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(Original Article)

Effect of Traditional and Modified Surface Irrigation Methods on Pomegranate Fruits Quality and Productivity in Assiut Governorate

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Abstract

This investigation was conducted during two successive seasons of 2019 and 2020 on 36 years old trees of Manfalouty pomegranate cultivar cultivated in a clay loam soil at the experimental orchard of Faculty of Agriculture, Assiut University, Assiut Governorate, for studying the effect of four irrigation methods: flood surface (control), terraces, ring and drip irrigation on vegetative growth and fruiting, yield, fruit physical and chemical properties and water use efficiency (WUE).

The obtained results indicated that, use modified flood irrigation (terraces), ring or drip irrigation significantly increased shoot length, number of leaves per shoot and leaf area. Using drip or modified irrigation recorded the highest water use efficiency (WUE). It is clear from the current results the importance of irrigation via modified surface irrigation (terraces) which leads to improve the growth and nutritional status of trees, hence increase the packable yield. In addition, such irrigation methods increase the water use efficiency and reduce the cost of production and avoid problems with drip irrigation.

Keyword : *Irrigation, Terraces, Drip, Pomegranate , Yield , Water use efficiency*

Introduction

The pomegranate (*Punica granatum* L.) is a favorite fruit of tropical and subtropical regions, pertinence of to the family Lythraceae. Manfalouty is considered one of the most important pomegranate cultivars grown successfully in Egypt. The total area of pomegranate trees was estimated to be about 0.5% of total fruit area in Egypt (76924 feddan). Assiut Governorate is considered the main producer of Egyptian pomegranate according to M.A.L.R. (2020).

Water scarcity is a global problem that challenges sustainability and places significant restrictions on food production needed to meet the growing food requirements (Molden, 2007). Egypt is one of the countries meeting major challenges for dryness and stationary share of given Nile waters. Water is necessary for plant, because it is an essential component of the biochemical reactions that occur within the plant. Water is also essential as it transfer plant

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nutrients and other substances inside the tree, as well as helps protect plant temperature through transpiration and preserving leaf and fruit turgidity. Water requirement differs extremely with season, soil type and tree cultivar. When a tree suffers from shortage of water, its yield decreases even it may regain after irrigation. On the other side, increasing the water quantity may result in harm to the crop and the soil besides being a squandering of water and labor.

The amount and quality of available irrigation water of the arid and semi-arid regions of the world such as Egypt are the main limiting factors for extension agriculture (Beaumont, 1993). Therefore, plant growth and development retarded when water supply was restricted (Wright and Stark, 1990). In Egypt the pomegranate is irrigated by surface flood irrigation system and trees could be developed under drought stress. So, the saving water uses became very national emergency and it must be converting the type of irrigation system from flood irrigation system to drip irrigation.

Improving irrigation efficiency has long been an important goal of water management in order to reduce loss and save water. Water can be kept by reduction loss of usable water to sinks, shortage of non-productive evaporation and reducing water pollution. Efficient irrigation methods such as furred, rings and drip irrigation ensure higher water use efficiency. Biologists are working to produce the highest production using the least with minimum inputs of irrigation and fertilization and fertilizers. Poor irrigation practices reduce water and fertilizers use efficiency (Abdel-Aziz *et al.,* 2013).

Recently, stimulated research in using new irrigation techniques with regulated deficit irrigation to improve water use efficiency and tree productivity. One of the most promising techniques involves the use of surface irrigation system. Which improve the water application efficiency as well as delivering water and nutrients directly to the root-zone and minimizing soil surface evaporation, runoff and deep percolation (Behnia, 1999).

Irrigation management is very important nowadays in Egyptian lands, due to the shortage in water resources, as well as the expansion of agriculture in the new lands. Therefore, it is necessary to determine the optimum amounts of water for fruit trees for maximum crop production.

Applying water to fruit tree crops is a widely used practice but efficient water use has become important only in recent years due to the rapid depletion of available water resources in many areas of the world (Kang *et al.*, 2002). For example, pomegranates are very drought tolerant but ensuring adequate soil moisture will result in a substantial improvement in plant vigor and fruit yield.

There was a little information about water use of pomegranate trees in relation to growth and productivity. Hence, studying the opportunities of improving the management of irrigation water to achieve real saving of water under the current conditions of water shortage.

The main goal of this investigation is to assess the actual water need for irrigation pomegranate orchards that give satisfactory growth and yield.

Materials and Methods

Field experiment

This experiment was undertaken during two successive seasons of 2019 and 2020 on 36 years old mature Manfalouty pomegranate trees grown in a clay loam soil at the distances of 5.0 meters between trees and between lines in the Experimental Orchard of Faculty of Agriculture, Assiut University, Assiut Governorate, Egypt.

Irrigation methods

The experiment included four irrigation methods

1-Flood irrigation or Traditional method (control): Water flows from one direction to the other end.

2- Terraces irrigation method (modified): the trees were on the terrace that with a width of one meter. Irrigation water was in lines with a width of 25 cm and depth 50 cm.

3- Rings irrigation method (basin system): rings were made a diameter of one meter around the trees and water was pushed around the rings, so that the irrigation was by drenching.

4- Drip irrigation method: the water is supplied drop by drop near the root zone in desired quantity as and when required.

The annual amount of irrigation water as m^3 per tree for each method in 2019 and 2020 seasons about 24.40, 13.85, 17.80 and 11.30 m^3 for each of traditional (flood), terraces, ring and drip irrigation respectively.

Flood, modified (terraces), ring irrigation were done according to climate conditions, while drip irrigation was done every two days.

Uniform thirty-six trees were selected randomly, where each irrigation method was replicated three times with three trees for each replicate and the randomized complete blocks design was used.

Ten shoots of one year old on each tree of the selected trees were labeled in the four directions points to study the following parameters:

Vegetative parameters

Length of the newly formed shoots (cm), diameter Shoot (cm) were measured at the end of growing season in September and the number of the leaves per shoot were counted.

Leaf area (cm^2) thirty full mature leaves/tree (from the 3^{rd} to 4^{th} basal nodes of shoot base) were randomly taken and weighing 60 sections of 1 cm^2 (2 sections of 1 cm^2/leaf) and then the average leaf area was estimated according to the following equation:

$$The\ average\ leaf\ area\ (cm^3) = \frac{Leaves\ weight(g)}{Sections\ weight(g)} \times 2$$

The increment percent of trail was tabulated as follow

$$\text{The increment percent} = \frac{\text{difference between modified irrigation methods and traditional}}{\text{traditional}} \times$$

Biochemical composition of leaves

Leaf total chlorophyll was estimated by using chlorophyll meter (Minolta SPAD 502 plus).

Nitrogen was measured by the micro-kjeldahl methods according to Bremner and Mulvaney (1982).

phosphorus and potassium were determined by colorimetrically and flame photometer, respectively (Jackson, 1958).

Fruiting and yield

Fruit Set (%)Total number of flowers per tree was counted at balloon stage and percentage of perfect flowers per tree were calculated. The number of perfect flowers which succeeded to set fruits was also counted and labeled and fruit set (%) was calculated according to the following equation

$$\text{Fruit set \%} = \frac{\text{number of set fruits}}{\text{total number of flowers (balloon stage)}} \times 100$$

Yield (kg/tree): Fruit were harvested at the recommended maturity standard and averages of total yield/tree were calculated as kg/tree.

Cracking (%), Sunburned (%) and Marketable fruits/tree (%) were also calculated. (Abou El-Wafa ,2006).

Fruit Quality Characteristics

Sample of fruits (n=10) of each treatment was randomly selected for determining the following physical and chemical properties:

Physical Fruit Properties

Fruit length and width (cm) were measured, the fruit weight (gm) was recorded, the arils % and juice percentage were calculated.

Chemical Fruit quality

as well as the chemical fruit quality such as total soluble solids (TSS %) was determined by using hand refractometer in fruit juice. Moreover, total acidity (%), total Tannins (%) and sugar contents in fruit juice were determined according to A.O.A.C. methods (1985). In addition, the total anthocyanin content (mg/100ml) in each of juice and rind (non-edible part) was calculated according to Rabino and Mancinelli (1986).

Water use efficiency (WUE)

Water use efficiency (WUE) was calculated as follows:

WUE = Y (Kg) / IR (m^3) which is the ratio of crop yield (Y) to the total amount of consumed irrigation water (IR) during the growing season. (Hussein, 2004).

Statistical analysis

The obtained data were tabulated and statistically analyzed according to Snedecor and Cochran (1980) and Mead *et al*. (1993). Differences between means were compared by the L.S.D. values at 5% level of probability.

Results

Effect of different irrigation methods on vegetative growth:

Data presented in Tables (1 and 2) exhibit a marked variation in most measurements of vegetative growth among the different irrigation methods used in this study. The longest shoot (cm) was scored by irrigation with terraces method. Moreover, the shoot diameter (cm), No. of leaves shoot and leaf area (cm^2) took similar trend as an average of two studied seasons (53.73, 0.963, 64.96 and7.98) respectively, followed by ring and drip irrigation methods. Whereas the minimum values attained by traditional irrigation method (36.17, 0.528, 44.00 and6.55) respectively.

Table 1. Effect of different irrigation methods on shoot length and diameter of Manfalouty pomegranate trees during 2019 and 2020 seasons

Irrigation methods	Shoot length (cm)			Shoot diameter (cm)		
Seasons	2019	2020	Mean	2019	2020	Mean
Traditional	35.33	37.00	36.17	0.520	0.536	0.528
Terraces	53.33	54.12	53.73	1.943	0.982	0.963
Ring	47.33	49.00	48.17	0.810	0.867	0.839
Drip	42.33	44.33	43.33	0.613	0.637	0.625
L.S.D.	2.98	2.92		0.061	0.064	

Table 2. Effect of different irrigation methods on some leaf traits of Manfalouty pomegranate trees during 2019 and 2020 seasons

Irrigation methods	No. of leaves/shoot			Leaf area (cm^2)			Chlorophyll SBAD value		
Seasons	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean
Traditional)	42.67	45.44	44.00	6.47	6.63	6.55	48.15	50.11	49.13
Terraces	64.25	65.67	64.96	7.95	8.00	7.98	54.78	58.45	56.62
Ring	52.28	55.60	53.94	7.11	7.23	7.17	52.39	55.13	53.76
Drip	49.33	51.88	50.61	6.89	7.03	6.96	51.31	53.82	52.57
L.S.D.	3.48	4.18		0.27	0.28		2.89	3.12	

The tabulated increment percentage of shoot length, leaves number and leaf area were attained (48.55, 33.18 & 19.80%), (47.64, 22.59 & 15.05%) and

(21.83, 9.47 &6.26%) as average of the two studied seasons, due to irrigate by terraces, ring and drip compared to use traditional irrigation, respectively.

Table 3. Effect of different irrigation methods on yield N, P and K percentage of Manfalouty pomegranate trees during 2019 and 2020 seasons

Irrigation methods	N%			P%			K%		
Seasons	**2019**	**2020**	**Mean**	**2019**	**2020**	**Mean**	**2019**	**2020**	**Mean**
Traditional	1.56	1.48	1.52	0.343	0.351	0.347	1.27	1.24	1.26
Terraces	1.75	1.67	1.71	0.392	0.389	0.391	1.46	1.41	1.44
Ring	1.68	1.60	1.64	0.375	0.370	0.373	1.41	1.36	1.39
Drip	1.66	1.57	1.62	0.368	0.369	0.369	1.37	1.33	1.35
L.S.D.	0.06	0.05		0.015	0.013		0.05	0.05	

Effect of different irrigation methods on chemical composition of leaves

The chemical analysis of leaves in Tables (2 & 3) observed the differences between the average of irrigation methods during 2019 and 2020 seasons. Chlorophyll content and N, P &K percentage in leaves were significantly affected by various methods of modified flood irrigation compared to use the traditional irrigation (control). Trees that irrigated by modified flood, (terraces), recorded the highest values of Chlorophyll content and N, P &K percentage (56.62, 1.71, 0.391 and 1.44) respectively, followed by the ring basin and drip irrigation, whereas the variance between them was very narrow. Otherwise, the least records attained by traditional method (49.13, 1.52, 0.347 and1.26) respectively, as the average of two studied season. In the contrary, the increment percentage of total chlorophyll, N% and K% were attained (15.25, 9.42 & 7.00%) (12.50, 7.89 & 6.58%) and (14.2, 10.32 & 7.14%) for average of two studied seasons, that is due to irrigation treatments by Terraces to Drip over the check treatment (Traditional), respectively.

Effect of different irrigation methods on fruiting and yield components

Data presented Tables (4 and 5) showed that, irrigated trees by each of modified flood irrigation (terraces), rings and drip ones significantly increased the fruit set %, yield/tree and decreased the fruit cracking & sunburn percentage, that led to a significantly increase in the marketable fruit's percentage comparing to use traditional flood irrigation. The maximum increase of the average fruit set (%), yield/tree and marketable fruits percentage in (Table 4) acquired by Terraces irrigating methods (91.16, 62.75 and 84.14) respectively, while a narrow variation was obtained by ring and drip irrigation. The minimal values attained by traditional method. The increment percentage of yield/tree was (23.89, 16.35 and 7.31%), due to Terraces to Drip over Traditional, respectively. Moreover, the corresponding increment marketable fruits percentage attained (35.19, 30.16 & 77%), due to terraces, ring and drip compared to traditional respectively.

Table 4. Effect of different irrigation methods on yield components of Manfalouty pomegranate trees during 2019 and 2020 seasons

Irrigation methods	Fruit set %			Yield/tree (kg/tree)			Marketable %		
Seasons	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean
Traditional	83.45	81.28	82.87	51.90	49.40	50.65	64.30	60.17	62.24
Terraces	92.56	89.76	91.16	62.31	63.19	62.75	83.00	85.28	84.14
Ring	88.74	88.93	88.64	58.34	59.52	58.93	79.86	82.15	81.01
Drip	87.79	87.43	87.61	53.47	55.23	54.35	80.10	82.67	81.39
L.S.D.	5.22	4.71		3.19	3.28		5.12	4.96	

As regard to the fruit cracking and sunburn percentages in (Table 5) it could be noticed that the Terraces irrigation method attained the least value of cracking (7.77 %) and sunburn (8.08 %) as an average of two seasons respectively. Whereas the maximum value attained by Traditional method. (18.30 % and 19.47 %). The decrement percentage of fruit cracking and sunburn due to modified, rings and drip irrigation comparing to traditional ones was (57.54, 45.90 & 50.87 %) and (58.50, 53.26 & 50.59 %) as an average of two seasons, due to irrigation treatments by Terraces to Drip, respectively.

Table 5.Effect of different irrigation methods on fruit splitting and sunburn of Manfalouty pomegranate trees during 2019 and 2020 seasons

Irrigation methods	cracking %			sunburn %		
Seasons	2019	2020	Mean	2019	2020	Mean
Traditional	16.95	19.65	18.30	18.75	20.18	19.47
Terraces	8.10	7.43	7.77	8.87	7.29	8.08
Ring	10.32	9.48	9.90	9.82	8.37	9.10
Drip	9.51	8.46	8.99	10.39	8.85	9.62
L.S.D.	1.03	1.04		0.90	0.92	

The heaviest weight yield/tree and marketable fruits % and lowest defective fruits percentage were recorded on the trees that irrigated with terraces irrigation, as modified flood irrigation (Terraces). Therefore, it is clear that irrigation by terraces have beneficial effects on the pomegranate production.

Effect of different irrigation methods on fruit quality

Physical Fruit Properties

Dealing with the specific effect of irrigation methods on physical fruit properties that presented in Table (6) noticed that irrigation with each of modified methods significantly improved the fruit quality in terms of increasing the fruit weight (gm), fruit dimension (cm) and aril (%) comparing to use the traditional flood irrigation which achieved the least records. Irrigation by terraces as a modified flood irrigation gave the highest values of traits under study. The recorded fruit weight, fruit length, fruit diameter and aril percentage were (402.1gm, 8.98 cm, 9.29 cm and 62.47 %) as average of two studied seasons respectively. Meantime, no significant differences on fruit dimension (cm) and aril (%) traits due to irrigation via either ring or drip irrigation methods. The least values attained by traditional method. The increment percentage in fruit weight was (16.05, 10.10 & 5.77 %) as an average of two studied seasons.

Table 6.Effect of different irrigation methods on some physical fruit properties of Manfalouty pomegranate trees during 2019 and 2020 seasons

Irrigation methods	Fruit weight			Arils %			Fruit length			Fruit diameter		
Seasons	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean
Traditional (I_1)	344.7	348.3	346.5	54.18	55.35	54.77	7.57	7.59	7.58	7.74	7.82	7.78
Terraces (I_2)	398.7	405.6	402.1	61.52	63.41	62.47	8.95	9.00	8.98	9.27	9.31	9.29
Ring (I_3)	379.7	383.3	381.5	58.29	59.97	59.18	8.13	8.16	8.15	8.37	8.43	8.40
Drip (I_4)	364.0	369.0	366.5	56.93	58.31	57.62	8.00	8.04	8.05	8.27	8.31	8.29
L.S.D.	6.29	6.19		2.63	2.58		0.41	0.39		0.42	0.37	

Fruit Chemical properties

The chemical analysis of fruit under different investigated methods of irrigation that tabulated Tables (7 & 8) indicated the existence of significant statistical differences among them for all measured parameters. As regards to the results of total soluble solids (%), reducing sugar (%) in juice and anthocyanin content(mg/100ml) in juice and rind in Table (7), it could be demonstrated that, the terraces irrigation gave the utmost high average of total soluble solids (17.4%) and total anthocyanin in juice (34.77) &rind (46.91) in 2019 and 2020 seasons. Whereas there were no differences were observed between each of ring and drip irrigation methods. Moreover, the highest reducing sugar (%) was scored by each of terraces and ring methods. In addition, the corresponding increment percentages of TSS% and juice anthocyanin were (18.86, 14.22 & 9.43%) and (21.43, 9.93 & 6.32%) as an av. of the two studied seasons, respectively. Similarly, the minimal decrease in the total acidity and tannins in Table (8) fulfilled by Terraces method (1.28 and 0.784%) compared to use the traditional flood irrigation which achieved the highest values (1.45, 1.064) respectively. Hence, the decrement percentage of total acidity and tannins under Traditional method attained (11.72, 8.96 & 6.21%) and (26.31, 16.07 & 15.69%) as an average the two studied seasons, due to use Terraces, Ring and Drip, respectively.

Table 7. Effect of different irrigation methods on TSS, sugar and anthocyanin of peel and juice of Manfalouty pomegranate trees during 2019 and 2020 seasons

Irrigation methods	TSS %			Reducing sugar %			T. Anthocyanin mg/100 g f. w. in rind			T. Anthocyanin mg/100 g. f. w. in juice		
Seasons	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean
Traditional	14.32	13.51	14.42	10.78	10.93	10.86	40.50	40.77	40.64	28.47	28.75	28.61
Terraces	17.03	17.25	17.14	13.36	13.92	13.78	46.73	47.09	46.91	34.63	34.90	34.77
Ring	16.37	16.56	16.47	13.10	13.52	13.31	43.57	43.79	43.68	31.27	31.63	31.45
Drip	15.57	15.99	15.78	12.33	12.81	12.57	42.67	43.11	42.89	30.20	30.64	30.42
L.S.D.	0.86	0.83		0.59	0.58		0.84	0.68		0.74	0.77	

Table 8. Effect of different irrigation methods on acidity, tannins and water use efficiency of Manfalouty pomegranate trees during 2019 and 2020 seasons

Irrigation methods	Acidity %			Total tannins			Water use efficiency kg/m^3 water		
Seasons	**2019**	**2020**	**Mean**	**2019**	**2020**	**Mean**	**2019**	**2020**	**Mean**
Traditional	1.36	1.53	1.45	1.040	1.087	1.064	2.13	2.03	2.08
Terraces	1.24	1.31	1.28	0.747	0.820	0.784	4.50	4.56	4.53
Ring	1.28	1.36	1.33	0.850	0.93	0.893	3.28	3.44	3.31
Drip	1.31	1.40	1.36	0.862	0.931	0.897	4.73	4.88	4.81
L.S.D.	0.05	0.07		0.109	0.103		0.42	0.36	

Hence, the cost wise evaluation of the irrigation methods of then application is in favor use terraces irrigation. Such irrigation method is very important for the production of pomegranate fruits, because the improvement of fruit quality induced leads to increase in packable yield. In addition, such irrigation method treatments reduce the production cost.

Effect of different irrigation methods on water use efficiency (WUE)

As a general, data presented in Table (8) illustrates the effect of different irrigation methods on water use efficiency in both seasons (2019 and 2020). It is obvious that, the results took similar trend during two studied seasons.

Water use efficiency (WUE) is defined by the ratio between the yield and the amount of water consumed by yield. The WUE indicator defined by that ratio is useful to identify the best irrigation methods.

Data indicated that, the water use efficiency significantly affected by various methods of irrigation used compared to use traditional irrigation (check treatment). Using modified flood irrigation (terraces), ring or drip irrigation significantly increased water use efficiency compared to use check treatment. Irrigation with drip gave the highest water use efficiency compared to other methods. There are no significant differences on WUE due to irrigate with either terraces or drip irrigation.

The obtained water use efficiency was (2.08, 4.53, 3.31 and 4.81 kg/m^3 water) as the av. of the two studied seasons, due to use traditional, terraces, ring and drip irrigation, respectively.

The increment percentage of the av. of water use efficiency during two studied seasons were (117.79, 59.13 and 131.25), due to irrigation with terraces, ring or drip irrigation over the check treatment (Traditional), respectively.

On other word, the drip irrigation or terraces had the highest significantly water use efficiency, while traditional flood recorded the least one, and use rings exhibited middle significant affect in both seasons. Moreover, the results showed the decrement percentage of annual water amount about 43.24, 27.05 and 53.71% due to use terraces, (modified), rings or drip irrigation compared to traditional (check treatment), respectively.

Discussion

Systems of irrigation were affected on the growth traits, yield and fruit quality of the fruit trees. Growth and fruiting traits were increased due to use modified flood or drip irrigation system compared with flood irrigation. In modified, ring and drip irrigation system, keeping the suitable moisture level in the active root zone of the trees and reduces the losing of nutrients acrosses the deepest soil course. Also, minimum disorders of roots plants that improve the tree health and induced to give high yield with good fruit quality compared with traditional flood irrigation system (Granatstein and Sánchez, 2009). In traditional flood irrigation system, highest amount of water used inside the field that induced an excessive growth of weeds that to necessary, repeated tillage to keep the field clean. This makes favorable condition for different soil borne diseases and eventually may lead to the tree decline (Steinmaus, 2014).

Fruit trees require optimum soil moisture to set of fruit, rapid cell division and cell enlargement of developing fruits. A regular supply of water is possible in terraces, ring or drip irrigation system compared with traditional flood irrigation system. Higher amount of water is applied in traditional flood irrigation more than compared with modified irrigation system. In addition, terraces or drip irrigation improved the concentration of essential nutrients such as N, P, K and Zn that gave high yield with good fruit compared with traditional flood irrigation. Irrigation has great effect on fertilizers use efficiency, yield and fruit quality. Faulty irrigation practices deteriorate fruit quality by reducing nutrients uptake from the soil (Hutton *et al*., 2007 and Quiñones *et al.*, 2007). Maximum nutrient uptake and minimize nutrient leaching were improved due to use modified irrigation system (Shirgure and Srivastava, 2013).

The same results were seen in our study, the higher nutrient contents N, P and K in leaf of Manfalouty pomegranate were noticed due to grown trees under terraces irrigation systems compared with trees under flood irrigation system.

Our results are in harmony with the conclusion given by Abo-Taleb *et al*. (1998), Abou El-Wafa (2002), Ibrahim and Abd El-Samad (2008) and Khattab *et al*. (2011) who revealed that shoot length number of leaves and leaf area of pomegranate significantly affected by irrigation regimes.

The yield of trees was increased due to of continuous improvement in the tree health that grown under terraces irrigation system such improving trend was not observed for the trees grown under traditional flood irrigation system. This can be due to induce poor health of the trees and losses of nutrients from the soil through leaching.

Thus, terraces or drip irrigation maintains the regular supply of moisture compared with traditional flood irrigation leading towards improved yield (Raza *et al.*, 2016). The trees in terraces (modified irrigation) gave the heaviest yield and marketable fruits with increment about (22.89 and 35.19% as an av. of two studied seasons) compared to traditional irrigation, respectively.

These results are in line with those reported by Abd El-Rahman (2010) and Khattab *et al*. (2011), they found that, fruit cracking of Manfalouty pomegranate decreased increase soil moisture level. So, it can be illustrated that, increasing fruit cracking with declining irrigation water application may be due to these fruits was taken from trees which grow under water stress. Also, they noticed that the highest yield was resulted with the highest moisture availability meanwhile, the lowest number of fruits was observed by least irrigation level (El-Khoreiby and Salem, 1989).

In our study, terraces irrigation reduced water by up to 45.02% compared with flood irrigation system, because in terraces irrigation system water is applied only into the terraces surround the tree canopy while the remaining area kept completely dry. However, in flood system too much water used inside of root zone of the tree. The trees in terraces systems produce highly yield and have better WUE because of frequent supply of irrigation water. We also observed higher WUE for yield (4.53 kg m^{-3}) for terraces irrigation system and lower (2.08 kg m^{-3}) for flood irrigation system.

The same results confirmed that receiving more frequent irrigation had greater water use than trees receiving less frequent irrigation under similar climatic conditions (Smitle *et al*., 1994; Abd El-Samad, 2005 and Khattab *et al*., 2011)

Conclusion

The use of either terraces, rings or drip irrigation improved the tree growth and nutrients status, as well as yield and fruit quality and leading to an increase in the marketable yield, as well as minimize the production costs.

These advantages will eventually enable growers to obtain high yield with good fruit quality. Furthermore, using modified irrigation improves the soil fertility and reduces water requirements that improved the water use efficiency.

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تأثير طرق الري بالغمر التقليدي والمعدل علي جودة وإنتاجية الرمان في محافظة أسيوط

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الملخص

أجريت هذه الدراسة بمزرعة كلية الزراعة – جامعة أسيوط – مصر خلال موسمي 2019 و2020 بهدف دراسة تأثير طرق الري المختلفة على نمو وإثمار أشجار الرمان المنفلوطي تحت ظروف محافظة أسيوط. حيث اشتمل البحث على أربع طرق من الري السطحي وهي الري السطحي التقليدي والري على المصاطب (سطحي مطور) والري بنظام الحلقات وكذلك الري بالتنقيط. وكان تصميم التجربة بنظام القطاعات كاملة العشوائية تحتوي على أربع معاملات وكل معاملة تحتوي على ثلاث مكررات وتتكون كل مكررة من أربع شجرات. وقد تم تقدير بعض صفات النمو الخضري ومكونات المحصول وخصائص الثمار خلال سنتي الدراسة لتقدير تأثير معاملات الري على هذه الصفات.

ويمكن تلخيص نتائج الدراسة كالتالي

سبب الري بنظام المصاطب (ري مطور) أو الحلقات أو التنقيط زيادة معنوية في صفات النمو الخضري (طول الفرع – مساحة الورقة – الكلوروفيل الكلي – محتوي العناصر) مقارنة بالري العادي وكانت أعلي القراءات نتيجة الري المطور.

أدي الري المطور أو الحلقات أو التنقيط زيادة جوهرية في نسبة العقد والمحصول/شجرة مع نقص معنوي في نسبة الثمار المشققة أو المصابة بلسعة الشمس وبالتالي سبب زيادة في كمية الثمار الجيدة مقارنة بالري السطحي (العادي).

أوضحت النتائج تحسين واضح في صفات الثمار من حيث الوزن ونسبة الحب ومحتواها من المواد الصلبة الذائبة الكلية والسكريات مع نقص الحموضة والتانينات نتيجة الري المطور.

تسبب الري بالتنقيط أو الري المطور (المصاطب) زيادة كفاءة استخدام الماء مقارنة بالري العادي. وهذا يؤدي إلى قلة الاحتياج المائي للأشجار ويعالج مشكلة ندرة المياه وكذلك يمكن استخدام الري المطور بدلاً عن الري بالتنقيط مما يقلل تكلفة الإنتاج وعلاج بعض مشاكل الري بالتنقيط.

من هذه الدراسة ينصح باستخدام الري المطور (مصاطب) حيث يؤدي إلي زيادة كفاءة الماء المستخدم مع تحسين النمو الخضري والحالة الغذائية للأشجار مما تسبب زيادة المحصول وتحسين خصائص الثمار وتقليل تكاليف الإنتاج.