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ENHANCING OLIVE TREES GROWTH AND PRODUCTIVITY BY USING HYDROGEL AND POTASSIUM HUMATE UNDER RAIN-FED CONDITION IN NORTHERN WESTERN COASTAL ZONE

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This study was conducted under water stress conditions at Ras-El Hekma region, Matrouh Governorate, Egypt for two successive seasons, 2015 and 2016 on Egazy olive trees (*Olea europaea* L.). This investigation was performed to study the effect of soil with addition of hydrogel polymer at 0, 100, 150 and 200 g/tree and potassium humate at 0, 40, 60 and 80 g/tree. The obtained results cleared that both hydrogel and K-humate significantly enhanced vegetative growth parameters, yield and fruit physio-chemical properties and leaf mineral contents in both studied seasons, either singly or in combinations. Using 200 g/tree of hydrogel with 80 g/tree K-humate were surpassed control and other hydrogel or K-humate rates and improved all vegetative growth parameters, yield, fruit physio-chemical properties and leaf mineral contents during 2015 and 2016. It can be concluded that the different application treatments significantly improved the studied vegetative growth parameters, yield, fruit physio-chemical properties and leaf mineral contents of Egazy olive trees that were cultivated under water stress conditions in the following arrangement; interaction of hydrogel + K-humate>hydrogel > K-humate.

Keywords: olive trees, hydrogel, potassium humate, growth, yield, fruit quality

Olive (*Olea europaea* L.) is the one of widely cultivated trees in arid and semi-arid soils in Mediterranean climate, where long times of soil water deficit are usually present. Olive tree has been considered as one of the best adapted species to the arid and semi-arid environmental conditions (Giménez et al., 1997). Drought is the main factor to induce stress, decreasing plant growth and crop production in arid and semi-arid soils (Polle et al., 2006). In Egypt, olive acreage reached 160000 feddan (64020.00 ha) and fruiting area recorded 140764 feddan (56305.6 ha) with total fruit production of 560610.00 metric tons (FAO, 2014).

Hydrogel is a superabsorbent polymer (SAP) that absorbs water hundreds of times of its own dry mass. Soil water and nutrients stored in hydrogel are released gradually for plant growth under water limiting conditions (Yazdani et al., 2007). Hydrogel is sometimes referred to "root watering crystals" or "water retention granules" because it swells like sponges to be as several times of its original size, when it contacts with freely available water, consequently increases soil water holding capacity and reduces irrigation frequency (Koupai et al., 2008 and Jamnicka et al., 2013). The different levels of SAP could absorb and hold water and consequently reduce the effect of drought stress, improve the growth characteristics and reduce the activity of catalase and peroxidase enzymes (Tongo et al., 2014 and Sannino, 2008).

Also, hydrogel or superabsorbent polymer (SAP) can increase the efficiency of coefficient agriculture water. Hydrogel polymers can absorb amounts of rainfall water, save a runoff and then slowly release again on arid soils. Addition of hydrogel (superabsorbent) in the landscape can decrease cost and irrigation amount. On the other hand, hydrogel can decrease drought stress, because it can absorb water until 400 upper its weight (Allahdadi, 2003 and Khoshnevis, 2003). Shirdel and Todehi (2009) found that, addition of hydrogel in the soil increases soil absorption capacity on grapevines. Buchholz and Graham (1998) showed that, the higher amount of water availability helps to reduce water stress during longer times of water drought. During the slow release, water phase of the hydrogel polymer, free pore volume will be created within the soil, offering additional space for root growth and air as well as water infiltration and storage. Stockosorb also strongly resists soil pressure at high soil depth without losing its swelling capacity. Consequently, water is stored in the root zone so that water and plant nutrient losses due to deep percolation and nutrient leaching can be avoided. In this way, water and nutrients are available to the plant over a longer period of time

Humic acid is one of bio-stimulants, which is known as the organic material that promotes plant growth and yield as well as helps plant to withstand harsh environments when applied in small quantities (Chen et al., 1994). Humic acids have been shown to stimulate plant growth and consequently yield by acting on mechanisms involved in cell respiration, photosynthesis, protein synthesis, water and nutrient uptake and enzyme activities (Chen et al., 2004). Also, humate is highly beneficial for both plant and soil; it maintains proper plant growth as well as increases nutrient uptake, tolerance to drought and availability of soil nutrients, particularly in calcareous soil and low organic matter of soil (Ismail et al., 2007). Potassium humate increases production and quality of a crop, plant tolerance to drought stress, salinity, heat, cold, disease and pests (Jalim et al., 2013). Abd El-Razek et al. (2012) found that foliar and/or soil application of humic acid had a positive effect on yield, fruit quality, leaf chlorophylls as well as leaf mineral content of NPK. Humic acid application as foliar spray combined with soil application at 0.50% for both is the promising treatment for improving growth and fruit quality of Florida Prince peach tree.

Fathi et al. (2008) indicated that soil application of humic acid effectively enhanced shoot length, number of leaves, leaf area and yield components of "Canino" apricot. Also, El-Shall et al. (2010) found that humic acid addition to the soil or foliar application increased the vegetative growth of plum trees with superiority for soil application compared to foliar application. Moreover, the combined amendments (soil and foliar application of humic acid) significantly increased the height and trunk diameter of the trees besides increasing number, length and diameter of shoots. Finally, the benefits ascribed to the use of humic acid, particularly in low organic matter, alkaline soil, include increased nutrient uptake, tolerance to drought and temperature extremes, activity of beneficial soil microorganisms and availability of soil nutrients (Russo and Berlyn, 1990). This investigation aimed to study the enhances Egazy olive trees growth and productivity by hydrogel (as superabsorbent polymer) and K-humate under rain-fed conditions in Northern Western Coastal Zone.

MATERIALS AND METHODS

This study was conducted at Ras El-Hekma region, Matrouh Governorate, Egypt for two successive seasons, 2015 and 2016, on about 20 years old olive tree cv. Egazy, similar in growth, vigor and health and received the recommended agricultural practices. They were planted at 7 x 7 meters apart, grown on sandy loam calcareous soil and depended on rainfall as the main source for irrigation. Experiment treatments were established in a split plot design arrangement with three replicates and two trees per each replicate. All treated trees were received one time (before fruit set in both seasons) superabsorbent amount hydrogel polymer at 0, 100, 150 and 200 g/tree and humic acid at 0, 40, 60 and 80 g/tree. Addition in the dug holes mixed with soil around canopy. At the same time, all treated trees received one supplemental irrigation of 150 L/tree. On early March of each season, twenty healthy one year old shoots were distributed around the canopy of each tree and were randomly selected and labeled (5 shoots of each direction) for carrying out the following measurements:

1. Vegetative Parameters

At the end of each growing season during first week of September, the following characteristics were measured: Number of new shoots, shoot length (cm) and leaf area (cm) according to Ahmed and Morsy (1999) using the following equilibration: Leaf area = 0.53 (length x width) + 1.66, total chlorophyll content in fresh leaves, which was measured in the field by using Minolta chlorophyll meter SPAD-502.

2. Yield

At maturity stage of two seasons (October), fruits of each tree were separately harvested, then weighted and yield as kg/tree was estimated.

3. Fruit Quality

Twenty fruit per each tree were randomly selected for carrying out the fruit quality measurements i.e., average fruit weight (g), fruit length (cm), fruit diameter (cm) and fruit volume (cm^3) were determined. Fruit oil percentage, total soluble salts (TSS) in juice using hand refractometer and acidity according to the method of A.O.A.C. (2005).

4. Leaf Proline Content

Extraction and determination of proline were performed according to the method of Bates et al. (1973) and expressed as mg/100g dry weight. Leaf samples (1 g) were extracted with 3% sulphosalicylic acid. Extracts (2 ml) were held for 1 h in boiling water by adding minhydrin (2 ml) and glacial acetic acid (2 ml), after which cold toluene (4 ml) was added. Proline content was measured by a spectrophotometer at 520 nm.

5. Leaf Mineral Contents

At the end of each growing season during first week of September, leaf samples were collected, washed and dried at 70°C until constant weight and then ground for determination of the following nutrient elements (percentage as dry weight): N, P, K, Zn and Fe as ppm in petioles from leaves opposite to basal clusters, according to methods outlined by Wilde et al. (1985).

6. Statistical Analysis

All the obtained data during both 2015 and 2016 experimental seasons were subjected to analysis of variances according to Snedecor and Cochran (1982).

RESULTS AND DISCUSSION

1. Tree Growth

Data in table (1) indicated that all vegetative growth parameters tested in this experiment i.e., number of new shoots, shoot length, leaf area and total chlorophyll of olive tree cv. Egazy were significantly increased in both seasons with hydrogel superabsorbent polymer (SAP) (0,100, 150 and

200 g/tree) and K-humate at 0, 40, 60 and 80 g/tree) under drought stress conditions. Besides, the combination between hydrogel and K-humate has given positive effect on all vegetative characteristics of Egazy olive trees as compared with the control in 2015 and 2016 seasons.

Table (1). Effect of hydrogel and K-humate on vegetative growth of olive tree cv. Egazy during 2015 and 2016 seasons.

Hydrogel (g)	No. of new shoots									
	2015				Mean	2016				Mean
	K-humate (g)					K-humate (g)				
	Cont.	40	60	80		Cont.	40	60	80	
Cont.	4.00	5.00	6.00	9.00	6.00	5.33	7.00	9.33	12.00	8.42
100	4.33	5.00	7.67	9.67	6.67	7.00	8.00	9.67	11.33	9.00
150	5.00	6.00	8.00	10.00	7.25	7.33	7.67	9.67	11.33	9.00
200	5.67	7.33	8.33	10.33	7.92	7.67	8.67	11.67	12.33	10.08
Mean	4.75	5.83	7.50	9.75		6.83	7.83	10.08	11.75	
LSD at 0.5%	H=0.66, P=0.66 , H×P=1.38					H=0.77, P=0.77 , H×P=1.51				
	Shoot length (cm)									
Cont.	12.03	15.04	19.88	20.32	16.82	13.14	20.63	23.99c	25.26	20.75
100	14.52	16.40	19.91	21.48	18.92	17.52	22.13	23.87	25.45	22.24
150	15.01	17.85	19.98	22.81	18.91	18.63	23.23	25.24	25.36	23.11
200	16.05	19.23	20.66	24.15	20.02	21.34	24.30	25.16	25.77	24.14
Mean	14.40	17.13	20.11	22.19		17.66	22.57	24.57	25.46	
LSD at 0.5%	H=0.66, P=0.66 , H×P=0.93					H=1.14, P=1.14 , H×P=1.25				
	Leaf area (cm^2)									
Cont.	4.07	4.11	4.36	4.77	4.33	3.77	4.95	5.46	5.57	4.94
100	4.12	4.19	4.45	4.89	4.41	4.41	4.70	5.20	5.68	5.00
150	4.19	4.21	4.51	5.07	4.49	4.54	5.19	5.34	5.70	5.19
200	4.38	4.33	4.59	5.21	4.63	4.91	5.39	5.63	5.61	5.38
Mean	4.19	4.21	4.48	4.98		4.40 c	5.06	5.41	5.64	
LSD at 0.5%	H=0.076, P=0.0.076 , H×P=0.15					H=0.25, P=0.25 , H×P=0.41				
	Total chlorophyll									
Cont.	38.81	36.60	37.68	40.78	38.47	39.20	43.36	44.81	45.99	43.34
100	37.85	38.30	41.34	45.49	40.75	39.58	44.12	44.71	44.97	43.35
150	36.80	39.18	43.12	45.50	41.15	40.45	44.31	45.93	48.00	44.67
200	42.31	42.18	46.36	46.89	44.44	40.79	43.87	46.00	47.82	44.62
Mean	38.94	39.07	42.13	44.66		40.01	43.91	45.36	46.69	
LSD at 0.5%	H=1.47, P=1.47 , H×P=2.34					H=1.26, P=1.26 , H×P=2.75				

Hydrogel separately gave clearly high significant effect on all vegetative parameters under drought stress in both studied seasons. In this respect, hydrogel treatment at 200 g/tree has given the highest values compared to control and other hydrogel treatments. Potassium humate separately at 80 g/tree recorded positive effect and high values on vegetative growth parameters in 2015 and 2016 seasons. From the previous results, it could be concluded that application of hydrogel with K-humate increased all vegetative growth characteristics. This may be due to improvement of soil water and nutrients absorption after this treatment. Also, the stimulating effect of hydrogel application may be attributed to the promotion effect on the parameters of plant growth enabling to store water and nutrients in hydrogel and then released gradually for plant growth under water limiting conditions. The present results are in agreement with those found by Yazdani et al. (2007), Sannino (2008) and Tongo et al. (2014). Furthermore, the enhancement effect of K-humate has been shown to stimulate plant growth by acting on mechanisms involved in cell respiration, photosynthesis, protein synthesis, water and nutrient uptake and enzyme activities. These results are in harmony with those reported by Allahdadi (2003), Khoshnevis (2003) and Shirdel and Todehi (2009). Also**,** the results are in line with those obtained by Fathi et al. (2008) on “Canino" apricot, El-Shall et al. (2010) on plum trees and Abd El-Razek et al. (2012) on Florida Prince peach tree.

2. Yield and Fruit Physical Properties

Regarding to data in table (2), it is clear that, yield and all fruit quality parameters i.e., fruit weight, length, width and volume of Egazy olive trees were significantly increased by the addition of hydrogel at 0, 100, 150 and 200 g/tree, and K-humate at 0, 40, 60 and 80 g/tree under drought stress conditions in both seasons. Regarding to data at the same table, it is mentioned that, addition of hydrogel as a superabsorbent polymer (SAP) singly has given the positive output on all tested parameters of Egazy olive trees yield, fruit weight, fruit length, fruit width and fruit volume under drought stress during 2015 and 2016 seasons. While, the high rate of hydrogel treatments at 200 g/tree has given the highest values compared to control and other hydrogel treatments. On the other hand, single addition of K-humate at 80 g/tree recorded positive effect and high values on yield and all physical fruit quality parameters of Egazy olive trees during 2015 and 2016 seasons. Furthermore, the combination of hydrogel and K-humate produced positive effect on all yield and fruit quality parameters of Egazy olive trees as compared with the control in both seasons. According to the interaction of hydrogel and K-humate with high rate (200 g hydrogel and 80 g K- humate/tree) succeeded in increase in yield and all physical fruit quality parameters and gave the highest values compared to control and other rates in both seasons. The beneficial effect of hydrogel polymer addition on enhancing yield (kg/tree) and fruit physical properties is due to the fact that the soil was wet for a longer time, which increasing the microbial activity and availability of nutrients.

Table (2). Effect of hydrogel and K-humate on yield and fruit physical properties of olive tree cv. Egazy during 2015 and 2016 seasons.

Hydrogel (g)	Yield (kg/tree)									
	2015				Mean	2016				Mean
	K-humate (g)					K-humate (g)				
	Cont.	40	60	80		Cont.	40	60	80	
Cont.	34.98	39.25	46.59	48.38	42.30	35.66	43.32	48.30	51.75	44.76
100	36.73	40.99	47.43	49.07	43.56	39.08	43.68	48.64	53.38	46.19
150	36.73	41.07	48.60	49.36	43.94	39.59	45.84	50.81	54.18	47.60
200	38.44	42.55	49.24	49.62	44.96	42.68	46.02	52.31	55.04	49.01
Mean	36.72	40.96	47.97	49.11		39.25	44.71	50.02	53.59	
LSD at 0.5%	H=0.76, P=0.76 , H×P=1.59					H=1.16, P=1.16 , H×P=2.27				
	Fruit weight (g)									
Cont.	3.61	4.43	4.73	4.82	4.40	3.90	3.96	4.74	5.10	4.42
100	3.98	4.59	4.70	4.86	4.53	3.83	4.03	4.85	5.21	4.48
150	4.25	4.64	4.77	4.88	4.64	3.91	4.19	4.91	5.23	4.56
200	4.50	4.70	4.86	4.90	4.74	3.93	4.39	4.97	5.26	4.64
Mean	4.09	4.59	4.76	4.87		3.89	4.14	4.87	5.20	
LSD at 0.5%	H=0.15, P=0.15 , H×P=0.21					H=0.20, P=0.20 , H×P=0.44				
	Fruit length (cm)									
Cont.	1.58	1.80	2.08	2.20	1.91	1.03	1.80	2.25	2.58	1.92
100	1.80	1.91	2.09	2.26	2.01	1.51	1.82	2.37	2.48	2.05
150	1.84	1.94	2.10	2.21	2.02	1.59	1.96	2.37	2.46	2.09
200	1.90	2.01	2.18	2.31	2.10	1.75	1.95	2.42	2.45	2.14
Mean	1.78	1.92	2.11	2.24		1.47	1.88	2.35	2.49	
LSD at 0.5%	H=0.11, P=0.11 , H×P=0.25					H=0.15, P=0.15 , H×P=0.24				
	Fruit width (cm)									
Cont.	1.35	1.41	1.66	1.74	1.54	1.42	1.55	1.66	1.84	1.62
100	1.36	1.51	1.67	1.77	1.58	1.45	1.58	1.67	1.83	1.64
150	1.38	1.53	1.72	1.79	1.60	1.50	1.59	1.76	1.84	1.67
200	1.40	1.61	1.74	1.78	1.63	1.50	1.63	1.81	1.84	1.70
Mean	1.37	1.51	1.70	1.77		1.47	1.59	1.73	1.84	
LSD at 0.5%	H=0.034, P=0.034 , H×P=0.062					H=0.036, P=0.036 , H×P=0.066				
	Fruit volume (cm^3)									
Cont.	2.98	3.50	3.69	3.87	3.51	3.11	3.53	3.76	3.85	3.56
100	2.98	3.52	3.67	3.89	3.51	3.27	3.65	3.75	3.85	3.63
150	3.20	3.47	3.66	3.95	3.57	3.45	3.76	3.76	3.84	3.70
200	3.23	3.49	3.80	3.99	3.63	3.49	3.72	3.78	3.92	3.73
Mean	3.10	3.50 c	3.71	3.92		3.33	3.66	3.77	3.86	
LSD at 0.5%	H=0.0058, P=0.058 , H×P=0.078					H=0.099, P=0.099 , H×P=0.19				

Potassium humate improved the soil capability to hold more water, enhances the plant growth, nutrient uptake, yield and fruit quality. These data are in agreement with those obtained by Fathi et al. (2008), who indicated that soil application of humic acid effectively enhances shoot length, number of leaves, leaf area and yield components of "Canino" apricot. Abd El-Razek et al. (2012) found that foliar and/or soil application of humic acid have a positive effect on yield, fruit quality, leaf chlorophylls as well as leaf mineral content of N, P and K. Humic acid application as foliar spray combined with soil application at 0.50% for both is the promising treatment for improving growth and fruit quality of Florida Prince peach tree. The present results are in an agreement with those found by Chen et al. (1994), Hoang and Böhme (2001), Zaky et al. (2006), Ismail et al. (2007), Karakurt et al. (2009) and Jalim et al. (2013).

3. Fruit Chemical Properties

Table (3) illustrates that, all fruit chemical properties of Egazy olive trees i.e., fruit oil percentage, proline, TSS % and acidity %, were significantly affected by hydrogel application at four rates (0, 100, 150 and 200 g/tree) and four rates of K-humate (0, 40, 60 and 80 g/tree) during 2015 and 2016. Furthermore, when hydrogel and K-humate were singly added, they have given positive output on all tested fruit chemical parameters of Egazy olive trees under drought stress in both studied seasons. While, the high rate of hydrogel treatment (200 g/tree) and K-humate at 80 g/tree) were surpassed compared to control and other hydrogel or K-humate treatments in both seasons. In this respect, the interaction of superabsorbent polymer (SAP) and K-humate succeeded in the enhancement and increase of all fruit chemical properties of Egazy olive trees i.e., fruit oil percentage, proline, and TSS %, except acidity percentage that has been insignificantly affected in both seasons when compared to control.

From the previously mentioned results, it could be concluded that application of hydrogel polymer enhanced fruit chemical properties due to the fact that the soil was wet for a longe time, microbial activity and availability of nutrient increased. Potassium humate application enhanced the plant growth, nutrient uptake, yield and fruit quality. The represent results are in an agreement with those of Jalim et al. (2013), who found that K-humate increases production and quality of a crop, plant tolerance to drought stress, salinity, heat and cold. Abd El-Razek et al. (2012) mentioned that foliar and/or soil application of humic acid have a positive effect on yield, fruit quality, leaf chlorophylls as well as leaf mineral content of N, P and K. Humic acid application as foliar spray combined with soil application at 0.50% for both is the promising treatment for improving growth and fruit quality of Florida Prince peach tree. Fathi et al. (2008) indicated that soil application of humic acid effectively enhances shoot length, number of leaves, leaf area, and yield fruit quality components of "Canino" apricot.

Table (3). Effect of hydrogel and K-humate on fruit chemical properties of olive tree cv. Egazy during 2015 and 2016 seasons.

Hydrogel (g)	Fruit oil percentage (%)									
	2015				Mean	2016				Mean
	K-humate (g)					K-humate (g)				
	Cont.	40	60	80		Cont.	40	60	80	
Cont.	15.76	16.19	17.26	18.85	17.02	16.10	17.82	18.29	19.20	17.85
100	15.82	16.78	17.61	19.58	17.45	16.61	17.80	18.81	19.82	18.26
150	16.07	16.92	17.75	19.05	17.45	16.52	18.42	18.89	19.95	18.45
200	16.78	17.76	18.95	19.66	18.29	17.4	18.84	19.26	20.31	18.96
Mean	16.11	16.91	17.89	19.28		16.66	18.22	18.81	19.82	
LSD at 0.5%	H=0.27, P=0.27 , H×P=0.49					H=0.35, P=0.35 , H×P=0.77				
	Proline (mg/100 g)									
Cont.	0.35	0.37	0.40	0.43	0.39	0.36	0.39	0.44	0.45	0.41
100	0.35	0.38	0.41	0.46	0.40	0.37	0.42	0.45	0.45	0.42
150	0.36	0.38	0.44	0.46	0.41	0.37	0.43	0.46	0.44	0.43
200	0.36	0.40	0.46	0.47	0.42	0.38	0.43	0.47	0.46	0.44
Mean	0.36	0.38	0.43	0.46		0.37c	0.42	0.46	0.45	
LSD at 0.5%	H=0.010, P=0.010 , H×P=0.017					H=0.013, P=0.013 , H×P=0.026				
	TSS (%)									
Cont.	10.53	10.50	10.74	11.62	10.85	10.49	10.76	11.26	11.76	11.07
100	10.32	10.51	11.05	11.7	10.90	10.62	11.14	11.46	11.79	11.25
150	10.49	10.65	11.21	11.84	11.05	10.74	11.21	11.62	11.79	11.34
200	10.57	10.70	11.58	11.93	11.19	10.78	11.77	11.73	11.86	11.53
Mean	10.48	10.59	11.14	11.78		10.66	11.22	11.52	11.80	
LSD at 0.5%	H=0.154, P=0.154 , H×P=0.26					H=3.68, P=3.68 , H×P=7.48				
	Oil acidity (%)									
Cont.	0.57	0.58	0.60	0.61	0.59	0.58	0.55	0.54	0.52	0.55
100	0.57	0.58	0.60	0.62	0.59	0.57	0.55	0.52	0.52	0.54
150	0.57	0.59	0.62	0.61	0.59	0.57	0.54	0.52	0.51	0.53
200	0.57	0.59	0.62	0.61	0.60	0.55	0.54	0.52	0.51	0.53
Mean	0.57	0.59	0.61	0.61		0.57	0.55	0.53	0.52	
LSD at 0.5%	H=0.023, P=0.020 , H×P=0.046					H=0.011, P=0.011 , H×P=0.023				

4. Leaf Minerals Content

Data presented in table (4) indicated that all leaf mineral contents of Egazy olive trees treated with hydrogel and K-humate under water stress conditions were significantly increased with the increasing of soil addition rates of superabsorbent polymer (SAP) and K-humate in both studied seasons. Moreover, addition of hydrogel polymer and K-humate separately or in combination have significantly increased the leaf mineral contents with superiority for high addition rate of 200 g/tree for hydrogel and 80 g/tree for K-humate as compared with the other treatments and compared to control in both seasons. From the aforementioned results it can be concluded that the different application treatments significantly improved the leaf minerals of Egazy olive trees that were cultivated under water stress conditions in the following order: interaction of hydrogel + K-humate>hydrogel>K-humate.

According to the previous results, it could be concluded that application of hydrogel polymer enhances leaf mineral contents because hydrogel enables absorbing and retaining considerable amount of water and nutrients that would be slowly released into tree roots. This may be due to increase in the nutrient use efficiency of soil treated with hydrogel polymers and improving in physio-chemical conditions of soil and affecting the trees response to mitigate drought. These results are in harmony with those reported by Allahdadi (2003), Khoshnevis (2003), Shirdel and Todehi (2009) and Tongo et al. (2014).

The enhancement effect of K-humate may be due to the fact that its application improves soil capability to retain much more water, keeps soil temperature for plant growth and increases the soil aeration and soil workability by enhancing the structure in the top soil. Also, K- humate application enhances the plant growth, nutrient uptake, yield and fruit quality. The represented results are in an agreement with those of Abd El-Razek et al. (2012), who found that foliar and/or soil application of humic acid have a positive effect on yield, fruit quality, leaf chlorophylls as well as leaf mineral content of NPK. Humic acid application as foliar spray combined with soil application at 0.50% for both is the promising treatment for improving growth and fruit quality of Florida Prince peach tree (Hoang Böhme, 2001; Zaky et al., 2006 and Karakurt et al., 2009).

Table (4). Effect of hydrogel and K-humate on leaf minerals content of Olive tree cv. Egazy during 2015 and 2016 seasons.

Hydrogel (g)	**2015**				**Mean**	**2016**				**Mean**
	K-humate (g)					**K-humate (g)**				
	Cont.	**40**	**60**	**80**		**Cont.**	**40**	**60**	**80**	
					N (%)					
Cont.	1.38	1.54	1.65	1.86	1.61	1.44	1.69	1.81	1.95	1.72
100	1.45	1.60	1.69	1.88	1.66	1.66	1.76	1.87	1.97	1.82
150	1.48	1.64	1.81	1.91	1.71	1.69	1.79	1.88	1.98	1.83
200	1.57	1.73	1.85	1.96	1.78	1.69	1.81	1.94	2.10	1.88
Mean	1.47	1.63	1.75	1.90		1.62	1.76	1.87	2.00	
LSD at 0.5%	H=0.023, P=0.32 , H×P=0.060					H=0.041, P=0.041 , H×P=0.064				
					P (%)					
Cont.	0.12	0.14	0.16	0.18	0.15	0.14	0.17	0.43	0.21	0.24
100	0.12	0.15	0.16	0.18	0.15	0.17	0.18	0.20	0.21	0.19
150	0.12	0.14	0.17	0.19	0.16	0.17	0.19	0.20	0.22	0.20
200	0.13	0.15	0.18	0.20	0.17	0.17	0.19	0.20	0.23	0.20
Mean	0.12	0.15	0.17	0.19		0.16	0.18	0.26	0.22	
LSD at 0.5%	H=0.010, P=0.010 , H×P=0.019					H=0.087, P=0.087 , H×P=0.17				
					K (%)					
Cont.	0.98	1.07	1.14	1.16	0.98	0.97	1.13	1.15	1.17	1.11
100	0.95	1.13	1.15	1.15	1.09	1.07	1.13	1.15	1.16	1.13
150	0.99	1.13	1.15	1.18	1.10	1.12	1.13	0.82	1.17	1.06
200	0.76	1.15	1.17	0.86	1.11	1.12	1.14	1.16	1.17	1.15
Mean	0.92	1.12	1.15	1.09		1.07	1.14	1.07	1.17	
LSD at 0.5%	H=0.159, P=0.159 , H×P=0.34					H=0.123, P=0.123 , H×P=0.24				
					Zn (ppm)					
Cont.	45.62	47.96	50.76	54.22	49.64	45.32	50.75	56.18	56.79	52.26
100	46.13	48.47	53.42	57.51	51.38	45.43	51.31	56.06	58.44	52.81
150	47.65	49.32	56.51	58.14	52.91	45.87	51.79	55.71	58.63	53.00
200	49.20	50.21	57.40	58.52	53.83	47.72	53.46	58.14	59.58	54.72
Mean	47.15	48.99	54.52	57.10		46.08	51.83	56.52	58.36	
LSD at 0.5%	H=1.19, P=1.19 , H×P=1.94					H=1.16, P=1.16 , H×P=2.57				
					Fe (ppm)					
Cont.	105.93	108.55	119.29	125.72	114.87	110.96	120.18	123.54	124.58	119.81
100	107.29	115.61	121.15	126.46	117.63	114.44	120.20	123.89	125.04	120.89
150	113.78	118.04	122.20	127.27	120.32	117.81	121.95	124.34	124.68	122.20
200	116.75	119.95	123.10	129.13	122.23	118.98	120.90	124.19	124.94	122.25
Mean	110.94	115.54	121.44	127.14		115.55	120.81	123.99	124.81	
LSD at 0.5%	H=3.10, P=3.10 , H×P=**6.19**					H=2.30, P=2.30 , H×P=4.52				

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تحسين نمو وإنتاجية أشجار الزيتون بإستخدام الهيدروجيل وهيومات البوتاسيوم تحت ظروف الزراعة المطرية بالساحل الشمالي الغربي

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أجريت هذه الدراسة في منطقة رأس الحكمة بمحافظة مطروح بمصر لمدة موسمين متتاليين ٢٠١٥ و٢٠١٦ على أشجار الزيتون صنف العجيزي. أجريت هذه الدراسة تحت ظروف الجفاف. تم إجراء هذا البحث لدراسة تأثير إضافة الهيدروجيل بوليمر إلى التربة بتركيز ٠، ١٠٠، ١٥٠ و٢٠٠ جم/شجرة) والبوتاسيوم هيومات بتركيز ٠، ٤٠، ٦٠ و٨٠ جم/شجرة) إضافة للتربة. أظهرت النتائج بوضوح أن كلًا من معاملات الهيدروجيل وهيومات البوتاسيوم قد إزدادت معنويًا بشكل فردي وعند الخلط. في حين أن الهيدروجيل وهيومات البوتاسيوم إضافة إلى التربة حسنت كل معاملات النمو الخضري، المحصول، الصفات الفيزيائية والكيميائية للثمار والمحتوى المعدني في الأوراق في كل من الموسمين المدروسين. إستخدام ٢٠٠ جم/شجرة من هيدروجيل مع ٨٠ جم/شجرة بوتاسيوم هيومات تفوقت على الكنترول وجميع معاملات الهيدروجيل وهيومات البوتاسيوم، وحسنت جميع معاملات النمو الخضري، المحصول، الصفات الطبيعية والكيماوية ومحتويات أوراق النبات من العناصر في كلا موسمي الدراسة ٢٠١٥ و٢٠١٦. من النتائج المذكورة أعلاه يمكن الإستنتاج بأن المعاملات المختلفة حسنت بشكل ملحوظ من قياسات النمو الخضري المدروسة والمحصول والخصائص الفيزيائية والكيميائية للثمار والمحتوى المعدني للورق في أشجار الزيتون العجيزي المنزرعة تحت ظروف الإجهاد المائي وكانت في الترتيب التالي: هيدروجيل + هيومات البوتاسيوم > هيدروجيل> هيومات البوتاسيوم.