Hydrogel as a soil conditioner affecting the growth, yield, and fruit quality of 'Murcott' mandarin trees under arid and semi-arid lands

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ABSTRACT

'Murcott' mandarin fruits are suffering from sunburn injury in arid and semi-arid lands. In this regard, hydrogel represents a promising approach in the citrus industry, since it improves growth, yield, and fruit quality under abiotic stress. This investigation aims to study the effect of adding of hydrogel (as soil conditioner) with or without water regime on growth and yield of 'Murcott' mandarin trees budded on Volkamer lemon rootstock grown in sandy soil. The experimental farm location belongs to arid and semi-arid lands. The treatments were as follows 1: control (100 %) of crop evapotranspiration (Et_c), 2: 75% of Et_c, 3: 75% of Et_c+250 g of hydrogel / tree, 4: 75% of Et_c+500 g of hydrogel/tree and 5:75% of Et_c+750 g of hydrogel/tree. The results indicated that all applications of hydrogel composite significantly improved vegetative growth, yield, and fruit quality characteristics of 'Murcott' mandarin trees compared to the control. Regarding the vegetative growth, hydrogel at 750 g/tree under 75% of Et_c had the optimal values of vegetative growth parameters such as leaf area, shoot length, and tree canopy volume compared to all the other treatments. A similar trend was noticed regarding yield and fruit quality, as the best values were obtained when the hydrogel was used at 750 g /tree under 75% of Et_c. In conclusion, the application of hydrogel agent can improve the production and fruit quality of 'Murcott' mandarin trees in arid and semi-arid lands.

Keywords: Citrus; Crop evapotranspiration (Et_c); Fruits sun-burned; Growth; Yield; Vitamin C.

INTRODUCTION

Citrus is one of the most significant fruit trees in the world, which ranks the third place among fruit trees after grapevines and apples. Such species also is planted in more than seven million hectares worldwide (FAO, 2018). In Egypt, citrus is the largest horticultural industry as its acreage, production, and exportation potentialities are concerned. The harvested area is increased rapidly from one year to another to reach about (172745 ha.) in 2019 which produced about (4245684 tons) with the average of (24.57 tons/ha.) (Annual Reports of Statistical Institute and Agricultural Economic Research in Egypt 2019). The mandarin variety 'Murcott' trees are moderately vigorous, producing fruits in clusters form 'Murcott' expressed as the latest maturing tangerine variety since the fruit is harvested from January to March. Such fruit is seedy and has a small size with a yellow-orange rind (Abobatta, 2019).

The ever-expanding worldwide request for irrigation water, mutual with the influences of global warming, is making water shortage a big problem in several countries. Seeking for the limit of the available clean water supply will cause an increase in competition for water. Also, irrigation to avoid water deficient is one of the main limiting issues that affect crop production and quality. Fruit tree productivity is often limited by adverse physical and chemical soil properties such as low infiltration rates as well as low water retention and low cation exchange water and nutrient holding capacity of newly reclaimed soils, in particular, are very limited. Soils are categorized by excessive drainage of rain and irrigation water, as well as plant nutrients leaching below the root extension area (Kazanskii and Dubrovskii, 1992; Al-Omran and Al-Harbi 1998). This dilemma leads to deficiencies for irrigation and nutrients utilizations in fruit trees. The previous conditions are intensified in shallow-rooted plants or when irrigation water or irrigation systems are missing. Increasing irrigation water level is producing a significant decrease in the available amount of N, P, and K in the studied soil, due to increase leachability (Ekebafe *et al.*, 2011).

Hydrogel is an organic cross-linked co-polymer with irrigation water-binding clusters. It is known in India as a raindrop. Hydrogel agent has been established as a soil conditioner to decrease soil water loss and increase fruit yield (Abobatta, 2018). In the dry formula, the hydrogel polymer is a white crystalline granule, especially articulated for harmless use in the production of fruit trees orchards (Austin and Bondari, 1992; Green *et al.*, 2004). Hydrogels are sometimes referred to as "root watering crystals" because they swell like sponges to be as numerous times of their original volume when in contact with freely available irrigation water, consequently increase soil irrigation water holding capacity and decrease irrigation frequency (Koupai *et al.*, 2008). The hydrogels were claimed to decrease nutrients (NPK) leaching. The hydrogel polymer compound seems to be extremely effective as a soil conditioner in fruit trees, to boost fruit tree tolerance and growth in a sandy or lightweight gravel substrate. Pattanaaik *et al.*, (2015) found that soil application with stockosorb at concentration 100 g/tree significantly increased the vegetative growth and productivity of Assam lemon (*Citrus limon*) in comparison to that of control. Thus, this study is aiming to throw light on the influence of hydrogel agent with two levels of irrigation requirements on the vegetative growth, yield, and fruit quality of 'Murcott' mandarin trees in arid and semi-arid lands.

MATERIALS AND METHODS

The present study was conducted during the two successive seasons of 2017-2018 and 2018-2019 on ten years old 'Murcott' mandarin trees [*Citrus reticulate* Blanco] grown in sandy soil in a private orchard located at Al-Salhia El-gadeedh City, El-Sharkia Governorate, Egypt. 'Murcott' mandarin trees budded on 'Volkamer' lemon (*Citrus volkameriana* Ten. and Pasq.) rootstock. The trees were planted at 3 × 5 meters apart and irrigated using a drip irrigation system with 8 adjustable discharge emitters/trees (8 litter/h) through 2 irrigation lines. The crop water requirements (Et_c) were estimated using the crop coefficient according to the following equation: ($Et_c = Et_o \times K_c$). Reference evapotranspiration by Penman-Monteith, Et_o, was calculated from weather information (data of maximum and minimum temperature, relative humidity, and wind speed) were obtained from the meteorological data of the Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center, Dokki, Egypt. The seasonal average crop coefficient (K_c), according to Castel (2000), was 0.48. However, during the season K_c values varied from 0.38, in May, to 0.59 in October in concordance with the plant physiological cycle. Two irrigation levels treatments were conducted as follows: the control was irrigated at 100% of crop evapotranspiration (Et_c) throughout the season. The deficit irrigation treatments consisted of 75% of (Et_c). received irrigation amount equivalent to 75% of control. The tasted irrigation levels are based on different rates of irrigation water i.e. 5831, 5962.6 and 4373.3, 4472 m^3/fed./ year respectively in both seasons. The experiment was arranged out in a randomized block design with five treatments and three replications for each treatment nearly similar in vigor and subjected to the same cultural practices that followed in the farm. The soil conditioner hydrogel was added to the soil under irrigation lines at 20 cm depth in both sides of trees in mid of January from each season for one time only. These composites are mixtures of polyacrylic of super absorption polymer (SAPs) and clay deposits (Bentonite) at rate 1:5 (v/v) according to (Farag, *et al.,* 2017). Also, the 'Murcott' mandarin trees were received the recommended fertilization program (1000 g N, 150 g P_2O_5, and 600 g K_2O g/tree/year), micronutrient was applied a mixture of 300,150,100,50 and 50 mg of the applied fertilizer from chelated Fe, Mn, Zn, Cu and B as boric acid, respectively, in March, May, and August. The recommended fertilization program was applied to all trees on equal bases according to the extension of the Ministry of Agriculture, Egypt. This study aimed to throw light on the effect of adding a hydrogel agent that can be used as a soil conditioner holding water under different levels of irrigation quantity on growth, yield, and fruit quality of 'Murcott' mandarin orchards.

Treatments

The following treatments were applied.

1- Control: 100 % of crop evapotranspiration (Et_c)

2-75% of (Et_c).

3- 75% of (Et_c) + 250 g of hydrogel / tree.

4- 75% of (Et_c) + 500 g of hydrogel / tree.

5- 75% of (Et_c) + 750 g of hydrogel / tree.

Measurements

Vegetative growth

The following parameters were undertaken:

Average shoots length (cm)

Twenty shoots/tree replicated 3 times (3 trees) were devoted to measuring the shoot length (cm) at the end of spring cycles.

Leaf area (cm^2)

Twenty mature leaves replicated three times were abscised in December the fifth distal leaf on the shoot), then leaf area (cm^2) was calculated according to the following equation of Ahmed and Morsy (1999). Leaf area (cm^2) = 0.49 (Length × Width) + 19.09.

Tree canopy volume (m^3)

Tree size, expressed as a canopy volume was calculated by the formula of Zekri (2000) as follows:

0.52 × tree height × ($diameter^2$).

Tree Yield

Harvesting was achieved during the regular commercial harvesting time on February 15th for each season (297–300 days from full bloom according to Arras and Usai, 1991), yield (Kg/tree) was recorded. Fruit yield increment percentage was compared to the control was calculated by the following equation:

Fruit yield increment than the control (%) =

(Fruit yield (kg)/ treatment- Fruit yield (kg)/ control × 100) / (Fruit yield (kg)/ control)

Physical characteristics of fruits

Samples of ten fruits were picked at harvesting time for each replicate, then transferred to the chemical analytical laboratory of the department of horticulture, Faculty of Agriculture in Cairo, Al-Azhar University, to determine the following parameters: fruit weight (g), fruit volume (cm^3), fruit peel weight (g), fruit pulp weight (g), fruit height (mm), fruit diameter (mm), juice volume (mm), peel thickness (mm), flesh firmness (lb. / $inch^2$) using a pressure tester (Digital force - Gouge Model IGV-O.SA to FGV-100A.Shimpo instruments) and sunburned fruits %.

Sunburned fruits (%)

At harvest time on 15 Feb. in the two studied seasons. Normal and sunburned fruit were counted. Thus, the percentage of sunburned fruits was calculated according to the following equation:

Sunburned fruits % = (No. of sunburned fruits/tree) / (Total No. of fruit/tree) × 100.

Chemical fruit characteristics

The chemical characteristics of the fruits were determined according to AOAC. Fruit juice TSS% was recorded using a digital refractometer. Fruit juice titratable total acidity expressed as citric acid was measured by titration against Na OH (0.1N), and fruit juice Vitamin C (ascorbic acid mg/100ml juice) by titration with 2-6 dichlorophenol indophenol pigment (AOAC, 2016).

Statistical Analysis

All data obtained during both seasons were performed using one-way ANOVA according to Snedecor and Cochran (1990) and Co-stat software (version 6.303) according to Stern, (1991).

RESULTS AND DISCUSSION

Vegetative growth of 'Murcott' mandarin trees

Shoot length (cm) and leaf area

Data in Table (1) showed that adding hydrogel at any concentrations under drip irrigation system of 'Murcott' mandarin on mid of January significantly improved both shoot length (cm) and leaf area compared with control treatment [100 % of crop evapotranspiration (Et_c)] and 75% of (Et_c) in both seasons. The highest shoot length (cm) and leaf area were obtained when 750 grams of hydrogel were applied under 75% of irrigation requirement compared to the control and other treatments. These results are in agreement with those of Pattanaaik *et al.*, (2015) who found that adding stockosorb at a concentration of 100 g/tree to the soil significantly increased the vegetative growth of Assam lemon (*Citrus limon*) in comparison to that of control. Similarly, Abobatta and Khalifa (2019) on Washington navel orange reported that adding hydrogel significantly increased growth parameters in comparison to control. The increase in shoot length and leaf area might be due to the role of the hydrogel in holding water, therefore improving shoot and leaf growth and producing large canopy volume comparing with those of control (Austin and Bondari 1992).

Tree canopy volume (m^3)

Similar results were gained in Table 1 regarding tree canopy where the data showed that adding hydrogel composite to the soil at any concentration caused a significant increase in canopy volume compared to control. Moreover, adding both 500 g and 750 g of hydrogel/tree combined with 75% of (Et_c) caused the highest tree canopy volume (m^3) in both seasons. The results showed that super absorbent hydrogels help to increase the capacity of soil cationic exchange and well absorption of irrigation water and nutrition materials. Our results are in the same line with those reported by Abobatta and Khalifa (2019) who claimed that these super absorbent polymers (hydrogel) can prevent water and nutrition materials from washing and therefore increase Navel Orange vegetative growth. Also, Abraham and Pillai-vnr, (1995) and Huttermann *et al.*, (1999) indicated that super absorbent polymer (hydrogel) increased the capacity of water storage in newly reclaimed land as well as improved stability and growth of *Pinus halepensis* trees. The previous results might be due to the positive effect of hydrogel composite in improving moisture retention by coarse soils (McGuire *et al.*, 1987).

It could be concluded from the obtained results that there are significant differences between hydrogel especially at a high level and control regarding shoot length (cm), leaf area, and tree canopy volume (m^3) where the best results were gained when hydrogel at either 500 or 750 combined g/tree with 75% of (Et_c) was used.

Effect of hydrogel and irrigation level on the yield of 'Murcott' mandarin trees

Yield (kg/tree)

The results in Table (2) showed that increasing the concentration of hydrogel from 250 up to 750 g/tree significantly increased yield than control. The highest values of both yield and yield-increasing percentage were found in the treatment of hydrogel at 750 g /tree + 75% of Et_c compared to all the other treatments. Besides, all treatments of hydrogel led to a decrease in the number of sun-burned fruits/tree (Fig. 1b) than those grown under a water regime without hydrogel. The minimum number of sun-burned fruits/tree, as well as sun-burned fruits (%) /tree, were achieved by adding 750 g/tree of hydrogel combined with75% of Et_c, while the highest number of sun-burned fruits per tree and sun-burned fruits (%) /tree were obtained when the trees were received 75% of the irrigation level only without hydrogel. The decrease in sun-burned fruits might be due to increasing of water availability by hydrogel which led to wetting of soil a long time therefore, the availability of nutrients would be increased and also helps in reducing the fruit drop due to water deficit. This agrees with the study of Pattanaaik *et al.*, 2015 who claimed that the yield of Assam lemon (*Citrus limon)* was increased by application of hydrogel in comparison to control trees.

Physical characteristics of 'Murcott' mandarin Fruit

Data in Figs. from 1 up to 5 showed that adding different levels of hydrogel to the soil with different irrigation levels enhanced fruit physical characteristics of 'Murcott' mandarin such as fruit weight (g), fruit height (mm), fruit diameter (mm), H/D ratio, fruit volume (mm), peel weight (g), pulp weight (g), juice volume and peel thickness (mm). It was clear that adding hydrogel at 750 g/tree combined with 75% of Et_c caused the highest values in all above mentioned physical characteristics in the two studied seasons in comparison to those of control and other treatments. On the other hand, irrigate the trees with 100 % or 75 % of (Etc) without adding hydrogel caused the lowest values. Also, data in Figure (8) presented the influence of hydrogel with several irrigation levels on fruit firmness. It was cleared that adding hydrogel at levels from 250 up to 750 g/tree to the trees irrigated with 75% of (Etc) led to an increase in fruit firmness (lb./ $inch^2$) in comparison to untreated trees (control). The highest fruit firmness (lb./ $inch^2$) was gained by adding hydrogel at 750 g/tree to the trees that were irrigated with 75% of (Etc). There was a significant relationship between the water deficit and the reduction of cell size and reduction of water in plant tissues, consequently, these results reflected that the highest values of the average of some fruit physical parameters such as fruit weight and fruit firmness recorded high values with an increase of hydrogel in the presence of 75% of (Etc). These results are in agreement with those reported by Doraji *et al.,* (2005). Similarly, Barakat *et al.*, (2015) found that adding a different level of hydrogel with different irrigation rate enhanced fruit physical characteristics of 'Grand Nain' banana cultivar compared with control, where the maximum values of physical characteristics were obtained when the hydrogel was added to the soil at either 100 or 150 g / plant with different irrigation level.

Chemical characteristics of the fruit

Total soluble solids %

Data presented in Table (3) indicated that total soluble solids showed the highest values when the hydrogel was added at 750 g/tree that received 75% of (Et_c) compared with control and other treatments, the lowest values were recorded when trees were grown under control treatment. These results are in harmony with those of Barakat *et al*., (2015) who found that soil addition of hydrogel with irrigation by 80% of IR increased TSS% of 'Grand Nain' banana plants in comparison to control. Similarly, Costa *et al.*, (2011) reported that the lowest TSS values in banana 'Pacovan'(var. SH3640) fruit pulp was obtained by the highest irrigation levels.

Titratable Acidity%

Data presented in Table (3) revealed that trees that grown under control treatment achieved the highest values of acidity followed in descending order by those irrigated with 75% of IR. On the other hand, adding hydrogel to the soil improved, in general, the total acidity of fruits. In this regard, the least values of acidity were recorded by adding 750 g hydrogel/ tree to the soil under 75% of (Et_c). Our results are in the same line with those reported by Abobatta and Khalifa (2019) who found that soil addition of hydrogel decreased total acidity % of Washington navel orange fruits in comparison to control.

T.S.S / acid ratio

The presented data in Table (3) showed that adding all tested concentrations of hydrogel to the soil caused an increase in T.S.S / acid ratio compared with those of control. The results in Table (3) pointed out that the maximum T.S.S / acid ratio was obtained by adding hydrogel at 750 g /tree compared with those of control and other treatments.

The ascorbic acid content in fruit juice (vitamin C)

Data in Table (3) indicated that most of the hydrogel treatments caused higher levels of ascorbic acid (vitamin C) in fruit juice than control, where the highest ascorbic acid content in fruit juice was achieved by adding hydrogel at 750 g /tree that received 75% of (Et_c) in comparison with those of other applications. From the above-mentioned results, it might be concluded that the application of hydrogel improved both fruit physical and chemical properties since the soil became wet for an extended period, microbial activity, and availability of nutrients increased. These results are in line with those of Pattanaaik et al., (2015) who stated that adding hydrogel as soil application caused a raise in ascorbic acid content in fruits of 'Khasi' mandarin cv. compared with those of control and other treatments.

CONCLUSION

In conclusion, it would appear that adding hydrogel (as substance holding irrigation water) at a concentration of 750 g/tree to the soil caused an improvement in growth, yield, and fruit quality of 'Murcott' mandarin trees besides, it saved about 25% of (Et_c) irrigation treatment, so it might be recommended to use hydrogel as a promising agent to improve growth, yield and fruit quality of citrus.

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Table 1. Effect of hydrogel and levels of irrigation water on leaf area (cm²), shoot length (cm), and tree canopy volume (m³) of 'Murcott' mandarin trees in 2017/2018 and 2018/2019 seasons.

Character. Treatments	Leaf area (cm²)	Average shoot length (cm) at the spring cycle	Tree canopy volume (m³)
	2017/2018		
1- Control: 100 % of (Et_c*)	9.4	16.3	24.4
2- 75% of (Et_c)	16.2	20.3	32.7
3- 75% of (Et_c) + 250 g of hydrogel / tree.	17.6	22.3	35.7
4- 75% of (Et_c) + 500 g of hydrogel / tree.	23.3	25.7	39.4
5- 75% of (Et_c) + 750 g of hydrogel / tree.	23.5	26.7	39.4
L.S.D at 5% =	4.09	3.60	3.08
	2018/2019		
1- Control: 100 % of (Et_c*)	8.5	15.0	26.1
2- 75% of (Et_c)	16.5	18.7	33.5
3- 75% of (Et_c) + 250 g of hydrogel / tree.	18.4	21.7	37.8
4- 75% of (Et_c) + 500 g of hydrogel / tree.	22.1	26.3	40.8
5- 75% of (Et_c) + 750 g of hydrogel / tree.	22.6	27.7	41.8
L.S.D at 5% =	3.81	2.73	2.18

(Et_c *): of crop evapotranspiration.

Table 2. Effect of hydrogel and levels of irrigation water on yield and number of sun-burned fruits per tree of 'Murcott' mandarin trees in 2017/2018 and 2018/2019 seasons.

Character. Treatments	Yield (Kg) /Tree	Increase in yield than control %	No. of sun-burned fruits/tree	Sun-burned fruits (%) / tree
	2017/2018			
1- Control: 100 % of (Et_c*)	71.1	0.0	12.0	2.24
2- 75% of (Et_c)	85.0	21.3	17.0	3.16
3- 75% of (Et_c) + 250 g of hydrogel / tree.	118.3	70.2	11.0	1.50
4- 75% of (Et_c) + 500 g of hydrogel / tree.	126.8	81.9	9.0	1.49
5- 75% of (Et_c) + 750 g of hydrogel / tree.	128.8	83.6	6.0	1.01
L.S.D at 5% =	12.68	3.16	3.04	0.43
	2018/2019			
1- Control: 100 % of (Et_c*)	72.5	0.0	13.0	2.38
2- 75% of (Et_c)	86.7	20.2	18.0	3.09
3- 75% of (Et_c) + 250 g of hydrogel / tree.	120.0	66.5	11.0	1.64
4- 75% of (Et_c) + 500 g of hydrogel / tree.	127.5	76.8	10.0	1.57
5- 75% of (Et_c) + 750 g of hydrogel / tree.	130.3	83.6	7.0	1.08
L.S.D at 5% =	8.11	1.59	3.25	0.50

(Et_c *): of crop evapotranspiration.

Table 3. Effect of hydrogel and levels of irrigation water on some chemical characteristics of fruits of 'Murcott' mandarin trees in 2017/2018 and 2018/2019 seasons.

Character. Treatments	T.S.S%	Titratable acidity %	T.S.S / acid ratio	Ascorbic acid mg/100 ml of juice
	2017/2018			
1- Control: 100 % of (Et_c*)	10.6	1.7	4.3	31.2
2- 75% of (Et_c)	14.2	1.4	5.2	34.0
3- 75% of (Et_c) + 250 g of hydrogel / tree.	15.0	1.2	5.4	39.7
4- 75% of (Et_c) + 500 g of hydrogel / tree.	15.4	1.0	5.5	43.4
5- 75% of (Et_c) + 750 g of hydrogel / tree.	14.8	1.0	5.3	62.3
L.S.D at 5% =	1.65	018	2.09	5.81
	2018/2019			
1- Control: 100 % of (Et_c*)	9.6	1.6	6.0	32.1
2- 75% of (Et_c)	12.6	1.5	8.5	36.8
3- 75% of (Et_c) + 250 g of hydrogel / tree.	15.0	1.3	11.3	36.8
4- 75% of (Et_c) + 500 g of hydrogel / tree.	15.2	1.2	12.4	41.6
5- 75% of (Et_c) + 750 g of hydrogel / tree.	15.4	1.1	14.0	65.2
L.S.D at 5% =	1.37	0.16	1.65	6.79

(Et_c *): of crop evapotranspiration.

A B

Figure. 1 (A) Sound fruit 'Murcott' mandarin trees. (B) Sun-burned fruit 'Murcott' mandarin trees.

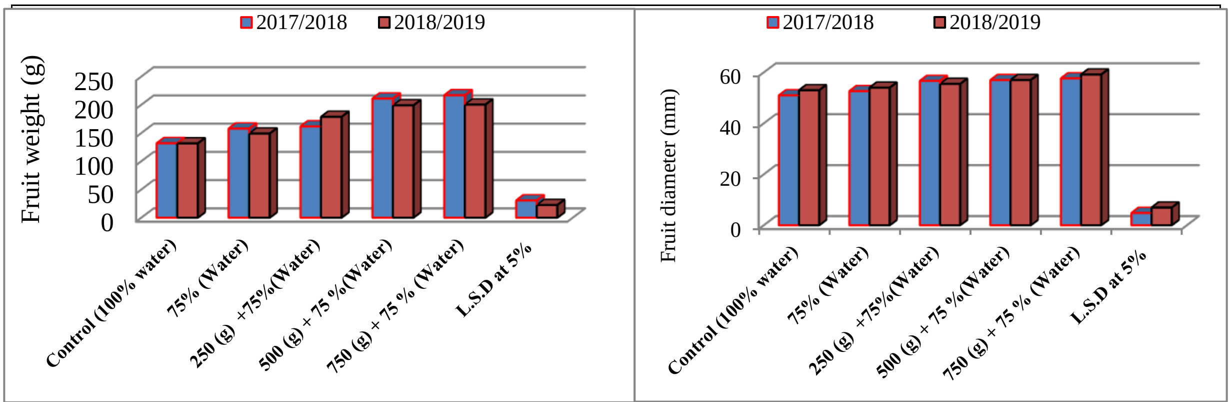

Figure 2. Effect of hydrogel and levels of irrigation water on fruit weight (g) and fruit diameter (mm) of 'Murcott' mandarin in 2017/2018 and 2018/2019 seasons.

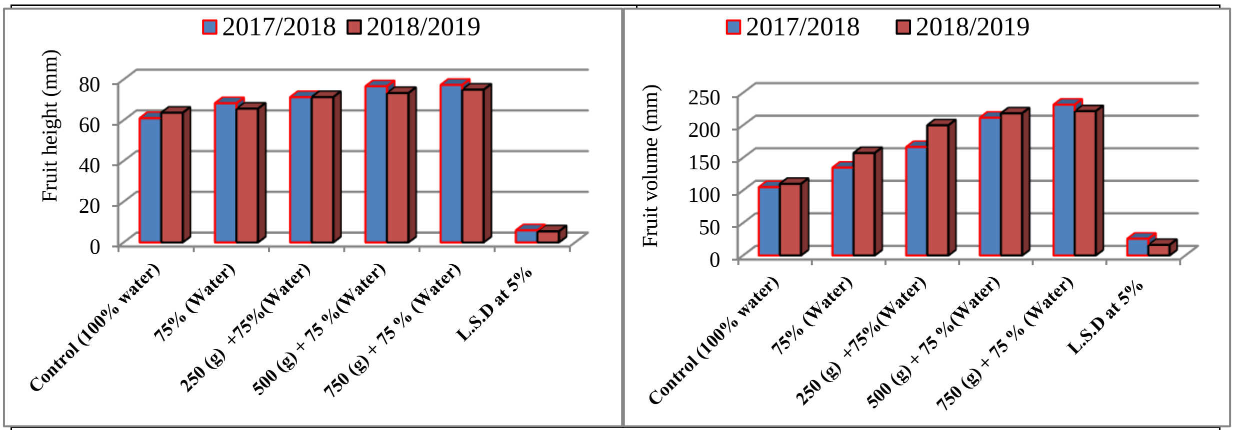

Figure. 3. Effect of hydrogel and levels of irrigation water on fruit heigh (mm) and fruit volume (mm) of 'Murcott' mandarin in 2017/2018 and 2018/2019 seasons.

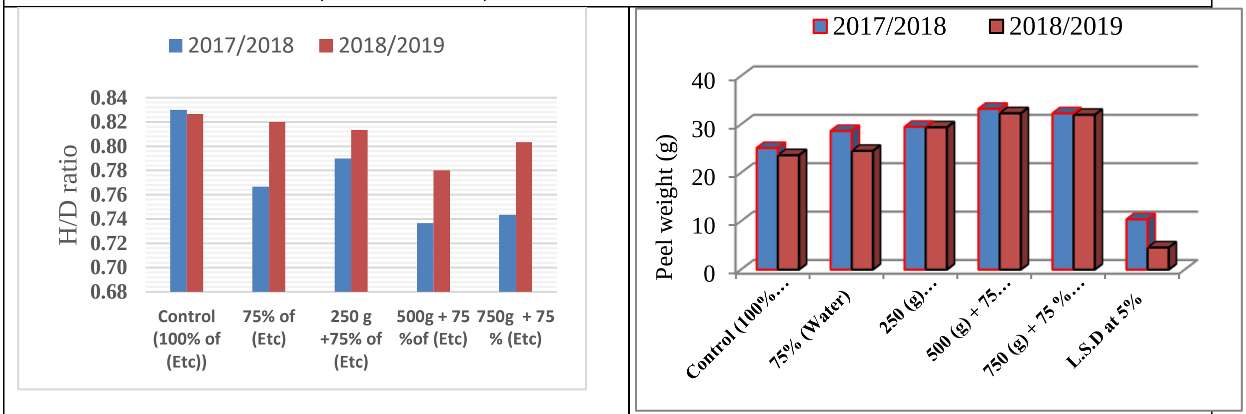

Figure. 4. Effect of hydrogel and levels of irrigation water on H/D ratio and Peel weight (g) of 'Murcott' mandarin in 2017/2018 and 2018/2019 seasons.

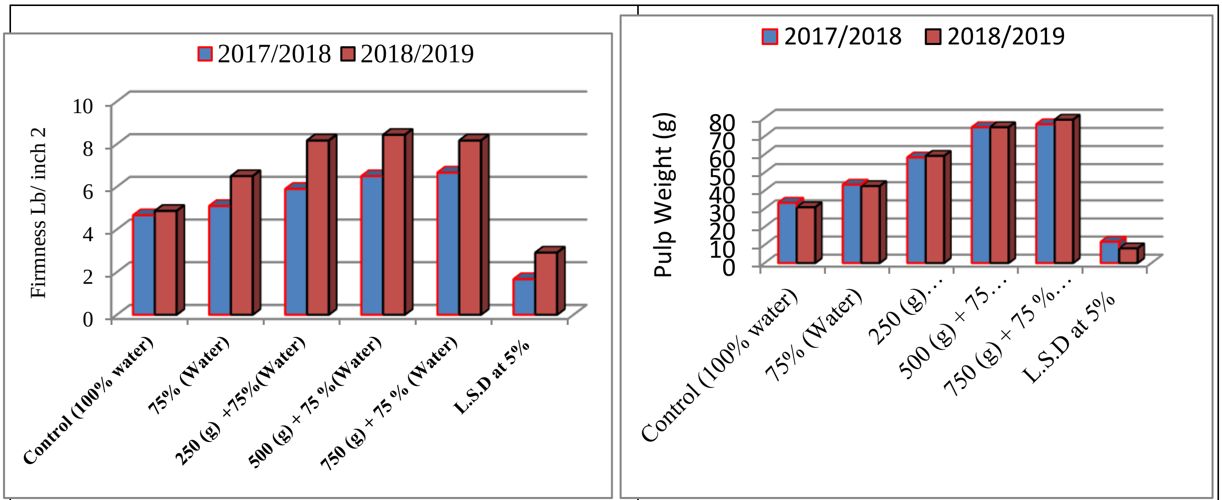

Figure. 5. Effect of hydrogel and levels of irrigation water on firmness Lb/ inch ^{2} and pulp weight (g) of 'Murcott' mandarin in 2017/2018-2018/2019 seasons.

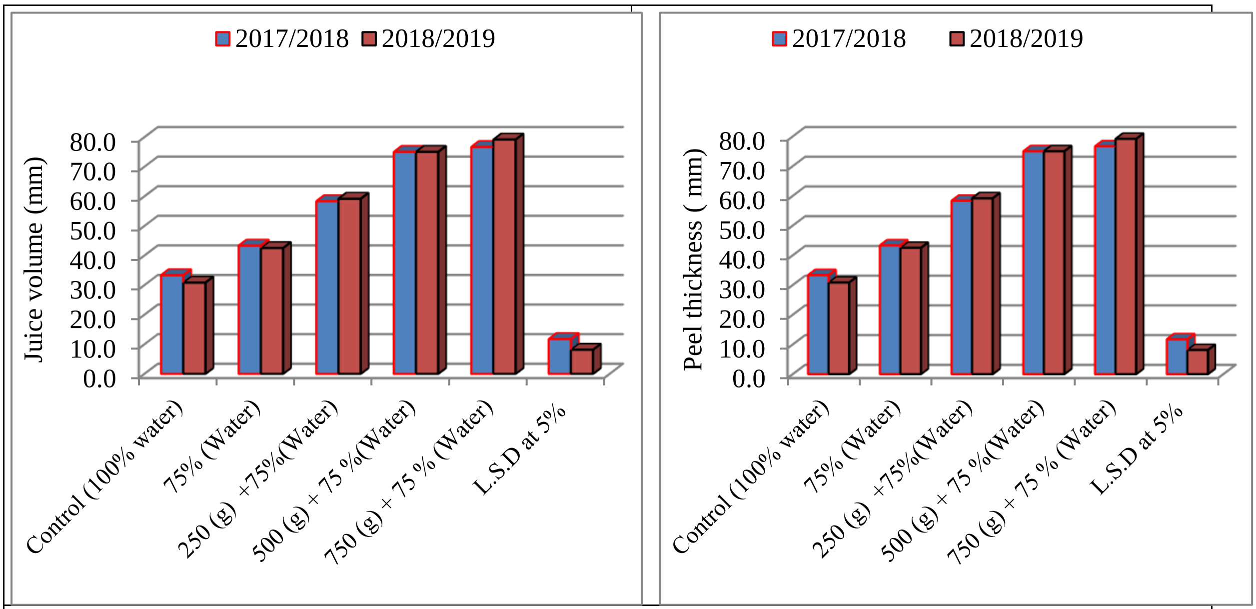

Figure. 6. Effect of hydrogel and levels of irrigation water and hydrogel on juice volume (mm) and Peel thickness (mm) of 'Murcott' mandarin in 2017/2018-2018/2019 seasons.

تأثير الهيدروجيل كمحسن للتربة على نمو ومحصول وجودة ثمار أشجار اليوسفي الموركيت تحت ظروف الأراضي الجافة وشبه الجافة

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الملخص العربي

تعاني ثمار اليوسفى موركيت من الإجهاد البيئي مثل لسعة الشمس في الأراضي الجافة وشبه الجافة. وتعتبر تقنية الهيدروجيل واعدة في إنتاج الموالح. حيث أنه يحسن النمو والمحصول تحت ظروف الإجهاد البيئي. ويهدف هذا البحث إلى دراسة إضافة مركب الهيدروجيل (كمحسن للتربة) مع أو بدون الإجهاد المائي على نمو ومحصول أشجار اليوسفي موركيت المطعومة على الأصل ليمون فولكاماريانا. أجريت هذه التجربة في بستان خاص بمنطقة الصالحية الجديدة بمحافظة الشرقية خلال موسمي 2018/2017 و 2019/2018 وتروى بنظام الرى بالتنقيط. وأجريت المعاملات كالتالي: 1- معاملة الكنترول (100 % من الاستهلاك المائي للمحصول والمعبر عنها بالمتر المكعب للفدان في السنة). 2- 75% من الأستهلاك المائي للمحصول. 3- 75% الأستهلاك المائي للمحصول + 250 جم هيدروجيل/شجرة. 4- 75% من الأستهلاك المائي للمحصول + 500 جم هيدروجيل/شجرة. 5- 75% من الاستهلاك المائي للمحصول + 750 جم هيدروجيل/شجرة. أوضحت النتائج أن كل معاملات مركب الهيدروجيل حسنت من صفات النمو الخضري والمحصول وجودة ثمار أشجار اليوسفي موركيت مقارنة بمعاملة الكنترول (بدون هيدروجيل). وبالنسبة للنمو الخضري أظهرت النتائج أن إضافة الهيدروجيل بمعدل 750 جم /شجرة تحت ظروف 75% من الأستهلاك المائي للمحصول أدت إلى أفضل قيم لقياسات النمو الخضري مثل مساحة الورقة، طول الفرخ، حجم مظلة الشجرة مقارنة بالكنترول والمعاملات الأخرى وفي اتجاه مماثل يمكن ملاحظة حالة المحصول وجودة الثمار حيث أن أفضل القيم نتجت عند استخدام الهيدروجيل بمعدل750 جم /شجرة تحت 75% من الاستهلاك المائي للمحصول مقارنة بمعاملة الكنترول وباقى المعاملات. وفي النهاية فإن إضافة الهيدروجيل يمكن أن تؤدي إلى تحسين إنتاج أشجار اليوسفي موركيت تحت ظروف الأراضي الجافة وشبه الجافة.

الكلمات الاسترشادية: الموالح، الأستهلاك المائي للمحصول، لسعة الشمس بالثمرة، النمو، المحصول، فيتامين ج.