Impact of pruning and training systems on the growth and productivity of pomegranate trees

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ABSTRACT

This experiment was conducted during the 2020 and 2021 seasons in the experimental orchard of the Horticultural Research Station in Shandaweel, Sohag Governorate, Egypt, on uniform four-year-old pomegranate trees of "Manfalouty" cultivar to evaluate the performance of trees under traditional pruning method (multi-trunk; five stems (control), four stems and three stems) as the first experiment and training systems (open centre, central leader and modified leader) as the second experiment. The results showed that, in the first experiment, the superiority of three stems in shoot length, total number of flowers /tree, fruit set (%) and number of fruits per tree, the value of juice total soluble solids, the ratio of TSS/acidity, total sugars content, anthocyanin content of peel & juice and least of acidity percent. In the second experiment, the superiority of modified leader in shoot length, fruit weight, volume, marketable (%) and least of cracking and sunburn percentage could be noticed. Wherese, the open centre system was superior in the total number of flowers /tree, fruit set (%), number of fruits per tree, yield, the value of juice total soluble solids, the ratio of TSS/acidity, total sugars content, content anthocyanin of peel and juice and minimum value of acidity content.

Keywords: Pomegranate – pruning- training systems - vegetative growth - fruit quality.

INTRODUCTION

Pomegranate is one of the oldest known edible fruits and can grow under different agro-climatic conditions ranging from tropical to sub-tropical and mild temperature regions.

The pomegranate trees tend to produce many suckers, when the trees are left untrained, an unbeneficial wild canopy is formed. Hence, like several other fruit plants, pomegranate trees also need a suitable training system to get a robust framework which gives yearly production and high sustainable yield with better fruit quality. The training system must be started after planting; otherwise, many suckers will have grown, which is hard to change (Hampson et al., 2002).

Training is one of the most important horticultural practices for commercial orchards. Training regulates tree shape in height and volume to reduce the deleterious effects of shading on flower bud induction and fruit development (Wünsche and Lakso, 2000). Proper training from the beginning will help promote a strong, productive tree that requires minimum pruning later in life. An appropriate canopy shaping and tree pruning system allow for obtaining high yields of good quality fruit, besides ease and quick harvesting (Hrotko, 2005). The achievement of an adequate higher-quality fruit yield and the setting of flower buds depend on light conditions, which can be improved by forming an adequate tree canopy (Buler and Mika, 2004 and Sosna and Marta, 2008). The training system affects tree growth, light penetration and distribution, yield and fruit quality (Hampson et al., 2002). These details for pomegranate are poor, and the tree is administered to help light spreading in the canopy, which improves photosynthetic activity that might increase yield. Choosing a suitable training system is very important to optimize penetration and photosynthetic activity, which leads to increase production and fruit quality (Durand, 1997 and Hampson et al., 2002).

Earlier, training and pruning were not typical applications in pomegranate orchards. Still, the knowledge for training and pruning has been formed among the growers due to the rising area of pomegranate plantations in recent years. Pomegranate trees tend to create multiple suckers that sprout from the stem underground or aboveground. So, pomegranate needs a proper training system to build a robust framework which gives a yearly high sustainable yield and fruit quality (Gill et al., 2011). The old way of training pomegranate trees is the multiple-trunk way. In this practice, the tree is let to build from 3 to 6 main trunks that sprout from the ground level (Blumenfeld et al., 2000). The harmful of multiple trunks is that it makes it difficult for many cultivation practices such as spraying, removal of unwanted growth, pruning, and fruit harvesting. However, drawbacks of the multi-trunk training system are numerous and include factors such as more suckers for trimming and time needed for pruning; difficulty in supporting fruiting branches to avoid excessive bending or breaks; difficult harvesting and longer harvesting time; low level of mechanization; and lower marketable fruit rate. Although the bush or multi-trunk training systems are the natural growth habit of the pomegranate, these systems can be adopted in small-scale orchards, backyards, parks and gardens (Chandra et al., 2011). Today, it is possible to trust the single stem system, which has several variations. Few farmers worldwide practice the single-trunk training system, which can be seen in countries like Israel, Spain, Italy and the USA. The benefits of this system include the ease of sucker and water-sprout removal and a higher level of mechanization can be applied (pruning, harvesting, pesticide and foliar applications, etc.). The fruit quality is generally higher than in the multi-trunk system (lower fruit temperature, less direct sun exposure, better fruit quality, and higher yield (Chandra et al., 2011).

Therefore, this study aimed to assess Manfaloty pomegranate trees' behaviour regarding vegetative and fruitful growth, productivity, and fruit quality under pruning and training methods.

MATERIALS AND METHODS

Field experiment

The investigation was undertaken during the 2020 and 2021 seasons on four years old pomegranate tree "Manfalouty" cultivar cultivated in the experimental orchard of Horticultural Research Station in Shandaweel, Sohag Governorate, Egypt, at a distance of 5 X5 meters between trees in clay soil under flood irrigation systemto study the performance of trees under the traditional method of pruning and difference training systems.

Two experiments (pruning and training) were performed in the present investigation to evaluate the morphological, phonological, fruiting and yielding behaviour of Manfaloty pomegranate trees.

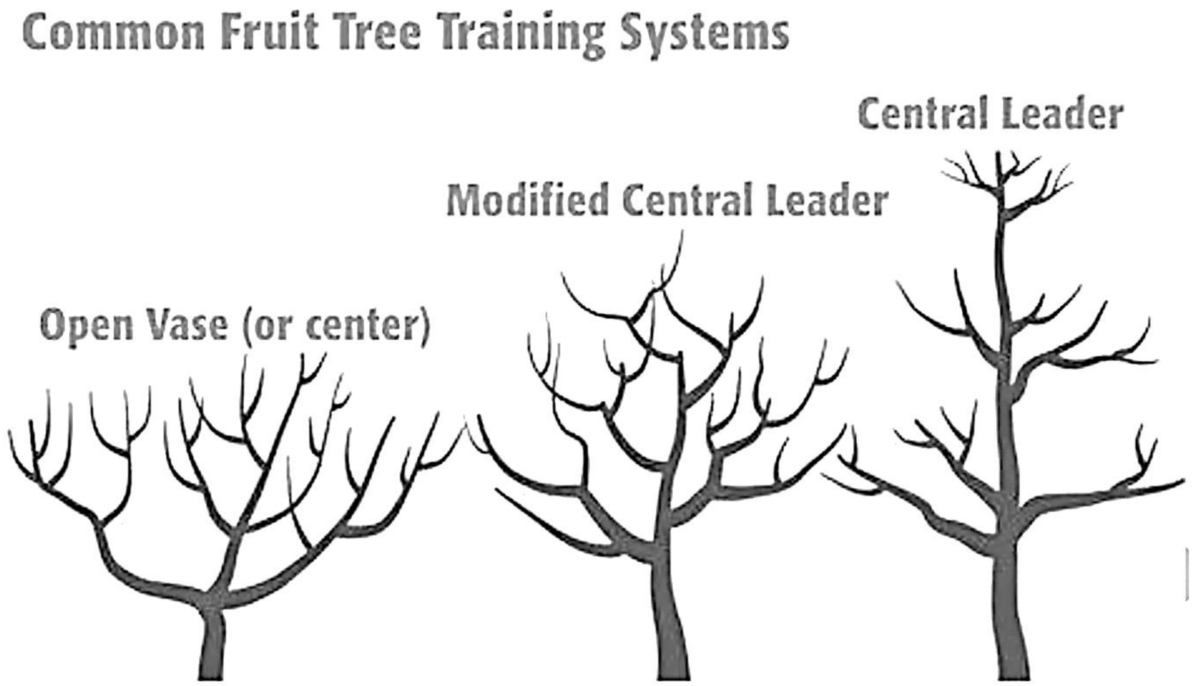
First: Multi-stem trees included three types of pruned systems **a)**five stems (control): **b)** four stems, **c)** three stems that developed directly from the ground. Pruning is done in winter (December) by heading back, thinning out and removing the crisscrossed, diseased, and dried branches.

Second: trees were trained based on single-stem training that included three types of training systems commonly used for shaping and forming the trees (Swati et al, 2018).

-Open centre: In this system, the main stem can grow to a certain height, and the leader is cut to encourage lateral branches (three to five scaffolds) that start three to four feet from the ground giving a vase-shaped plant.

-Central leader: In this system, the central axis of the plant is allowed to grow without **any** disturbance. The lateral branches can rise from the main trunk (central axis) with wide angles in three or four layers. The top layers are shorter than the bottom, forming an oval or pyramidal shape.

-Modified central leader: the main branch is allowed to grow for a few years and then headed back. A well-distributed five to six lateral branches grow outward at about six feet from the ground.



The experiment was designed in a completely randomized block design with six treatments; three replicates represented each treatment. Field observations and laboratory measurements were carried out in the fourth year as follows:

Vegetative characteristics:

In the four directions points, twelve shoots of one year old were tagged for measuring; shoot length, the number of shoots and number of leaves/new shoots at the end of the growing season (September).

Floweringand fruiting attributes:

The total number of flowers/trees was counted and recorded.

The fruit set percentage: was calculated according to the formula:

$$Fruit\ set\ \% = \frac{Number\ of\ set\ fruits}{Total\ number\ of\ flowers}\ x\ 100$$

No. of fruits/tree and yield kg/tree: Counting the fruits on each treated tree was done at harvest time. Then weighing and recording the yield (kg) per tree.

Yield characteristics: The number of cracked and sunburned fruits on each tree was counted, and the proportion of these fruits was calculated. The percentage of marketable fruits per tree was also determined.

Fruit physical and chemical properties: Ten fruits from each tree were collected at harvest time to measure the fruit weight (g), fruit volume (cm^3), Total soluble solids (TSS), total acidity in fruit juice (expressed as citric acid per 100 ml juice), TSS/Acid ratio following AOAC (1985). According to Dubois et al. (1956), total sugars were determined colourimetrically (phenol 80%) in fresh weight. The total anthocyanin (%) of peel and arils was determined by spectrophotometer as described by Hsia et al. (1965).

Statistical analysis: According to Snedecor and Cochran (1967), all data were examined for the impact of treatments on various parameters using the one-way analysis of variance (ANOVA).

RESULTSAND DISCUSSIONS

Vegetative growth parameters:

Dealing with the specific effect of two experiments (pruning and training methods) under investigation that are presented in Tables (1a and1b) on the vegetative growth of Manfalouty pomegranate trees during the 2020 and 2021 seasons reflected that control trees (5 stems) gave the highest significant number of new shoots/ tree (17.00 and 22.67) in the both first and second experiment. Moreover, the results took a similar trend in the total number of leaves/ new shoots in both experiments, whereas the control treatment attained the maximum values of (20.27 and 17.61) in both seasons. The minimum values of the number of new shoots/trees and the number of leaves/new shoots were recorded by three stems in the first experiment and the central leader in the second one during 1st and 2nd season. Similarly, the modified leader system mentioned the longest shoot by three stems (19.84 and 13.38 cm) in the first experiment and (25.93 and 21.38 cm) in both seasons. On the other side, the lowest values of this trait were recorded on control trees (5 stems) in both experiments. Also, there is a positive relationship between the number of new shoots and the total number of leaves. These results are in harmony with the conclusion given by (Richard& Donald(2000), Mayer & Pereira, 2011 and Uberti &Giacobbo,2019). they proved that trees trained with open vase shapes were more significant than central leader shapes and marked more productive branches.

Table (1 a): Effect of pruning systems on vegetative growth parameters of pomegranate trees during the 2020 and 2021 seasons.

Treatments	Number of new shoots/tree		Shoot length (cm)		No. of leaves/new shoot	
	2020	2021	2020	2021	2020	2021
Control (5 stems)	17.00	22.67	15.12	11.89	20.27	17.61
Four stems	15.33	21.33	16.74	12.29	18.55	14.72
Three stems	12.67	19.33	19.84	13.38	16.55	13.14
LSD at 5 % =	0.1331	0.145	0.0842	0.1384	0.2155	0.1796

LSD: test at the 5% level of significance (P=0.05)

Table (1 b): Effect of training systems on vegetative growth parameters of pomegranate trees during the 2020 and 2021 seasons.

Treatments	Number of new shoots/tree		Shoot length(cm)		No. of leaves/new shoot	
	2020	2021	2020	2021	2020	2021
Control (5 stems)	17.00	22.67	15.12	11.89	20.27	17.61
Open center	12.33	19.63	21.36	15.83	16.98	15.05
Central leader	9.66	15.33	23.49	20.14	16.42	13.05
Modified leader	10.00	16.00	25.93	21.38	18.64	13.77
LSD at 5 % =	0.2526	0.2729	0.3261	0.3368	0.2143	0.1756

LSD: test at the 5% level of significance (P=0.05)

Flowering and fruiting properties:

Displayed data in Tables (2a and 2b) showed that the flowering and fruiting were affected by the pruning and training methods during the two studied seasons. Pruning treatments of three stems in (Table 2a) recorded the highest number of flowering and fruiting, while the control treatment achieved the lowest one. Similarly, there was no clear trend of treatments on fruit set percentage in both seasons. Data in table (2 b) declared that the open center system registered the highest number of flowers /trees (131. 0-155.6), maximum fruit set the percent (53.90 & 51.50%). They scored the highest number of fruits per tree (47.60 & 58.62), respectively, in both seasons, whereas the last one was achieved by control treatment. In general view, it seems that traditional methods (4 and 3 stems) in the first experiment and training systems (open center, modified leader and central leader) in the second one was superior to the control treatment (five stems). The abovementioned results of flowering behavior and fruit set follow the findings of (Wünsche and Lakso, 2000; Seong et al., 2006and Jose et al., 2019).They reported that the open center system booked the maximal values of total number of flowers and fruit set percentage, due to the increasing light interception, which improves the flowering growth.

Table (2 a). Effect of pruning systems on total number of flowers/tree, fruit set (%) and number of fruit/ tree of pomegranate trees during the 2020 and 2021 seasons.

Treatments	Total no. of flowers/ tree		Fruit set (%)/tree		No. of fruits/tree	
	2020	2021	2020	2021	2020	2021
Control (5 stems)	88.37	100.0	42.24	44.17	23.85	29.61
Four stems	117.67	142.67	42.35	45.66	32.09	42.37
Three stems	124.33	149.90	42.03	45.51	33.38	47.31
LSD at 5 % =	1.902	1.918	0.1619	0.1631	0.3368	0.3206

LSD: test at the 5% level of significance (P=0.05)

Table (2 b). Effect of training systems on total number of flowers/tree, fruit set (%) and number of fruit/ tree of pomegranate trees during the 2020 and 2021 seasons.

Treatments	Total no. of flowers/ tree		Fruit set (%) / tree		No. of fruits/tree	
	2020	2021	2020	2021	2020	2021
Control (5 stems)	85.37	100.0	42.24	44.17	23.85	29.61
Open center	131.0	155.6	53.90	51.50	47.60	58.62
Central leader	88.65	110.9	46.97	46.28	27.03	38.20
Modified leader	111.3	122.7	43.66	47.65	34.56	45.29
LSD at 5 % =	1.893	1.91	0.2917	0.2455	0.2855	0.2595

LSD: test at the 5% level of significance (P=0.05).

Yield characteristics:

Data of pruning treatment summarized in table (3a) declared the superiority of the control treatment, which achieved the lowest fruit sunburn percentage in both seasons than the rest treatments. Otherwise, the control treatment gave the highest fruit cracking (16.87-18.27%) in both seasons. Similarly, there was a convergence in fruit marketable (%) in the first season, while three stems were superior in the second. On the other hand, in Table (3b), the minimal significant percentage of fruit sunburn (15.12-10.58%) and fruit cracking (13.78-11.93%) was observed by trees that the modified leader training. In contrast, fruits picked from control trees showed the maximum significant percentage of fruit sunburn and cracking in 2021 and 2022. According to fruit marketable (%), the modified leader system obtained the highest percentage (71.10-77.49). The lowest was shown by five stems (control) in the first and second seasons (Table 3b). The raising of fruit sunburn and cracking percentage because increasing the fruit’s exposure directly to the sun and increase light penetration (Lal and Sahu, 2017).Moreover, (Richard and Donald, 2000) found that the training methods increase the marketable yield more than the traditional method.

Table (3 a). Effect of pruning systems on the percentage of fruit sunburn, cracking and marketable of pomegranate fruits during 2020 and 2021 seasons.

Treatments	Fruit sunburn (%)		Fruit cracking (%)		Fruit marketable (%)	
	2020	2021	2020	2021	2020	2021
Control (5 stems)	19.18	14.69	16.87	18.27	63.95	67.04
four stems	20.35	18.37	15.30	16.58	64.35	64.05
Three stems	21.32	15.81	14.79	14.84	63.89	68.35
LSD at 5 % =	0.1715	0.1048	0.2382	0.2306	0.0705	0.0776

LSD: test at the 5% level of significance (P=0.05).

Table (3 b). Effect of training systems on the percentage of fruit sunburn, cracking and marketable of pomegranate fruits during 2020 and 2021 seasons.

Treatments	Fruit sunburn (%)		Fruit cracking (%)		Fruit marketable (%)	
	2020	2021	2020	2021	2020	2021
Control (5 stems)	19.18	14.69	16.87	18.27	63.95	67.04
Open centre	18.62	13.20	13.98	13.66	67.40	73.14
Central leader	17.70	11.91	14.39	13.52	67.91	74.57
Modified leader	15.12	10.58	13.78	11.93	71.10	77.49
LSD at 5 % =	0.1494	0.1587	0.0863	0.0883	0.3812	0.3718

LSD: test at the 5% level of significance (P=0.05)

Fruit physical properties and yield:

According to the demonstrated data of fruit physical properties in Tables (4. a and 4. b), it could be concluded that in the first experiment (Table 4a), the traditional method (four stems) ranked the highest in each of fruit weight (414.0 and 425.0 g), fruit volume (425.0 and 440.0 cm^3) in both seasons respectively. Otherwise, the control treatment gave the worst results in these patterns. Moreover, each of the four and three stem treatments gave the highest significant values in yield (kg/tree) than the control (5 stems). In the second experiment presented in Table (4. b), the modified leader gave the highest significant values in fruit weight (423.3 & 441.7 g) and fruit volume (432.7 & 450.0 cm^3) in both seasons. Moreover, training by the open center method attained the heaviest yield/ tree (17.72 & 23.39 kg/tree).

These results agreed with (Richard & Donald, 2000; Yamini & Singh, 2018;Uberti & Giacobbo, 2019). They found that the increment of yield and fruit quality due to training methods compared with other pruning systems may be due to the higher number of productive branches that led to a larger canopy area to bear more fruits. On the other hand, the open center detected the highest yielding compared to both the leader center and modified leader. Otherwise, un-pruning peach trees negatively influenced flower bud density, fruit set, size, and yield. This may be due to reduced radiation penetration in the tree canopy (Whiting et al., 2005 and Mayer & Pereira, 2011 and Iglesias, 2019).

Table (4 a). Effect of pruning systems on fruit weight(g), volume(cm^3) and yield (Kg/tree) of pomegranate fruits during 2020 and 2021 seasons.

Treatments	Fruit weight (g)		Fruit volume (cm^3)		Yield (kg/tree)	
	2020	2021	2020	2021	2020	2021
Control (5 stems)	306.7	327.7	314.3	333.3	7.31	9.62
four stems	414.0	425.0	425.0	440.0	13.29	18.01
Three stems	389.0	407.7	401.7	426.7	12.98	19.29
LSD at 5 % =	1.977	2.001	2.471	2.52	0.2595	0.3151

LSD: test at the 5% level of significance (P=0.05).

Table (4 b). Effect of training systems on fruit weight(g), volume(cm^3) and yield of pomegranate fruits during 2020 and 2021 seasons.

Treatments	Fruit weight (g)		Fruit volume (cm^3)		Yield (kg/tree)	
	2020	2021	2020	2021	2020	2021
Control (5 stems)	306.7	324.7	314.3	333.3	7.31	9.62
Open centre	372.3	399.0	383.3	410.0	17.72	23.39
Central leader	410.3	431.7	420.3	436.7	11.09	16.49
Modified leader	423.3	441.7	432.7	450.0	14.63	20.00
LSD at 5 % =	0.6603	0.7095	0.7194	0.7555	0.6630	0.6468

LSD: test at the 5% level of significance (P=0.05)

Fruit chemical properties:

It is quite clear from the tabulated data that fruit chemical properties were affected by different pruning methods in table (5a) and training methods in table (5b). The total soluble solids, acidity and ratio of TSS/acidity presented in Table (5. a) took a similar trend in both study seasons. Fruits harvested from the trees under the traditional method (3 stems) have a value of juice total soluble solids, the highest ratio of TSS/acidity and a minimum value of acidity content than other treatments. In addition, the training methods in table (5b) showed superiority in total soluble solids (%) and the ratio of TSS/acidity to control, and the trained by open center method showed the maximum one. Otherwise, the control treatment attained more acidity than other training methods.

Table (5 a). Effect of pruning systems on juice TSS, acidity content and TSS/acid ratio of pomegranate fruitsduring 2020 and 2021 seasons.

Treatments	Total soluble solids (%)		Acidity (%)		TSS/acid ratio	
	2020	2021	2020	2021	2020	2021
Control (5 stems)	13.47	14.14	1.96	1.84	6.87	7.68
Four stems	13.71	14.53	1.97	1.82	6.96	7.98
Three stems	14.47	15.03	1.77	1.40	8.18	10.74
LSD at 5 % =	0.0628	0.1031	0.06245	0.08628	0.2063	0.2228

LSD: test at the 5% level of significance (P=0.05)

Table (5 b). Effect of training systems on juice TSS, acidity content and TSS/acid ratio of pomegranate fruits during 2020 and 2021 seasons.

Treatments	Total soluble solids (%)		Acidity (%)		TSS/acid ratio	
	2020	2021	2020	2021	2020	2021
Control (5 stems)	13.47	14.14	1.96	1.84	6.87	7.68
Open centre	15.90	16.75	1.40	1.18	11.36	14.19
Central leader	14.60	15.31	1.70	1.58	8.59	9.69
Modified leader	14.47	15.70	1.74	1.39	8.32	11.29
LSD at 5 % =	0.0934	0.9275	0.0595	0.0624	0.2595	0.2533

LSD: test at the 5% level of significance (P=0.05)

According to the presented data in each table (6. a and 6. b). Three stems attained the highest peel &juice anthocyanin content and total sugars (%), whereas three controlled the lowest (experiment 1). Moreover, data in table (6. b) cleared that the fruits harvested from the training system (open center) had significantly higher peel &juice anthocyanin content and total sugars (%) than other training methods (central leader and modified leader), whereas, control treatment recorded the least one in both seasons.

Table (6 a). Effect of pruning systems on peel and juice anthocyanin concentration and total sugar of pomegranate fruits during 2020 and 2021 seasons.

Treatments	Peel anthocyanin concentration(%)		Juice anthocyanin concentration (%)		Total sugars (%)	
	2020	2021	2020	2021	2020	2021
Control (5 stems)	0.04	0.09	0.29	0.31	10.38	11.10
Four stems	0.17	0.19	0.34	0.36	10.80	11.30
Three stems	0.23	0.28	0.39	0.39	11.51	12.40
LSD at 5 % =	0.01883	0.0206	0.0215	0.0185	0.0776	0.0903

LSD: test at the 5% level of significance (P=0.05).

Table (6 b). Effect of training systems on peel and juice anthocyanin content and total sugar of pomegranate fruits during 2020 and 2021 seasons.

Treatments	Peel anthocyanin concentration(%)		Juice anthocyanin concentration(%)		Total sugars (%)	
	2020	2021	2020	2021	2020	2021
Control (5 stems)	0.04	0.09	0.29	0.31	10.38	11.10
Open centre	0.31	0.36	0.49	0.48	13.37	14.17
Central leader	0.29	0.33	0.44	0.45	11.74	12.43
Modified leader	0.28	0.33	0.41	0.42	11.58	13.03
LSD at 5 % =	0.0188	0.1882	0.0326	0.03766	0.122	0.132

LSD: test at the 5% level of significance (P=0.05).

These findings are in close conformity with those reported by Gill et al., (2011), Shafiq et al., (2014) and Yamini, (2016) found that trained trees by open center system exhibited higher total soluble solids due to the abundance of sunlight for fruits which causing in degradation of malic acid. Whilst, Giovannini and Liverani, (2005), Gill et al., (2011), Shafiq et al., (2014) and Rahmani et al., (2015) documented that the training system had no significant effect on acidity. The increment in fruit acidity content may be due to reduction in light penetration, which affected fruit quality negatively. Shaded apple fruits significantly increased acidity (Cortell and Kennedy, 2006). Other workers also found that un-shaded fruit exhibit higher concentrations of sugars than shaded fruits (Ristic et al., 2007; Rahmani et al., 2015).

Moreover, the total sugar content was affected by training treatments. Higher concentrations of sugars under training treatments may be due to exposed fruit to more light than the control. Decreasing the sugar level in the fruits was associated with a reduction in radiation penetration within canopy trees (Singh, 2001 and Yamini, 2016). Additionally, Shafiq *et al*. (2014) reported that the highest accumulation of total anthocyanins in the skin of the harvested fruit from the open centre training system was the highest value of the other training system. The higher anthocyanin content in the fruit from the open center system may be attributed to more light penetration. Similarly, fruits harvested from the shaded part of the tree were less coloured than fruit that exposure to light, whereas exposure fruit to sunlight is necessary to stimulate anthocyanin accumulation and fruit colouration through regulation of anthocyanin biosynthetic genes (Farina et al., 2005; Vimolmangkang et al., 2014; Zhang et al., 2016 and Guan et al., 2016).

CONCLUSION

It can be concluded from the two experiments (pruning and training methods) under investigation that, in the first experiment that included the traditional pruning method, the superiority of three stems in shoot length, the total number of flowers /tree, fruit set (%) and number of fruits per tree fruit marketable, the value of juice total soluble solids, the ratio of TSS/ acidity, total sugars content, anthocyanin content of peel and juice and lowest acidity percent. Additionally, the highest fruit weight, volume and yield are attained by both tree and four stems. Regarding the effect of training methods in the second experiment, the superiority of the modified leader in shoot length, fruit weight, volume, marketable (%), least of cracking and sunburn percentage could be noticed. At the same time, the open center system was superior in the total number of flowers /tree, fruit set (%), number of fruits per tree, yield, the value of juice total soluble solids, the ratio of TSS/acidity, total sugars content, content anthocyanin of peel and juice and minimum value of acidity content. Finally, it can be recommended that the pomegranate orchard, which uses multi trunks method, modify it to three stems. While in the case of a pomegranate orchard using only one trunk, it is preferred to use an open-center system.

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تأثير نظم التقليم و التربية على نمو وإنتاجية أشجار الرمان

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أجريت هذة الدراسة خلال عامي 2020-2021م بالمحطة البحثية لمعهد بحوث البساتين بشندويل- محافظة سوهاج- مصر على أشجار رمان منفلوطي عمر 4 سنوات لتقييم أداء الأشجار تحت طرق التقليم التقليدية (التجربة الاولى) متعددة السيقان خمس سيقان(الكنترول)– أربعسيقان - ثلاث سيقان،ونظم التربية (التجربة الثانية) القلب المفتوح- القائد الوسطي- الوسطي المعدل.

وأوضحت نتائج التجربة الاولى أن معاملة ثلاث سيقان كانت الأفضل في طول الفرع، عدد الازهار/الشجرة، النسبة المئويةللعقد (%)، عدد الثمار/الشجرة، نسبة المواد الصلبة الذائبة الكلية ونسبتها الى الحموضة، محتوى السكريات الكلية، محتوي القشرة، العصير من الانثوسيانين وأقل محتوى من الحموضة. وفي التجربة الثانية، كانت معاملة القائد المعدل الأفضل في طول الفرع، وزن الثمار، حجم الثمار، نسبة الثمار القابلة للتسويق، أقل نسبة من الثمار المتشققة ولسعة الشمس. نظام القلب المفتوح كان الأفضل في عدد الازهار/الشجرة، نسبة العقد، عدد الثمار/الشجرة، المحصول، محتوى العصير من المواد الصلبة الذائبة الكلية ونسبتها الى الحوضة، السكريات الكلية، محتوى القشرة والعصير من الانثوسيانين وأقل حموضة.