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INFLUENCE OF REDUCING IRRIGATION RATE AND ADDITION OF SUPER ABSORBENT POLYMER ON PEACH TREES GROWTH UNDER NORTH SINAI CONDITIONS

Mohamed A. Belal[1*]; H.A. Elalakmy[2]; A.A. Abdelhameed[1] and M.M. Sourour[2]

1. Unit. Fruit, Dept. Plant Prod.; Cent. Desert Res., Egypt.

2. Dept. Plant Prod., Fac. Environ. Agric. Sci., Arish Univ., Egypt.

ABSTRACT

Peach trees (*Prunus persica* L.) about 6 -years- old planted in sandy soil were used and spaced at 4 × 5 m and received nearly the same cultural care under drip irrigation system during 2013/2014 and 2014/2015 seasons in private Farm "Sleem Elbalwy" orchard at "El-Masmy" farms area in El-Arish district, North Sinai Governorate, Egypt to study the effect of regulated deficit irrigation and super absorbent polymer on vegetative growth of peach trees under North-Sinai Conditions. Three irrigation treatments were applied: a control (100 % of ETc) and two regulated deficit irrigation at 75 % and 50 % of ETc treatments using modified Penman and Monteith's modified equation and three polymer additions: No addition (control), 25 g/tree and 50 g/tree. The results showed that treated with 100% ETc achieved the highest value of each of number of new shoot, new shoots length, new shoots diameter, number of leaves per new shoots, leaf area and tree circumference followed by 75% in both seasons while irrigated with 50% ETc gave the lowest values. Also, the results showed that addition 50g/tree of super absorbent polymer increased all vegetative growth parameters followed by trees treated with 25g/tree compared with no addition treatment in both seasons. All treatments were applied on December 20th in both seasons. Results indicate that regulated deficit irrigation at 75% of ETc, addition 50g absorbent polymer/tree showed the highest increase in vegetative growth compared with 50% of ETc treatment.

Key words: Regulated deficit irrigation, super absorbent polymer, Peach (*Prunus persica* L.).

INTRODUCTION

Peach (*Prunus persica*) is revered as one of the most important fruit species grown in the most temperate regions of the world. Peach trees are classified as a stone fruits and follows the family (Rosaceae) and genus (*Prunus*) which native to China and then go to Iran and from there to Greece, Syria, Italy, America and then to the rest of the world. In Egypt the total area is 65920 feddans and the productive area is 50498 feddans with total productivity of 262572 tons **According to NECS (2013).**

The average yield in Egypt is 5.33 tons/fed. Moreover, North Sinai has the highest peach total area (30341 fed.) and the lowest average yield (2.14 tons/fed) compared with the other governorates according to Statistical data **of North Sinai Governorate (2010-2011).** Drought is one of the most important factors limiting peach cultivation in North Sinai Governorate and it has a negative effect on peach yield and fruit quality.

Sotiropoulos *et al.* (2010) indicated that regulated deficit irrigation (RDI) at 35% of

* **Corresponding author: Tel.:** +201286058184
E-mail address: maabdrc@yahoo.com

water in comparison to the control as well as the combined treatment reduced shoot length of the vigorous shoots inside the canopy. Also, **Lopez *et al.* (2008)** noticed a gradual reduction in the amount of light intercepted as the productive cycle progressed in peach trees, while water sprout removal trees showed an immediate reduction in the amount of light intercepted. Moreover, the mechanisms responsible for vegetative growth reduction were different in the regulated deficit irrigation (RDI) and the water sprout removal techniques.

Super absorbent polymer applications can play an important role in retain large quantities of water and nutrients when it incorporated with soil. **Dragicevic *et al.*, (2011)** studied the positive impact of the polymer on a pecan growth which was observed through the significant increases in the fresh matter of the shoots, compared to the other treatments. Also, **Nazarli *et al.*, (2011)** indicated that polymer have the best effect to all vegetative characteristics of sunflower in all levels of water stress treatment. The findings strongly suggest that the irrigation period of sunflower cultivation can be increased by application of polymer.

The aim of current study was studying the effect of levels of crop Evapotranspiration and super absorbent polymer on peach trees growth and productivity.

MATERIALS AND METHODS

The investigation was carried out during the two consecutive seasons of 2013-2014 and 2014-2015 in private farm "Sleem Elbalwy" orchard at "El-Masmy" Farms area in El-Arish region, North Sinai Governorate, Egypt.

One hundred and sixty-two "Sheikh Zewayed peach" trees (*Prunus persica* L.) budded on Nemaguard peach rootstock about six years old and planted at 4×5m apart and grown in sandy soil were selected. Irrigation depends mainly on ground water from wells. In addition to rainfall which amounted to about (165 mm/year) during the rain full seasons. The climatic data of North Sinai Governorate during research time which used for calculating ETo were collected from the Central Laboratory for Agricultural Climate.

These trees were similar in their grown, and received the common agricultural practices in all seasons and it had been added organic matter during last November around the trees in both seasons. Three random soil samples were taken from the field before starting the experiment at depth 0-60 cm from the soil surface and tested for mechanical and chemical analyses (Table, 1) according to **Piper (1947)**.

Treatments of study

Irrigation level treatments

Meteorological data were investigated before conducting the experiments to calculate reference evapotranspiration (ETo) as follow (Table 2).

Drip irrigation system was used in this experiment. Two irrigation hose were used for each tree. In addition four drippers have been installed for each tree including two drippers in each direction. The trees were irrigated one hour weekly in winter and the water amount was increased to two hours daily in summer, Figure 1. The amount of water was controlled through the drippers discharge rate. The experiments included three treatments as follows:

1. ETc_{100} = 100% from ETo (Non limiting irrigation).
2. ETc_{75} = 75% from ETo
3. ETc_{50} = 50% from ETo

Drip irrigation system was used to transfer water from underground wells to the trees through the irrigation network

Table (1): Soil and water salinity analyses of the investigated orchard at El-Arish region North Sinai Governorate.

Soil properties	Physical analysis					E.C	pH	Chemical analysis								Water salinity analysis
								Cations (ml.l-1)				Anions (meq.l-1)				
	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Soil texture			Ca++	Mg++	Na+	K+	CO3--	HCO3-	Cl-	SO4--	ppm
0-45 cm	0.8	94.3	1.78	3.12	Sandy	3.5	9.7	1	20	19	3	-	1	13	-	3560

*According to Soil and water analysis lab data, Department of Agriculture, El-Arish (2013).

Table (2): Meteorological data in El-Arish area, North Sinai Governorate during investigated seasons according to central laboratory for agricultural climate.

Date	Max Temp. (^{o}C)		Min Temp. (^{o}C)		Mean humidity (%)		Mean wind speed (Km/h)		Rainfall (mm)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
January	19.1	20.3	7.5	7.9	84	85.1	1.9	2	1.02	1.62
February	20.6	21.1	8.3	8.5	78.3	78.6	5.6	5.6	6.09	6.12
March	22.9	23.2	10.8	11.1	73.6	74.1	8.6	9.1	11.18	8.6
April	26.1	26.4	12.6	12.8	73.5	73.9	6.4	6.7	0	1.1
May	28.8	29.1	16.6	17.1	67.4	67.9	6.3	6.5	1.02	0.8
June	31.1	32	18.9	19.2	67.9	68.4	6.4	6.9	0	0
July	31.6	32.3	21.2	22.1	74.9	75.4	6	6.4	0	0
August	32.8	33.2	22.3	23	73.3	74	6.5	7.1	0	0
September	31.6	32.4	20.3	20.7	66.9	77.3	4.8	5.3	0	0
October	28.2	28.4	16.6	16.9	67.4	67.9	4.4	4.9	2.03	1.6
November	23.9	24.2	13.8	14	75.9	76.2	4.3	4.1	22.35	19.01
December	22.5	22.7	9.5	9.4	76.8	76.9	4	3.2	4.56	4.3

*According to Agricultural climate lab data, Agriculture Research Center (2016).

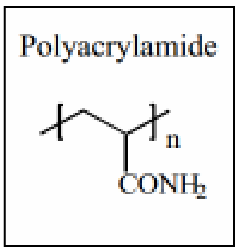

Fig. (2): Constructive installation of Polyacrylamide.

which divided into three sections and control the amount of added water per tree by accurate valves which have been calibrated in the field by measuring drippers' discharge rate.

Evapotranspiration for crop (ETc) was calculated as follow:

$$ET_c = ET_o \times K_c$$

ET_c : crop evapotranspiration

ET_o : reference crop evapotranspiration

K_c : crop coefficient

Also, ETc was calculated from a modified Peman- determined reference crop water use (ETo) (**Doorenbos and Pruitt, 1977**) with estimated crop coefficient (Kc) adapted from (**Goldhamer, 1989**) (ETc=ETo×Kc) and modified in situ based on plant water status.While reference crop evapotranspiration was calculated using Penman and Monteith's modified equation according to **Penman (1948) and Monteith (1965)**.

Modified Penman and Monteith's modified equation

$$ETo = \frac{0.408\,\Delta\,(Rn - G) + y\,\frac{900}{T + 273}\mu_2\,(e_s - e_a)}{\Delta + y\,(1 + 0.34\,\mu_2)}$$

Where:

ETo =reference evapotranspiration.

Rn = net radiation at the crop surface.

G = soil beat flux density.

T = air temperature at 2 m height.

μ_2 = wind speed at 2m height.

e_s = saturation vapor pressure.

e_a = actual vapor pressure.

Δ = slope vapor pressure curve.

y = psychometric constant.

As shown in Fig. 1, Irrigation water counts which were added to trees were calculated monthly and for four seasons. About 2010.96 m3 of water was added annually with an average (7litre/hour/drip).

Super absorbent polymer treatments

On mid-December and after adding the organic fertilizers to the soil, amounts of super polymer "Polyacrylamide" were added at three levels (Fig. 2) as follows:

- P_0 = No addition (control)
- P_{25} = 25 gram of Polyacrylamide per tree
- P_{50} = 50 gram of Polyacrylamide per tree

Super absorbent polymer treatments were added as a powder in a small hole with a depth no more than 30 cm directly down the wettability cone of soil for one more time according to **Yu *et al.* (2012)**.

Study measurements

Vegetative growth

In February, for each tree four similarly branches distributed around the tree canopy were labeled in each season. A sample of uniform shoots of the spring cycle was chosen at random and labeled on each experimental tree to determined growth measurements such as shoot lengths, diameters and leaf area were determined.

Four main branches as similar as possible were chosen at the four cardinal points of each treated tree were tagged and the average of the current shoot per selected branch was counted, for lengths and diameters were measured on late June, in both seasons.

Number of new shoots per brunch

Four branches (one year old) were labeled in originally four directions and the number of new shoots was measured by counting.

Table (3): Effect of different levels of irrigation quantity and polymer on number of new shoots and new shoots length of "Sheikh Zewayed peach" trees.

Irrigation	Number of new shoots				New shoots length			
	Polymer (Control)	Polymer 25 g	Polymer 50 g	Mean	Polymer (Control)	Polymer 25 g	Polymer 50 g	Mean
1st Season (2013/2014)								
Control (ETc100%)	871.8 ab	752.7 bc	836.1 ab	820.2 A	27.95 cd	30.10 bc	37.42 a	31.82 A
ETc 75%	405.7 de	863.0 ab	934.7 a	734.5 B	20.67 e	29.09 c	33.22 b	27.66 B
ETc 50%	296.3 e	524.0 d	686.8 c	502.4 C	14.51 f	20.01 e	24.70 d	19.74 C
Mean	524.6 C	713.2 B	819.2 A	-	21.04 C	26.40 B	31.78 A	-
2nd Season (2014/2015)								
Control (ETc100%)	912.2 bc	782.7 b	1030 a	602.6 C	27.15 c	29.30 bc	30.40 ab	28. 95 A
ETc 75%	504.7 e	894.7 bc	934.1 ab	755.9 B	19.87 e	28.29 bc	32.20 a	26.79 B
ETc 50%	390.8 f	590.2 e	816.0 cd	926.6 A	13.71 g	17.21 f	23.90 d	18.28 C
Mean	908.3 A	777.8 B	599.0 C	-	20.24 C	24.93 B	28.83 A	-

Values having the same letter(s) did not significantly different according to LSD at 0.05.

Shoot length and number of leaves per shoot

The determinations of shoots length (cm) and number of leaves per shoot were carried out during June on current season growth. Sixteen growing shoots per tree were randomly selected on late September (at growth cessation) to estimate the maximum shoot length and number of leaves.

New shoots diameter

About ten new shoots (Same year) were selected. New shoots diameter was measured by using vernier caliper and the average was calculated.

Leaf area

On late June, Sixteen growing shoots per tree were randomly selected and marked to measure in late September (at growth cessation) to estimate the maximum leaf area according to **El-Deeb and Abbas (1993**).

Ten mature leaves of every new shoot growth from spring cycle were taken at random from each tree and placed on paper sheets. The leaf area was measured by counting the squares to the nearest cm by using the fresh weight method. Certain known disks were taken from the leaves with a cork borer and weighted. The leaf area was calculated using the following formula:

$$\text{Leaf area (L.A)} = \frac{\text{LFW}}{\text{Disk fresh weight}} \times \text{Area of disks} \quad (\text{cm}^2)$$

LA = Leaf area (cm^2)

LFW = Leaf fresh weight (g).

Tree circumference

Trees circumference was calculated by measuring the diameter of the tree consistent trend then calculate the radius as follows:

Trees circumference = $2\pi r$

$\pi = 3.14$

r = radius

Statistical analysis

The results in this study were exposed to proper statistical analysis of variance for a Split Plot Design (SPD) with (two factors split plots) using M-STATE C computer program for Agricultural analyses V.6.13 (Co. Hort. software, Berkeley, CA 94701) with three replicates contents two trees. Duncan's multiple range tests was used for comparison between means. Different alphabetical letters in the column are significantly differed at (0.05) level of significance (**Duncan, 1955**). The same trees were used throughout both experimental seasons.

RESULTS AND DISCUSSION

Vegetative parameters

Number of new shoots

The number of new shoots was significantly affected by all treatments in both seasons, as shown in Table 3. Irrigation with 100% of ETc significantly increased number of new shoots followed by 75% and 50% ETc, respectively, in both seasons. Also, P_{50} significantly increased number of new shoots followed by P_{25} and P_0, respectively in both season. Regarding to the interaction between ETc and polymer results showed that trees treated with $ETc_{75}P_{25}$ in both seasons were given the highest values compared with $ETc_{50}P_0$ in both seasons.

New shoots length

New shoots length of peach trees was significantly affected by all treatments in both seasons, as shown in Table 3. New shoots length was significantly increased by 100% ETc followed by 75%, while 50% ETc gave the lowest values, in both seasons. New shoots length was significantly affected by polymer addition on in both seasons; treatment with 50 g/tree recorded the highest significant values followed by 25g/tree and control, respectively.

The interaction between ETc and polymer gave the highest values with $ETc_{100}P_{50}$ and $ETc_{75}P_{50}$ in the first season, respectively. But the trees which were treated with $ETc_{75}P_{50}$ achieved the highest values in the second season followed by which were treated with $ETc_{100}P_{50}$while the lowest values in this respect were noticed with $ETc_{50}P_0$.

New shoots diameter

As shown in Table 4 new shoots diameter of peach trees was significantly affected by all treatments in both seasons. Peach trees which irrigated with ETc_{100} or ETc_{75} gave the highest values of new shoot diameter, while ETc_{50} gave the lowest value in both seasons. Also, shoots diameter significantly increased by polymer additions of 50g/tree followed by 25g/tree, the control was at least.

Data presented in (Table 5) show that the interaction between irrigation and polymer achieved the best values with $ETc_{75}P_{50}$ and $ETc_{100}P_{50}$ comparing with control treatment.

Number of leaves/ new shoot

As shown in Table 4, irrigation levels significantly affect number of leaves/new shoot. Trees treated with ETc_{100} obtained the best values, while ETc_{50} gave the lowest values in this respect in both seasons.

As for polymer additions, P_{50} significantly increased number of leaves/new shoot followed by P_{25} and P_0 obtained the lowest values in both seasons.

The interaction between irrigation levels and polymer additions affected on leaves/new shoots in both seasons. While $ETc_{50}P_0$ accorded the lowest value, $ETc_{100}P_{50}$ gave the highest value.

Leaf area

Results in Table 5 showed that leaf area was significantly affected by all treatments in both seasons. Trees which treated with ETc_{100} gave the highest significantly values, while which were treated with ETc_{50} gave the lowest.

Table (4): Effect of different levels of irrigation quantity and polymer on new shoots diameter and number of leaves/new shoot of "Sheikh Zewayed peach" trees.

Irrigation	New shoots diameter (cm)				Number of leaves/ new shoot			
	Polymer (Control)	Polymer 25 g	Polymer 50 g	Mean	Polymer (Control)	Polymer 25 g	Polymer 50 g	Mean
	1st Season (2013/2014)							
Control (ETc100%)	0.5200 c	0.6144 b	0.7144 a	**0.676 A**	31.92 c	33.34 bc	37.34 a	**34.20 A**
ETc 75%	0.5544 bc	0.5989 b	0.7478 a	**0.634 A**	24.52 e	32.43 c	35.24 b	**30.73 B**
ETc 50%	0.3989 d	0.5167 c	0.5867 b	**0.501 B**	20.27 f	24.02 e	27.89 d	**24.06 C**
Mean	**0.4911 C**	**0.577 B**	**0.683 A**	**-**	**25.57 C**	**29.93 B**	**33.49 A**	**-**
	2nd Season (2013/2014)							
Control (ETc100%)	0.8700 b	1.087 a	1.111 a	**1.023 A**	39.53 b	40.70 b	44.43 a	**41.55 A**
ETc 75%	0.8622 b	0.8867 b	1.179 a	**0.976 A**	32.18 d	40.24 b	43.51 a	**38.64 B**
ETc 50%	0.7500 b	0.7489 b	0.7300 b	**0.743 B**	27.40 e	31.02 d	35.10 c	**31.17 C**
Mean	**0.8274 B**	**0.91 Ab**	**1.007 A**	**-**	**33.04 C**	**37.32 B**	**41.01 A**	**-**

Values having the same letter(s) did not significantly different according to LSD at 0.05.

Table (5): Effect of different levels of irrigation quantity and polymer on Leaf area (cm^2) and Trees circumference (m) of "Sheikh Zewayed peach" trees.

Irrigation	Leaf area (cm^3)				Trees circumference (m)			
	Polymer (Control)	Polymer 25 g	Polymer 50 g	Mean	Polymer (Control)	Polymer 25 g	Polymer 50 g	Mean
	1st Season (2013/2014)							
Control (ETc100%)	31.92 c	33.34 bc	37.45 a	**34.23 A**	8.823 c	8.848 c	8.496 cd	**8.722 A**
ETc 75%	24.52 e	32.43 c	35.24 b	**30.73 B**	7.270 e	8.653 c	9.960 a	**8.628 A**
ETc 50%	20.27 f	24.02 e	27.89 d	**24.06 C**	7.077 e	8.207 d	9.263 b	**8.183 B**
Mean	**25.57 C**	**29.93 B**	**33.53 A**	**-**	**7.723 C**	**8.569 B**	**9.240 A**	**-**
	2nd Season (2013/2014)							
Control (ETc100%)	24.88 b	27.70 a	28.85 a	**27.14 A**	10.24 c	10.27 c	9.822 cd	**10.11 A**
ETc 75%	24.52 e	32.43 c	35.24 b	**30.73 B**	8.261 e	10.02 c	11.69 a	**9.991 A**
ETc 50%	20.27 f	24.02 e	27.89 d	**24.06 C**	8.017 e	9.456 d	10.80 b	**9.424 B**
Mean	**25.57 C**	**29.93 B**	**33.53 A**	**-**	**8.839 C**	**9.917 B**	**10.77 A**	**-**

Values having the same letter(s) did not significantly different according to LSD at 0.05.

The highest significantly values of leaf area in the two seasons were recorded with polymer addition of 50g/tree, while the lowest values were given with control (P_0).

The interaction between irrigation and polymer showed that $ETc_{100}P_0$ or $ETc_{75}P_{50}$ gave the highest significantly values comparing with $ETc_{50}P_0$ in both seasons.

Trees circumference

In both seasons, trees irrigated with ETc_{100} obtained the highest values of tree circumference, while the lowest values were achieved with ETc_{50} (Table 5).

Polymers additions treatment of 50g/tree gave the highest significant values followed by 25g/tree, while control gave the lowest values in both seasons.

The interaction between irrigation levels and polymer additions significantly boosted tree circumference.

ETc75P50 gave the highest significant values, while the lowest values were given by ETc50P0 in both seasons.

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الملخص العربى

تأثير تنظيم خفض مياه الري والبوليمر فائق الإمتصاص على النمو الخضري لأشجار الخوخ تحت ظروف شمال سيناء

محمد أحمد بلال[1]، هاني عبدالله العلاقمي[2]، عبدالحميد عبدالهادي عبدالحميد[1]، محمد محمود سرور[2]

١- وحدة الفاكهة، قسم الإنتاج النباتي، مركز بحوث الصحراء، مصر.
٢- قسم الإنتاج النباتي، كلية العلوم الزراعية البيئية، جامعة العريش، مصر.

أجريت هذه الدراسة خلال موسمي ٢٠١٤/٢٠١٣ و٢٠١٥/٢٠١٤ في مزرعة خاصة بمنطقة المسمي جنوب مدينة العريش، شمال سيناء، مصر. تم اختيار عدد ١٦٢ شجرة خوخ متماثلة في الشكل عمر ٦ سنوات صنف خوخ الشيخ زويد مطعومه علي أصول النيماجارد، تروي بنظام الري بالتنقيط بمعدل أربع نقاطات (٧ لتر/ ساعة) حول كل شجرة، وقد تم تحديد عاملين بحثيان لإجراء التجربة، العامل الأول مستويات مختلفة من البخر نتح للمحصول وهي ١٠٠% و٧٥% و٥٠% والعامل الثاني هو إضافة البوليمر فائق الامتصاص لكل شجرة في حفره تحت النقاطات بمعدل صفر (كنترول) و٢٥ و٥٠ جرام لكل شجره وتم توزيع معاملات الدراسة عشوائياً علي الأشجار بهدف التغلب علي مشاكل الجفاف في ظل نقص المياه والأمطار وكذلك دراسة تأثير تداخل العوامل علي نمو وانتاجية وكفاة استخدام المياه لأشجار الخوخ في تلك المنطقة، وأظهرت النتائج تأثير واضح لعوامل الدراسة علي الصفات المختلفة حيث أعطت معاملة الأشجار بنسبة ١٠٠% من البخر نتح للمحصول أفضل نتائج لصفات النمو الخضري من حيث عدد وطول وسُمك النموات الجديدة وعدد الأوراق في كل نمو جديد وأيضاً المساحة الورقية ومحيط الأشجار يليها المعاملة بنسبة ٧٥% في كلا الموسمين بينما أعطت الأشجار المعاملة بنسبة ٥٠% أقل القيم, كما أظهرت النتائج أن إضافة البوليمر بكمية ٥٠ جرام/شجرة من مادة البوليمر فائق الامتصاص أدي إلي زيادة في كل الصفات الخضرية في الموسمين يليها المعاملة بمعدل ٢٥ جم/شجرة بالمقارنة بالأشجار غير المعاملة، حيث تمت الإضافة ٢٠ ديسمبر في كلا الموسمين. تشير النتائج إلي أن الري بمعدل ٧٥% مع إضافة ٥٠ جرام بوليمر/شجرة أعطي أعلي معدل لزيادة النمو بالمقارنة بعدم الإضافة.

الكلمات الاسترشادية: مياه الري، البوليمر فائق الامتصاص، النمو الخضري، أشجار الخوخ، ظروف شمال سيناء.

المحكمـــــون:
١- **أ.د. محمد دياب الديـــب** أستاذ الفاكهة المتفرغ، كلية العلوم الزراعية البيئية، جامعة العريش، مصر.
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