solids, acidity and maturity index. Humic acid application to the standard practice irrigation enhanced growth parameters, fruit set, yield and fruit weight, but did not affect peel thickness and total soluble solids in the first season, acidity, vitamin C and maturity index. There were no significant effects for humic acid on growth and fruit quality parameters in deficit irrigation treatments except for fruit weight in both seasons and yield in the first season.

Keywords: Deficit, Irrigation, Humic, Valencia, Fruit quality

Water is becoming an economical scare resource in many areas of the world, especially in arid and semi-arid regions. Recently, the need for water is increasing in all sectors of the economy worldwide. Agricultural industry is one of those sectors and its vital role widely depend on water availability. Therefore, increasing water use efficiency, fruit management and production and saving irrigation water are important tasks. Of all the materials used by fruit trees water seems to be taken up in the largest amounts. It would not to be surprising then, that in semi-arid environment, water is considered the most important limiting factor determining the growth and productivity of fruit trees. Nevertheless, even under adequate soil moisture, water stress might develop in plant tissues causing great variations in most, if not all, the physiological and biochemical processes.

It was believed long ago that crop production was unaffected by soil water stress until the cell turgor and plants wilt. In recent years, however scientists were surprised by the pronounced effects of very small dehydration leading to relatively low water potentials. Faust (1989), for example, mentioned that small water stress caused drastic physiological and metabolic changes, especially those concerning the photosynthetic behavior as well as food production and utilization.

Cultivation in arid sandy soil requires large quantities of water. The low water holding capacity of this soil causes rapid infiltration and deep percolation below the root zone. The addition of humic acid even to sandy soils, can improve water retention up to 44%. This is due to the ability of humic acids to penetrate the pores and cracks in sand particles agglomerating the particles which improves their ability to hold water and also to retain nutrients in the soil. Humic acid (HA) is one of the major components of humus. Humates have long been used as a soil conditioner, fertilizer and soil supplement (Albayrak and Camas, 2005). Humic acid can be used as growth regulate-hormone level improve plant growth and enhance stress tolerance (Albayrak & Camas, 2005, Piccola *et al*., 1992, Tan and Nopamornbodi, 1979). Fortun *et al.* (1989) and Kononova (1966) reported that humic acid improve soil structure and change physical properties of soil, promote the chelation of many elements and make these available to plants, aid in correcting plant chlorosis, enhancement of photosynthesis density and plant root respiration has resulted in greater plant growth with humate application (Chen & Avid, 1990 and Smidova, 1960). Increase the permeability of plant membranes due to humate application resulted in improve growth of various groups of beneficial microorganisms, accelerate cell division, increased root growth and all plant organs for a number of horticultural crops. Humic materials stimulate root growth, which allows for a greater coverage of plant nutrition and greater activity of biotic and abiotic anti-stress enzyme systems (Garcia *et al*., 2014).

Therefore, this investigation was carried out in order to elucidate the influence of various suboptimal water levels on growth, yield and fruit quality of one of the most spreading fruit species in newly reclaimed lands, Valencia orange. In addition, to provide Egyptian growers with more reliable information on the use of deficit irrigation (DI) for optimizing water management. Besides, the efficiency of one of the most used soil conditioners, humic acid, on controlling the various hazards accompanying water deficit was also undertaken.

Material and Methods

The study was conducted during 2010 and 2011 growing seasons at a private farm in Mariot region (30^{o} 55′ 33.34″ N and 29^{o} 46′ 31.81″ E) at Alexandria Desert Road, Egypt. Five-years-old orange trees (*Citrus sinensis* L., cv. Valencia) grafted on Volkamer lemon rootstocks were used. The experimental area was a block of oranges trees grown under intensive citrus plantation, comprising 3 rows of 12 trees each, oriented north-south. Trees spacing was 4.5 x 1.5 m. Trees were grown in sandy soil in raised beds (0.4 m high and 1.5 m wide). Water was delivered for each bed via two drip irrigation tubing run down along each bed (dripper spacing 30 cm, with a flow rate of 4L/hr/dripper). Weekly fertigation scheduling of a liquid fertilizer was applied. The total units of N- P_2 O_5 - K_2 O applied during the experimental season were 280-155-340 (g/tree/season), respectively, and four sprays of complete micro-element containing calcium and magnesium fertilizer. A regular pest management program was maintained. Soil moisture tension was monitored by placing tensiometers (Irrometer, USA) at a depth of 20 cm.

Three irrigation regimes were tested through monitoring and adjusting soil moisture tension at three different levels using tensiometer. The 3 irrigation regimes were imposed: (1) Control (C):Re-irrigation immediately when soil moisture tension reached 15 kPa, (2) Moderate deficit irrigation (MDI): Re-irrigation 2 days after reaching a soil moisture tension of 15 kPa, and (3)Severe Deficit irrigation (SDI): Re-irrigation 4 days after reaching a soil moisture tension of 15 kPa. However, irrigation was scheduled on the basis of the 20 cm soil moisture tension, the total amount of water supplied to each tree during the sixty weeks of experiment in the control, MDI and SDI were 8600, 5670 and 2840 L/tree, respectively.

Humic acid in the form of Actosol (75cm^3/tree/season) were added to the tree soil. The treatments were frequently applied every two weeks from February till April). Actosol is acommercial product that contains 3% humic acid and 10-10-10 NPK. It is manufactured by Arctick Inc., Chentilly, VA, USA. Each treatment was replicated three times in a complete randomized block design with two trees in each replicate.

Thirty non-fruiting spring shoots were selected at random and tagged in May every year, and the length of each shoot was measured in August to determine the average shoot length. In the meantime, a sample of 20 leaves was collected randomly from the middle part of the spring shoots to measure the leaf area using planimeter.

Harvesting was achieved during the regular commercial harvesting time under Alexandria Governorate conditions (1st week of May in 2010 and 2011 seasons).Yield expressed in weight (Kg) was recorded. Two branches with a diameter of 1.5 inch from two directions were selected on each tree in early March of each year. The total number of flowers on each selected branch was counted during late March and early April. The number of fruits on each branch that reached a diameter of ¼ inch was counted from late April to early May to estimate fruit set percent.

Ten fruits were taken randomly from the yield of each tree and the percentage of total soluble solids (TSS %) was determined using a hand refractometer. The acidity was determined by titrating 5 ml of fruit juice against

0.1 N NaOH using phenolphthalein as an indicator, then, acidity was calculated as grams of citric acid per 100 ml of fruit juice, according to A.O.A.C (1980). The maturity index was expressed as the soluble solids/acidity ratio. Vitamin C content was determined by the dye method. This method essentially depends upon the oxidation of the ascorbic acid with the 2, 6 dichlorophenol endophenol dye. Vitamin C content in fruit juice was calculated as mgs. Per 100ml of fruit juice (A.O.A.C. 1980).

The data obtained throughout the course of this study were statistically analyzed according to the analysis of variance as described by Snedecor and Cochron (1990). Simple regression and determination coefficients were done using GLM model with STATISTICA RELEASE 7.

Results

Vegetative growth

The data in Table 1 & 2 clearly indicated that the shoot length and leaf area of the experimental trees tended to respond negatively to deficit irrigation. There was a gradual decline in shoot length and leaf area of the trees with increasing water stress. This decline was evident during both experimental seasons. For example, in 2011 season, shoot length of Valencia orange trees subjected to SDI and MDI showed a reduction of as much as 20.0% and 35.5% respectively, in comparison with control (field capacity range). The corresponding values for leaf area were 13.2% and 25.2%. Similar results were also reported by numerous investigators, such as: Khalil *et al*. (2003), Symeonidou & Buckley (1999) and Lange & Lenz (1999), working on different fruit species.

The effect of humic acid application on shoot length and leaf area of the experimental trees is shown in Table 1& 2. The results generally indicated that the shoot length and leaf area of Valencia orange trees obviously increased as a result of humic acid applications in comparison with those grown without humic acid. The magnitude of this increment reached as much as 16.6% for shoot length and 15.2% for leaf area in the first season.

Fruit set (%) and yield (Kg/tree)

The results obtained throughout both seasons showed that trees grown under control treatment gave the highest fruit set percentage followed by those of the MDI and SDI. Differences between control and the other treatments were statistically significant (Table 1 and 2). There was a clear response of the tree yield related to irrigation treatments. The strongest effects were appreciated in the SDI treatment, with an average yield reduction of 51.4% in 2010 season and 34.2% in 2011 season with regard to control treatment. The yield was statically similar in the control and MDI for the two study years.

Concerning the humic acid effects, the data of the present study indicated that fruit set and yield generally increased in response to humic acid application. Fruit set and yield during 2010 season increased by12.4% and 18.1% respectively, with humic, in comparison with those not receiving humic acid treatment.

Considering the interaction effect of deficit irrigation and humic acid on yield, it might be concluded that humic acid treated trees often showed higher yield values than untreated ones. The yield of humic acid treated trees under MDI and SDI significantly higher than untreated trees grown under the same soil moisture tension levels during the first season, while, in 2011, there were no significant differences.

Fruit quality

The effect of various soil moisture tensions and humic acid application on fruit quality, total soluble solids (TSS), acidity (TA), maturity index (MI), vitamin C (Vit.C), fruit weight and peel thickness is shown in Table 1 & 2.

The results obtained throughout the two years of the present study showed that fruit weight was decreased as soil moisture tension increased. In both seasons, SDI and MDI significantly decreased fruit weight as compared with control.

The peel thickness of fruits was increased by subjected the trees to higher deficit irrigation. In both seasons, the data showed that trees grown under SDI yielded fruits characterized by a thicker peel than those from MDI and control.

The data revealed that SDI produced the highest TSS and TA values followed by MDI and control treatments. The differences among all treatments were statistically significant in both seasons. On the other hand, the obtained results in both season revealed that varying soil moisture tension did not significantly affect the MI in the second season and Vit.C content of the juice in the first season.

The effect of humic acid treatments on fruit quality of the experimental trees is shown in Table 1 and 2. In 2010 season, significant differences were noted between humic acid treatments in fruit weight only. The results for the other variables were statistically similar. On the other hand, in 2011 season, application of humic acid generally caused a significant increase in fruit weight, peel thickness and TSS and no effect on TA, Vit.C and MI.

As for the effect of the interaction between deficit irrigation and humic acid application on fruit weight, the results of the present study revealed that humic acid treated trees often showed higher fruit weight values than untreated ones. The fruit weight of humic acid treated trees raised under MDI and SDI significantly was higher than untreated trees grown under the same soil moisture tension level during both season of study.

An analysis of the relationship among yield and fruit quality parameters with soil moisture tension was performed in order to define the parameter that provides the greatest information about the crop response to the deficit irrigation (Table 3). In 2010 season, the deficit irrigation registered strong correlations with some parameters of the yield and fruit properties. Especially noteworthy were the regression coefficients with yield (r^2 = 0.87), fruit weight (r^2 = 0.89), Peel thickness (r^2 = 0.93), TSS (r^2 = 0.62), TA (r^2 = 0.78), Vit.C (r^2 = 0.52) and MI (r^2 = 0.72). In 2011 season, DI offered significant correlations with yield (r^2 = 0.88), fruit weight (r^2 = 0.94), Peel thickness (r^2 = 0.95), TSS (r^2 = 0.60) and

Vit.C (r^2 = 0.52). Other parameters such as TA and MI showed no significant correlations.

TABLE 1. Effect of deficit irrigation and humic acid application on the shoot length, leaf area, fruit set%, yield and fruit quality of Valencia orange tress during 2010 season.

Treatments	Shoot length (cm)	Leaf area (cm^2)	Fruit set %	yield (Kg $tree^{-1}$)	Fruit weight (g)	Peel thickness (cm)	TSS %	TA %	Vit.C Mg/100ml	MI (TSS/TA)
Main effects										
Deficit irrigation (DI)	2010									
C	13.12a	28.16a	2.39a	31.97a	256.55a	0.42c	8.10b	0.75c	44.70a	5.44c
MDI	11.99a	24.05b	2.16b	31.01a	238.00b	0.48b	9.20b	1.18b	44.50a	8.50b
SDI	9.70b	19.68c	1.73c	17.17b	213.60c	0.54a	11.00a	1.57a	46.40a	14.99a
L.S.D. (0.05)	1.93	3.29	2.21	2.32	1.99	0.03	1.36	0.27	1.57	3.05
Humic acid application (H)										
H0	10.72b	22.27b	1.97b	25.09b	223.77b	0.48a	9.33a	1.18a	45.20a	9.66a
H1	12.50a	25.65a	2.21a	28.34a	248.33a	0.48a	9.53a	1.14a	45.23a	9.62a
L.S.D. (0.05)	1.58	2.69	1.81	1.89	1.55	0.03	1.11	0.22	1.28	9.42
Interaction										
Control (H0)	12.33	26.20	2.36	29.69	237.6	0.40	8.00	1.55	44.30	5.25
(H1)	13.90	30.10	2.41	34.25	275.5	0.43	8.20	1.59	45.10	5.62
MDI (H0)	11.21	21.76	1.91	28.69	235.2	0.49	9.10	1.19	45.20	8.01
(H1)	12.78	26.32	2.41	33.06	240.8	0.47	9.30	1.16	43.90	8.99
SD (H0)	8.60	18.84	1.64	16.64	198.5	0.55	10.90	0.81	46.10	15.72
(H1)	10.80	20.52	1.82	17.71	228.7	0.55	11.10	0.68	46.70	14.24
Analysis of variance (*F-test*)										
Deficit irrigation (DI)	**	***	***	***	***	***	***	***	*	***
Humic application (H)	*	*	*	***	***	NS	NS	NS	NS	NS
DI X H	NS	NS	NS	4.23*	2.71***	NS	NS	NS	NS	NS

Deficit irrigation (DI): C = control, MDI= moderate deficit irrigation, SDI= sever deficit irrigation, humic acid application (H):H0= without humic, H1= with humic, TSS, total soluble solids, TA, titrable acidity, Vit.C, vitamin c, MI, maturity index. Means in a column followed by a different letter differ significantly at P = 0.05 by L.S.D test.

Discussion

The results of the foregoing investigation generally revealed that all growth criteria adapted herein to describe the different growth processes of the experimental fruit trees showed a general reduction along with decreasing the soil moisture level. Noteworthy, an explanation for this negative relationship between growth and soil water deficit was offered by Hsiao (1973) and Levitt (1980). They generally reported that the maintenance of plant cell turgor is the most critical factor in the growth process and that growth reduction or inhibition is a function of turgor loss. They also pointed out that the involvement of cell turgidity in stomatal movement and carbon assimilation would participate in interpreting the general growth reduction trees subjected to prolonged water stress conditions. In the meantime, the influence of humic acid on the structure and other related physical soil properties have been studied by many investigators such as: Lobartini *et al*. (1994), Olk & Cassman (1995), Çimrin *et al*. (2010) and Rizk-Alla & Tolba (2010). They all agreed that humic caused a great influence on the hydrophysical properties of different soil types and consequently on the concentration of nutrients in soil solution which would ultimately positively effect on plant growth. Moreover, Khalil (2003) found that soil water retention increased with the treatment by different soil conditioners and water loss was reduced in the treated soil.

TABLE 2. Effect of deficit irrigation and humic acid application on the shoot length, leaf area, fruit set%, yield and fruit quality of Valencia orange tress during 2011 season.

Treatments	Shoot length	Leaf area	Fruit set	yield	Fruit weight	Peel thickness	TSS	TA	Vit.C	MI
	(cm)	(cm^2)	%	(Kg $tree^{-1}$)	(g)	(cm)	%	%	Mg/100ml	(TSS/TA)
Main effects										
Deficit irrigation (DI)	2011									
C	18.24a	30.15a	2.74a	34.81a	271.00a	0.41c	9.20a	0.83a	48.73b	11.35a
MDI	14.59b	26.18b	2.31b	34.25a	251.47b	0.52b	10.45b	0.97a	50.45b	13.02a
SDI	11.76c	22.54c	1.83c	22.89b	226.65c	0.62a	11.45c	1.09a	52.50a	13.80a
L.S.D. (0.05)	2.15	1.63	2.44	3.59	2.87	0.02	0.90	0.34	1.78	5.50
Humic acid application (H)										
H0	14.09a	24.95b	2.11b	29.52b	237.87b	0.52a	9.73b	0.95a	50.57a	12.47a
H1	15.63a	27.63a	2.47a	31.77a	261.55a	0.50b	11.00a	0.97a	50.55a	12.98a
L.S.D. (0.05)	1.75	1.33	1.99	2.93	2.35	0.02	0.73	0.28	1.46	4.49
Interaction										
Control (H0)	17.57	27.71	2.57	34.05	260.50	0.43	8.60	1.10	48.30	9.79
(H1)	18.89	32.59	2.90	35.56	281.50	0.39	9.80	1.07	49.16	12.90
MDI (H0)	13.73	25.45	2.01	33.14	240.50	0.52	9.70	0.92	50.20	14.34
(H1)	15.44	26.89	2.60	35.35	262.44	0.52	11.20	1.01	50.70	11.70
SD (H0)	10.95	21.68	1.75	21.38	212.60	0.62	10.90	0.82	53.20	13.28
(H1)	12.55	23.39	1.90	24.40	240.70	0.61	12.00	0.84	51.80	14.31
Analysis of variance (*F-test*)										
Deficit irrigation (DI)	***	***	***	***	***	***	***	NS	***	NS
Humic application (H)	NS	**	***	**	***	*	**	NS	NS	NS
DI X H	NS	NS	NS	NS	3.86*	NS	NS	NS	NS	NS

Deficit irrigation (DI): C = control, MDI= moderate deficit irrigation, SDI= sever deficit irrigation, humic acid application (H):H0= without humic, H1= with humic, TSS, total soluble solids, TA, titrable acidity, Vit.C, vitamin c, MI, maturity index. Means in a column followed by a different letter differ significantly at $P = 0.05$ by L.S.D test.

TABLE 3. Relationships among deficit irrigation (DI) and yield and fruit quality parameters.

Variables	Regression equation	Regression Coefficient (R^2)	Correlation Coefficient (r)	Regression equation	Regression Coefficient (R^2)	Correlation Coefficient (r)
Deficit irrigation (X_1)	2010			2011		
Yield	$Y_1 = 1714.984-16.343X_1$	0.76	- 0.87**	$Y_1 = 1595.6033-15.08X_1$	0.78	- 0.88**
Fruit weight	$Y_2 = 2217.8667-19.55X_1$	0.79	- 0.89**	$Y_2 = 2286.3026-20.0696X_1$	0.89	-0.94**
Peel thickness	$Y_3 = -7.17+0.075X_1$	0.86	0.93**	$Y_3 = -7.7367+0.0809X_1$	0.91	0.95**
TSS	$Y_4 = -138.5667+1.45X_1$	0.38	0.62**	$Y_4 = -90.2289+0.9794X_1$	0.35	0.60**
TA	$Y_5 = 38.9233-0.37X_1$	0.61	0.78**	$Y_5 = 12.9947-0.118X_1$	0.08	n.s
Vit.C	$Y_6 = -46.6+0.9X_1$	0.27	0.52**	$Y_6 = -163.5629+2.0979X_1$	0.67	0.82**
MI	$Y_7 = -524.3073+5.235X_1$	0.53	0.72**	$Y_7 = -139.1202+1.4856X_1$	0.06	n.s

df = 14, *$P<0.05$, **$P < 0.01$.

One of the main causes of poor fruit set is water stress during the critical periods when fruitlets tend to drop. The most critical are the three weeks following bloom and the May-June drop period. Koo (1967) showed that irrigation during this earlier fruit development period in Florida reduced premature drop to 1/4 of non-irrigated trees. Under drought conditions, the leaves may be better competitors for limited available water. This appears to be the case for young leaves competing with developing fruit (Albrigo, 1977). Since many of the fruitlets are marginally capable of staying on the tree, less than 5% will last past the May-June drop period (Erickson and Brannanman, 1960), water stress from this competition with leaves could easily contribute to fruit losses. The above results are in agreement with those found by Borroto *et al*. (1981) working on Valencia oranges, who stated that withholding irrigation for 15-45 days increased flower bud formation but decreased fruit set. Meanwhile, Abdel-Messih *et al*. (1977) on Washington Navel orange trees found that the highest fruit set yielded from trees receiving irrigation at 41% soil moisture content.

The relationship between deficit and yield in Valencia orange was clearly demonstrated. In this study, frequent irrigation (control) gave a marked yield increase over infrequent irrigation (SDI) treatment, the strongest effects were appreciated in the SDI treatment, with an average yield reduction of 51.4 % in the first season and 34.2% in the second season with regard to the control treatment. Yield reductions could have been caused by a decline in the fruit weight. Also, this may be due to the many effects of deficit irrigation on citrus tree physiology and productivity involving reactions ranging from subcellular level to whole tree. Also, deficit irrigation was found to reduce canopy development of tree and canopy volume is known to be one of the main factors determining yield.

The result generally indicated that yield of Valencia orange trees obviously increased as a result of humic acid application in comparisons with those grown without humic. Similar trend was also found by Liu *et al*. (1998) and Abd El-Monem *et al*. (2008). The increase in yield of the experimental trees as a result of humic acid treatment could be interpreted on the basis of its capability in increasing the water holding capacity of the soil and hence increasing water availability to the trees. Also, root growth and enhancing the sandy soil ability to retain and not leach out vital plant nutrients Khaled and Fawy (2011).

The results indicated that the main effects of deficit irrigation are reflected in fruit parameters, such as TSS, TA, peel thickness and fruit weight. Deficit irrigation was less obvious in other variables such as Vit.C content and maturity index.

In both seasons, severely stressed trees (SDI) yielded fruits having the highest total soluble solid percentage followed by those of MDI and control. The remarkable increase of TSS as a consequence of irrigation deficits has been reported by several authors. Such as: Hrazdina *et al*. (1984) and Reynolds and Naylor (1994). Yakushiji *et al*. (1996) suggested that sugar accumulation in Satsuma mandarin fruit was not caused by dehydration under water deficit but rather that sugars accumulated by osmoregulation in response to water deficit. Previous work has shown that, during grape berry ripening, ABA accumulates simultaneously with sugar (DÜring *et al*., 1978). Moreover, recent investigations have provided strong evidence that ABA is synthesized in roots in drying soil, and that growth of plants is affected by this hormonal signal (Davies and Zhang 1991). In grapes (Okamoto *et al*., 2004) and peaches (Kobashi *et al*., 1997, 2000), grown under water deficits during maturation, a remarkable increase of ABA was recorded in fruit. In another study ABA was injected into citrus fruit (Kojima *et al*., 1995), it stimulated the increase in glucose and fructose but not in sucrose.

As for the specific effect of humic acid application on fruit quality, the data indicated that the fruit weight in both season and TSS in the second season only were significantly higher than that of the untreated trees. Whereas no significant effect of humic acid application on TSS, TA and Vit.C content and maturity index with the exception of TSS in the second season statistically vary in this concern. Long-term effects of humic acid on Valencia orange trees fruit quality need to be further investigated.

Conclusion

Our results confirm that deficit irrigation successfully improved water productivity in Valencia orange trees, cultivated under limited water resources in the Mediterranean area without causing sever yield reductions so long as a certain minimum amount of seasonal irrigation water is guaranteed. There were no significant effects for humic acid on growth and fruit quality parameters in deficit irrigation treatments except for fruit weight in both seasons and yield in the first season. However, humic acid application to the standard practice irrigation enhanced growth parameters, fruit set, yield and fruit weight. Moderate deficit irrigation strategy are recommended during the growth season maintained vegetative growth and total tree yield, and improved some fruit quality parameters of Valencia orange trees which reflect on saving water and grower income increment.

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تأثير نقص الري والمعاملة بحامض الهيوميك علي النمووالمحصول وجودة الثمار لأشجار البرتقال الفانشيا

هدي علي عبد المحسن خليل* و ضياء اسامة الأنصاري**
*قسم الفاكهة و**معمل الزراعة المنضبطة - قسم الفاكهة - كلية الزراعة - جامعة الإسكندرية – الإسكندرية – مصر.

اجري هذا البحث خلال موسميين متتاليين ٢٠١٠ و ٢٠١١ وذلك لدراسة تأثير نقص كميات المياه المستخدمة في الري والمعاملة بحامض الهيوميك أسيد علي النمو والمحصول وجودة الثمار لأشجار البرتقال الفانشيا . وقد استخدم لإجراء هذا البحث أشجار عمرها ٥ سنوات نامية في ارض رملية تحت نظام الزراعة المكثفة ١,٥م x ٤,٥م علي مصاطب وذلك في مزرعة خاصة بمنطقة مريوط الزراعية في الكيلو ٤٥ من طريق إسكندرية الصحراوي. وقد تم اضافة ٣ معدلات للري وهي: ١- معاملة الكنترول وفيها يتم الري عندما يصل مستوي الشد الرطوبي للتربة ١٥كيلوبسكال ، ٢- معاملة نقص مستوي ماء الري المتوسط وفيها يتم الري بعد مرور يومين علي وصول مستوي الشد الرطوبي للتربة الي ١٥ كيلوبسكال، ٣- معاملة نقص مستوي ماء الري الشديد وفيها يتم الري بعد مرور أربعة ايام علي وصول مستوي الشد الرطوبي للتربة الي ١٥كيلوبسكال. تم اضافة حمض الهيوميك كمحسن للتربة وذلك بمعدل ٧٥ملليميتر لكل شجرة خلال موسمي التجربة وذلك لاختبار مقدرة حمض الهيوميك علي تقليل الاثار السلبية الناجمة عن نقص مستوي ماء الري. وقد أوضحت النتائج ان نقص مستوي ماء الري قد أدي معنويا الي نقص طول الأفرخ، مساحة الورقة،عقد الثمار، وزن الثمار وكذلك المحصول بينما أدي الي زيادة سمك القشرة، السكريات الذائبة الكلية، الحموضة ودليل اكتمال النمو. اما معاملة الهيوميك بالنسبة لأشجار الكنترول فقد أدت الي تحسين دلائل النمو، زيادة عقد الثمار، زيادة المحصول ووزن الثمرة ولكن لم يكن لها تأثير معنوي علي سمك قشرة الثمرة، السكريات الذائبة الكلية في الموسم الاول ، الحموضة، فيتامين سي وكذلك دليل اكتمال النمو. وقد وجد انه لا يوجد تأثير معنوي لحمض الهيوميك علي جميع دلائل النمو وجودة الثمار تحت معاملات نقص مستويات ماء الري وذلك فيما عدا وزن الثمار في كلا موسمي التجربة والمحصول في الموسم الاول.