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Influence of Growth Regulators Treatments on Suckers Growth Control, Yield and Fruit Quality of Pomegranate Trees cv. Manfalouty and Their Economics Effect

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Abstract: *A two years trial was conducted during 2012 and 2013 seasons on 13 years old Manfalouty pomegranate trees grown in sandy soil under drip irrigation system from well at El Maghara Station, Desert Research Center, North Sinai Governorate, Egypt. Three concentrations of each Naphthaleneacetic acid (NAA) i.e. 5000, 10000 and 15000 ppm, Paclobutrazol (PP_{333}) i.e. 500, 1000 and 1500 ppm and Maleic hydrazide (MH) i.e. 500, 1000 and 1500 ppm and hand removal (control) treatments were trunk applied on 1st February after suckers removal from the trunk. The results indicated that all NAA, PP_{333} and MH treatments reduced number of suckers, sucker length and suckers weight of Manfalouty pomegranate trees. Moreover, 1500 ppm PP_{333} treatment proved to be the most effective application treatment for controlling the growth of suckers with some advantage over the traditional hand removal (control treatment) of growth of suckers but gave an intermediate positive effect on yield and fruit quality. Briefly, the results showed that the reduction of concentration level of PP_{333} and MH led to an enhancement of yield and fruit quality. In addition, NAA gave an intermediate positive effect for controlling the growth of suckers than PP_{333} and MH respectively. Moreover, NAA treatments gave a high positive effect on yield and fruit quality as compared with hand removal treatment (control). Generally, 15000 ppm NAA treatment proved to be the most efficient treatment on enhancing yield and fruit quality excepted 10000 ppm NAA treatment induced high positive effect on fruit total sugar , T.S.S. and ascorbic acid content. Moreover, economic study indicated that some growth regulators treatments attained the highest values of both total revenue per feddan (L.E/ feddan), net revenue per feddan (L.E/ feddan), technological efficiency, economic efficiency, and high sealing price at harvest time, because of increasing the fruit quality which leads to the best revenue value but the best treatment is Paclobutrazol PP_{333} at 500 ppm . This treatment attained the highest values of both technological efficiency and economic efficiency. It leads to improve the "Manfalouty" pomegranate fruit quality and raising the net income farmer which reflect positively on pomegranate in El maghara in North Sinai governorate*

Keyword: *Pomegranate; suckers; Naphthalene acetic acid (NAA); Paclobutrazol (PP_{333}); Maleic hydrazide (MH); yield; fruit quality ; Cost analysis; Technical efficiency; Total revenue; Net revenue; Economic efficiency.*

I. Introduction

Pomegranate tree has a propensity to develop suckers on tree trunk and crown during the growing season. These suckers vigorous growth without branching, long weak shoots and bear very little crop, also, expose tree to a greater degree of pathogens attack. Pomegranate suckers must be removed to maintain trunk vigor, prevent interference some of horticultural practices such as soil tillage and weed control. Suckers can be removed by hand during the growing season or at the end of growing season using sharp knife like tools. This practice is a temporary solution to the problem; also, periodic removal of suckers from trunk during the growing season is laborious job and consumes a lot of labour and time. In order to reduce this labour cost by mechanical removal of suckers is not easy because the irregular form and difficult access to the basal part of the tree. To overcome this problem, chemical control of growth suckers is valid alternative and could gradually substitute mechanical removal. The related review concerning the effect of the tested treatments on pomegranate trees are somewhat rare, thereupon the review were supported with other species rather than pomegranate in this respect. Many investigators have studied the effect of chemical control of sprouted suckers such as 1-Naphthaleneacetic acid (NAA) in controlling suckers growth of several fruits crops, Ahmedullah and Wolfe (1982) illustrated that NAA treatment at 1.0% gave satisfactory control of sucker growth of grapevines and no deleterious effects on vine growth , yield and fruit quality. On the other hand, Eynard et al. (1986) and Reynolds (1988) showed that control of sucker growth of grapevines by trunk application NAA treatment. Moreover, (Aly and Shehata, 1990) mentioned that NAA treatments gave a reduction of pear and guava sucker growth. In addition, Reynolds et al. (1991) reported that NAA treatments gave a reduction in suckers per vine and increased berry weight. Moreover, Aly et al. (1999) reported that NAA treatments gave a reduction in regrowth of sucker number and length of fig and pomegranate trees, Generally, 20000 ppm NAA treatment increased the mean number of fruits as well as yield per tree, total sugar percentage of fig trees but reduced TSS percentage slightly in pomegranate trees. On the other hand, Paclobutrazol (PP_{333}) has been effective in controlling suckers growth of several fruits crops. Reynolds (1988) and Reynolds et al. (1991) showed that trunk applications of paclobutrazol enhanced yield components and advanced fruit maturity in grapevines. However, Aly et al. (1999) mentioned that paclobutrazol treatments gave a reduction in regrowth of sucker number and length of fig and trees, however, paclobutrazol treatments increased TSS percentage and vitamin C in fig and pomegranate fruits. In addition, Maleic hydrazide (MH, 1,2-dihydro-3,6-pyridazinedione; coline salt) is a growth regulator. It is widely used in agriculture, as an inhibitor of sucker development of tobacco, an inhibitor of lateral bud growth of potato, and as a retardant of shoot growth of grape (Kamuro, 1995). MH is translocated to meristematic tissues where mitosis is disrupted (Darlington and McLeish, 1951; Hoffman and Parups, 1964 and NoodeÂn, 1972). Hoffman and Parups (1964) suggested that MH acts as an anti-auxin or a regulator of auxin metabolism reviewed by. This trial aimed to study the effect of NAA, Paclobutrazol and Maleic hydrazide at different rates on controlling suckers growth, yield and fruit quality of pomegranate trees cv. Manfalouty. Also, economic study aim to identify the effects of the implementation and activation of using the growth regulators on suckers growth control of Manfalouty pomegranate trees on the most important economic variables and assess the impact of such treatments on crop production and to educate farmers the importance of conducting such for increase the feddan productivity and the expected revenue. Consequently, for increasing their net incomes, then, increase the weight of the fruit and increase the content of total sugars, and improve the fruits quality in addition, overcome disadvantages of hand cut method. Finally, ensure the highest available price for yield which can farmer (producer) get. The most important economic indicators to measure effects of using the growth regulators treatments are technological efficiency and economic efficiency These indicators help in identifying the effect of the use such treatments and illustrate the importance of this applied study.

II. Material And Methods

This investigation was conducted during two successive seasons of 2012 and 2013 at Experimental orchard of El Maghara Station of Desert Research Center, North Sinai Governorate (latitude 30.35 N, longitude 33.20 E) in Egypt. Thirteen years old Manfalouty pomegranate trees grown in sandy soil, and spaced 3.6 x 3.6 m apart (324 tree / fed) under drip irrigation system from well were devoted for this study. Physical and chemical analysis of the experimental soil shown in Table, 1. Chemical analysis of used water for irrigation is recorded in Table, 2.

Sixty Manfalouty pomegranate trees healthy, nearly uniform in growth vigor and productivity and received the same horticulture practices, were subjected to nine treatments as follows:

1. Hand removal of suckers (control).
2. Naphthaleneacetic acid (NAA) at 5000 ppm
3. Naphthaleneacetic acid (NAA) at 10000 ppm
4. Naphthaleneacetic acid (NAA) at 15000 ppm
5. Paclobutrazol (PP_{333}) at 500 ppm
6. Paclobutrazol (PP_{333}) at 1000 ppm
7. Paclobutrazol (PP_{333}) at 1500 ppm
8. Maleic Hydrazide (MH) at 500 ppm
9. Maleic Hydrazide (MH) at 1000 ppm
10. Maleic Hydrazide (MH) at 1500 ppm

The experiment was designed as randomized complete block design with three replicates for each treatment and each replicate was represented by two trees.

On February 1st of 2012 and 2013 seasons. The developed suckers on tree trunk were removed, and then all treatments were applied directly after suckers removal on trunk (from the crown up to trunk for a distance of 50 cm along the trunk tree) by paint brush.

Response of Manfalouty pomegranate trees to tested NAA, PP_{333} and MH treatments was evaluated through the following determinations.

Table 1. Analysis of experimental soil of El-Maghara Station, North Sinia Governorate.
I - Physical analysis of El-Maghara soil.

Soil Depth (cm)	Particle size distribution				Texture class	Bulk Density (g/cm)	Organic matter %	Moisture content (%)	
	Coarse sand	Fine sandy	Silt	Clay				Field Capacity	Wilting Point
0-30	0.00	98.00	1.00	1.00	sand	1.55	0.24	10.23	4.45
30-60	0.00	98.50	0.80	0.70	sand	1.58	0.23	9.98	4.51
60-90	0.00	99.00	0.50	0.50	sand	1.60	0.19	10.35	4.64

II- chemical analysis of El-Maghara soil.

Soil Depth cm	$CaCO_3$	pH Soil past	E.C. (dSm^{-1})	Soluble cations (meq/l)				soluble anions (meq/l)			
				Ca^{2+}	K^+	Na^+	Mg^{2+}	Cl^-	SO_4^{2-}	HCO_3^-	CO_3^{2-}
0-30	5.89	7.70	0.60	2.50	0.05	1.26	1.50	1.40	2.11	1.80	-
30-60	3.80	7.70	0.70	3.00	0.08	1.57	2.00	2.00	2.85	1.80	-
60-90	4.35	7.40	1.10	3.50	0.05	3.04	2.00	6.10	2.09	2.40	-

Table 2. Chemical analysis of water used for irrigation at El-Maghara Station, North Sinai Governorate.

pH	E.C. dSm^{-1}	O.M %	Soluble cations (meq/l)				soluble anions (meq/l)			
			Ca^{2+}	Mg^{2+}	Na^+	K^+	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}
8.36	4.38	1.40	11.40	3.48	24.60	0.69	0	4.40	3.57	32.20

2.1. Growth of suckers

Number and length of regrowth suckers of each tree were recorded at the end of the experiment. The developed suckers on each treated tree were removed and weighed.

2.2. Yield (kg)/tree and No. of fruits/tree

At harvest time, number of fruits per each treated tree was counted and reported then yield (Kg) per tree was determined and recorded.

2.3. Fruit physical and chemical properties.

Ten fruits were taken at harvest from each treated tree for determination of the following physical and chemical properties. Fruit weight (g), fruit length (cm), fruit diameter (cm), weight of fruit grains (g), weight of 100 grains (g), juice volume (cm^3) per fruit, peel thickness. Furthermore, total sugar (%), total soluble solids (T.S.S.) was determined by Hand refrectometer, total acidity in fruit juice (expressed as citric acid per 100 ml juice) and ascorbic acid (mg ascorbic acid/100 ml juice) according to A.O.A.C. (1995).

2.4. Economic analysis

2.4.1. Data source

Economic data was collected using a questionnaire specially prepared to achieve the objectives of the research. It contained cost items, selling price, total production, amount of treatments and its price.

2.4.2. Analytical method

2.4.2.1. Cost analysis

The cost of hand cut method (control) was calculated as following: Suckers are removed from pomegranate trees twice a year and worker ability is 30 trees /day .The density of trees per feddan is 324 tree per feddan So, feddan needs about (11) Workers each time . The worker costs L.E (100) / day, the costs per feddan = 22 (No. of workers) x100 (wage) = L.E 2200, and the waste from this practice needs (3) workers each time they cost (80) L.E/day. The costs per feddan = 6 (No. of workers) x 80(wage) = L.E480 Thus, the total costs/feddan/year = 2200+480=L.E 2680(as costs of labour).

The cost of using experimental treatments was estimated through the following equations:

a- The required weight from treatment (gram) = $\frac{\text{the density per feddan x package weight}}{\text{Package weight/ liter concentration}}$

b-The required number of package = the required weight per feddan/ package weight.

c- Cost of treatment =the number of package x the price of each package.

d- Difference cost = hand cut (control) cost (2286 L.E) – cost of each treatments.

The cost experimental treatments based on:

- Manfalouty pomegranate trees spaced 3.6 x 3.6 m apart (324 tree / feddan).
- The package weight of (NAA) is 500 gram, and the price of each package is L.E. 600.
- The package weight of (PP 333) is 25 gram, and the price of each package is L.E. 75.
- The package weight of (MH) is 10 gram, and the price of each package is L.E. 200.

2.4.2.2. Technological efficiency is measured by the ratio of units of output to units of input: (Heady, 1963) and (Heady and Jensen, 1961)

$$\frac{\text{Units of output}}{\text{Units of input}}$$

2.4.2.3. Economic efficiency is defined as the ratio of the value of output to the value of input: (Johnston, 1984) and (Heady, 1963)

Economic efficiency = Value of Output / Value of Input

$$\text{Economic efficiency} = \frac{(\text{Price of output})\ X\ (\text{Units of Output})}{(\text{Price of input})\ X\ (\text{Units of Input})}$$

Economic efficiency occurs when the cost of producing a given output is as low as possible. It depends on the factors' prices of the production thus total and Net revenue per feddan was calculated was estimated through the following equations:

a- Average production/feddan = average productivity /tree x number of trees in feddan (324).
b- Total revenue/feddan= Average production/feddan x sale price of pomegranate at harvest time L.E/ton.
c- Net revenue/feddan from each treatment=Total revenue from treatments- total revenue from hand cut.
d- Economic Efficiency of each treatment = Net return of each treatment /cost of each treatment.

Statistical analysis

The obtained data of 2012 and 2013 seasons were subjected to analysis of variance according to Clarke and Kempson (1997). Means were differentiated using Rang test at the 0.05 level (Duncan, 1955).

III. Results and Discussion

3.1. Growth of suckers

3.1.1. No. of regrowth suckers/tree

Table, 3 demonstrates that all tested treatments induced a pronounced reductive effect on number of regrowth suckers per tree as compared with hand removal treatment (control) in both seasons of study. Moreover, the results showed the increase in concentrations level of PP_{333} led to progressive reduction of number of suckers per trees. Generally, 1500 ppm paclobutrazol treatment induced maximum reduction of number of suckers per tree (9.6 and 6.0) against (73.6 and 63.3) for control treatment on 2012 and 2013 seasons, respectively. Moreover, MH and NAA treatments induced an intermediate effect in this concern.

Table 3. Effect of trunk application with NAA, PP_{333} and MH treatments on No. of regrowth suckers/tree, length of suckers/tree, weight of suckers /tree and No. of fruit/tree of Manfalouty pomegranate variety (2012 and 2013 seasons)

ts	No. of regrowth suckers /tree		Length of suckers/tree		Weight of Suckers /tree (g)		No. of fruits /tree	
	2012	2013	2012	2013	2012	2013	2012	2013
Hand removal (control)	73.6 a	63.3 a	95.0 a	99.6 a	197.2 a	199.1 a	80.7 g	81.3 f
NAA at 5000 ppm	41.3 b	35.5 b	80.0 b	86.6 b	178.6 b	174.1 b	104.0 b	95.0 b
NAA at 10000 ppm	27.6 c	19.6 b	71.0 c	78.3 c	119.0 c	75.6 c	108.0 a	95.3 b
NAA at 15000 ppm	19.3 de	12.6 ef	26.3 fg	25.0 f	57.3 e	30.8 f	108.0 a	100.3 a
PP_{333} at 500 ppm	20.0 de	16.3 d	38.3 e	33.3 e	50.1 f	47.9 e	102.0 c	93.3 bc
PP_{333} at 1000 ppm	13.6 f	10.3 f	25.0 g	23.0 g	31.3 i	24.9 g	99.0 d	87.0 de
PP_{333} at 1500 ppm	9.6 g	6.0 g	20.0 h	17.3 h	23.8 j	17.8 i	97.0 e	86.7 e
MH at 500 ppm	21.0 d	20.0 c	41.3 d	35.3 d	62.9 d	49.1 d	102.0 c	90.7 cd
MH at 1000 ppm	17.0 e	13.6 de	28.6 f	26.0 f	49.3 g	31.3 f	97.0 e	87.0 de
MH at 1500 ppm	12.3 fg	9.6 de	21.0 h	17.6 h	36.5 h	23.26 h	94.0 f	86.3 e

Means within each column followed by the same letter (s) are not significantly different at 5% level.

3.1.2. Length of suckers/tree

It is clear from Table, 3 that all tested treatments gave a great reductive effect on length of suckers per tree as compared with hand removal treatment (control) in both seasons of study. Generally, 1500 ppm paclobutrazol treatment gave maximum reduction of suckers length per tree (20.0 and 17.3) compared with (95.0 and 99.6) for hand removal treatment (control) in the first and second seasons, respectively. However, MH and NAA treatments gave an intermediate values in this respect.

3.1.3. Weight of suckers /tree (g)

Table, 3 shows that all tested treatments gave a high reductive effect on weight of suckers per tree of Manfalouty pomegranate tree as compared with hand removal treatment (control) in both seasons of study. However, the results showed the increase of PP_{333} concentrations led to increase in reduction of weight of suckers per trees. Generally, 1500 ppm paclobutrazol treatment induced a great reduction in suckers weight per tress (23.8 and 17.8) against (197.2 and 199.1) for control treatment in the first and second seasons, respectively. However, MH and NAA treatments induced an intermediate effect in this respect.

The enhancement effect of NAA on sucker growth may be attributed that higher concentrations of NAA inhibited shoot regrowth on the trunk through the inhibition of cell division and enlargement (Takeda et al 1982).

On the other hand, Paclobutrazol is physiologically reported as an inhibitor of vegetative development of the plants. Hence it caused a slower movement of IAA in shoot tips (Browning et al., 1992). Moreover, Paclobutrazol has been reported as growth retardant that inhibits gibberellin biosynthesis (Graebe, 1982).

However, Maleic hydrazide (MH) was reported as an inhibitor of sucker development in tobacco and as a retardant of shoot growth in grape (Kamuro, 1995).Moreover, MH is translocated to meristematic tissues where mitosis is disrupted (Darlington and McLeish, 1951; Hoffman and Parups, 1964 and NoodeÂn, 1972). Other research has suggested that MH acts as an anti-auxin or a regulator of auxin metabolism (Hoffman and Parups, 1964).

The obtained results of NAA, paclobutrazol and maleic hydrazide regarding their positive effect on the control of regrowth suckers are in harmony with the findings of Ahmedullah and Wolfe (1982) who illustrated that NAA at 1.0% treatment gave satisfactory control of sucker growth of grapevines On the other hand, Eynard et al. (1986) and Reynolds (1988) reported that NAA treatments induced successful inhibition of suckers of grapevines. However, Aly and Shehata (1990) mentioned that trunk applied NAA produced reductive effect of sucker growth of pear and guava trees. In addition, Reynolds et al. (1991) reported that NAA treatments gave reduction in suckers per vine. Moreover, Aly et al. (1999) reported that NAA treatments gave a reduction in regrowth of sucker number and length of fig and pomegranate trees, Generally, 20000 ppm NAA treatment increased the mean number of fruit as well as yield per tree, total sugar percentage in fig but reduced TSS percentage slightly in pomegranate.

Moreover, Gaash (1986) stated that 1000-4000 ppm of paclobutrazol decreased the lateral shoot length of Canino apricot cultivar. As well as, Blanco (1988) stated that paclobutrazol decreased the shoot development of peach and "Crimsongold" nectarines. However, Reynolds (1988) and Reynolds et al. (1991) reported that trunk application of paclobutrazol reduced sucker growth of grapevines. However, Aly et al. (1999) mentioned that paclobutrazol treatments produced a reductive effect on number and length of regrowth suckers of fig trees.

In addition, Maleic hydrazide(MH) is an inhibitor of sucker development in tobacco, an inhibitor of lateral bud growth in potato, and as a retardant of shoot growth in grape (Kamuro, 1995).

3.2. Yield

3.2.1. No. of fruits/tree

Table, 3 illustrates that NAA, paclobutrazol and maleic hydrazide treatments succeeded in increasing number of fruits than hand removal treatment (control) in both seasons of study. However, the results showed the increase in concentrations level of NAA led to increase in number of fruits per tree. Generally, 15000 ppm NAA treatment shows superiority in this respect. However, other treatments gave an intermediate values in this respect.

3.2.2. Yield (kg)/tree

Table, 4 illustrates that the tested NAA, paclobutrazol and maleic hydrazide treatments succeeded in improving tree yield of Manfalouty pomegranate tree as compared with hand removal treatment (control) in both seasons of study. However, the results showed the increase in concentrations level of NAA led to increase in tree yield per tree. Generally, 15000 ppm NAA treatment showed to be the highest production trees (38.70 and 34.77 kg/tree) against (25.79 and 24.77 kg/tree) for hand removal treatment control in 2012 and 2013 seasons, respectively.

3.3. Fruit quality

3.3.1. Fruit weight (g)

Table, 4 demonstrates that the tested treatments excepted 1500 ppm PP_{333} and (1000 and 1500 ppm) MH treatments produced statistically similar higher positive effect on fruit weight of Manfalouty pomegranate as compared with hand removal treatment (control) in both seasons of study. Generally, 15000 ppm NAA treatment showed superiority in this concern as it recorded (358.71 and 357.30 g) compared with (321.08 and 302.30 g) for hand removal treatment (control) in the first and the second seasons, respectively.

3.3.2. Fruit length (cm)

Statistical analysis illustrates that all tested treatments exerted a positive enhancing effect on fruit length of Manfalouty pomegranate as compared with hand removal treatment (control) in both seasons of study. Generally, 15000 ppm NAA treatment produced the longest fruits in both seasons. Other treatments gave an intermediate values in this concern.

3.3.3. Fruit diameter (cm)

Table, 4 indicates that the all tested treatments produced a pronounced positive effect of fruit diameter ac compared with hand removal treatment (control) in both seasons of study. Moreover, 15000 ppm NAA treatment produced the widest fruits in both seasons. Other treatments occupied an intermediate position in this sphere.

Table 4. Effect of trunk application with NAA, PP_{333} and MH treatments on yield and some fruit physical properties of Manfalouty pomegranate variety (2012 and 2013 seasons).

Treatments	Yield (Kg)/tree		Fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)	
	2012	2013	2012	2013	2012	2013	2012	2013
Hand removal (control)	25.79 i	24.77 f	321.08 f	302.3 g	7.31 i	7.23 j	8.30 h	8.29 h
NAA at 5000 ppm	36.80 c	33.96 b	338.62 c	345.0 c	7.86 c	7.83 c	8.71 c	8.69 c
NAA at 10000 ppm	37.64 b	33.67 b	354.96 b	350.6 b	7.89 b	7.89 b	9.02 b	8.69 c
NAA at 15000 ppm	38.70 a	34.77 a	358.71 a	357.3 a	8.61 a	8.17 a	9.50 a	9.30 a
PP_{333} at 500 ppm	34.55 d	31.58 c	334.08 d	334.0 d	7.74 d	7.77 d	8.71 c	8.99 b
PP_{333} at 1000 ppm	32.66 f	26.92 e	325.42 e	309.6 f	7.69 f	7.74 e	8.58 d	8.56 d
PP_{333} at 1500 ppm	30.97 h	26.61 e	319.75 f	303.6 g	7.15 j	7.65 g	8.47 f	8.42 f
MH at 500 ppm	33.91 e	29.23 d	331.70 d	330.6 e	7.71 e	7.69 f	8.53 e	8.51 e
MH at 1000 ppm	31.63 g	26.81 e	322.67 ef	305.0 g	7.64 g	7.51 h	8.44 f	8.45 f
MH at 1500 ppm	30.93 h	26.68 e	320.33 f	303.3 g	7.50 h	7.32 i	8.39 g	8.37 g

Means within each column followed by the same letter (s) are not significantly different at 5% level.

3.3.4. Weight of fruit grains (g)

Table, 5 demonstrates that all tested treatments enhancing fruit grains weight of Manfalouty pomegranate fruit as compared with hand removal (control) treatment in both seasons. Generally, 15000 ppm NAA treatment gave the highest fruit grains weight (253.60 and 254.73 g) against (216.97 and 201.24 g) for the hand removal treatment (control) in the first and second seasons, respectively. Other tested treatments produced intermediate positive values in this respect.

Table 5. Effect of trunk application with NAA, PP333 and MH treatments on some of fruit physical properties of Manfalouty pomegranate variety (2012 and 2013 seasons).

Treatments	Weight of fruit grains (g)		Weight of 100 grains (g)		Juice volume/fruit (cm3)		Peel thickness (cm)	
	2012	2013	2012	2013	2012	2013	2012	2013
Hand removal (control)	216.97 j	201.24 i	31.33 f	33.67 f	119.1 h	118.0 f	0.40 g	0.40 h
NAA at 5000 ppm	241.78 c	234.42 c	37.33 b	40.33 b	136.0 d	135.0 bc	0.52 b	0.52 c
NAA at 10000 ppm	247.60 b	248.86 b	37.67 b	41.0 b	137.2 c	136.0 bc	0.56 a	0.54 b
NAA at 15000 ppm	253.60 a	254.73 a	40.67 a	44.33 a	141.2 a	140.0 a	0.57 a	0.57 a
PP_{333} at 500 ppm	227.90 d	221.19 d	35.33 c	37.67 c	138.6 b	138.0 ab	0.50 c	0.51 d
PP_{333} at 1000 ppm	223.80 f	216.80 e	35.0 c	36.67 d	136.0 d	135.0 bc	0.43 e	0.47 e
PP_{333} at 1500 ppm	221.67 g	209.67 h	33.67 d	36.66 d	130.6 f	130.0 d	0.43 e	0.43 f
MH at 500 ppm	225.80 e	216.80 e	34.0 d	36.0 d	137.2 c	132.6 cd	0.46 d	0.43 f
MH at 1000 ppm	220.90 h	214.90 f	32.67 e	36.0 d	134.1 e	133.0 cd	0.41 f	0.42 g
MH at 1500 ppm	219.37 i	214.36 g	32.67 e	35.0 e	127.2 g	124.0 e	0.40 g	0.41 g

Means within each column followed by the same letter (s) are not significantly different at 5% level.

3.3.5. Weight of 100 grains (g)

Table, 5 illustrated that all tested treatments scored statistically higher values of weight of 100 grains as compared with hand removal treatment (control) in both seasons of study. Generally, 15000 ppm NAA treatment induced the highest values of 100 grains weight (40.67 and 44.33 g) against (31.33 and 33.67 g) for hand removal treatment (control) in 2012 and 2013 seasons, respectively. Other treatments produced in most cases similar values and occupied an intermediate position in this respect.

3.3.6. Juice volume/fruit (cm^3)

Table, 5 indicate that all tested treatments induced high positive effect on juice volume per fruit as compared with hand removal treatment (control) in both seasons. Generally, 15000 ppm NAA treated trees produced the most juices fruits. However, other tested treatments induced an intermediate values in this respect.

3.3.7. Peel thickness (cm)

Table, 6 indicates that the all tested treatments produced a pronounced positive effect on peel thickness as compared with hand removal treatment (control) in both seasons of study. Generally, 15000 ppm NAA treatment produced high values of peel thickness throughout the two seasons. However, other treatments scored an intermediate values in this sphere.

Table 6. Effect of trunk application with NAA, PP_{333} and MH treatments on some fruit chemical properties of Manfalouty pomegranate variety (2012 and 2013 seasons).

Treatments	Total sugar (%)		T.S.S. (%)		Acidity (%)		Ascorbic acid (mg/100 ml juice)	
	2012	2013	2012	2013	2012	2013	2012	2013
Hand removal (control)	13.31 f	14.16 e	14.33 d	14.0 c	1.17 a	1.18 a	13.73 h	11.80 e
NAA at 5000 ppm	13.82 e	14.38 c	15.16 bc	15.16 b	1.11 cd	1.13 f	13.80 f	13.30 b
NAA at 10000 ppm	14.74 a	15.14 a	15.67 a	15.83 a	1.09 d	1.12 g	14.49 a	13.65 a
NAA at 15000 ppm	13.26 g	14.19 de	15.0 c	14.16 c	1.09 d	1.09 h	13.71 h	12.59 c
PP_{333} at 500 ppm	13.32 f	14.21 de	14.5 d	15.0 b	1.14 b	1.16 b	14.27 b	13.29 b
PP_{333} at 1000 ppm	14.16 b	14.25 d	15.16 bc	15.33 b	1.12 bc	1.15 c	14.21 c	13.29 b
PP_{333} at 1500 ppm	14.72 a	14.79 b	15.5 ab	16.0 a	1.12 bc	1.14 e	14.10 d	12.06 d
MH at 500 ppm	13.93 d	14.19 de	14.33 d	15.33 b	1.14 b	1.16 b	13.80 f	13.20 b
MH at 1000 ppm	14.15 b	14.19 de	15.33 abc	15.33 b	1.14 b	1.15 c	13.89 e	12.60 c
MH at 1500 ppm	14.0 c	14.20 de	15.5 ab	15.83 b	1.14 b	1.14 e	14.09 d	12.10 d

Means within each column followed by the same letter (s) are not significantly different at 5% level.

3.3.8. Fruit total sugar content

Table, 6 reveals that most tested treatments produced similar and high positive effect on fruit total sugar content of Manfalouty pomegranate fruits as compared with hand removal treatment (control) in both seasons. However, 10000 ppm NAA treatment in both season and 1500 ppm paclobutrazol treatment in first season proved to be the most efficient treatments in this concern. Moreover, other tested treatments showed an intermediate values in this respect.

3.3.9. T.S.S. (%)

Table, 6 indicates that all tested treatments scored statistically similar and higher values of T.S.S. as compared with hand removal treatment (control) in both seasons of study. Generally, 10000 ppm NAA treatment in both seasons, and 1500 ppm paclobutrazol treatments in the second season proved to be the most efficient treatment in this concern. However, other tested treatments produced an intermediate effect in this respect.

3.3.10. Fruit total acidity content (%)

Table, 6 shows that all tested treatments induced a pronounced reductive effect on fruit total acidity content as compared with hand removal treatment (control) in both seasons of study. Briefly, 15000 ppm NAA treatment proved to be the most efficient treatments in reducing fruit total acidity content. Moreover, other tested treatments showed nearly similar values in this respect from the statistical standpoint.

3.3.11. Fruit ascorbic acid content

Table, 6 illustrates that NAA, paclobutrazol and maleic hydrazide treatments succeeded in increasing fruit ascorbic acid content than hand removal treatment (control) in both seasons of study. Generally, 10000 ppm NAA treatment showed superiority in this respect. However, other treatments gave an intermediate values in this respect.

The enhancement effect of NAA on yield and fruit quality may be attributed may be due to increasing fruit set and or reducing fruit drop as well as increasing weight of the fruit through encouraging cell enlargement during fruit stages (Reynolds, 1988).

On the other hand, paclobutrazol caused a slower movement of IAA in shoot tips (Browning et al., 1992). However, Paclobutrazol has been reported as a growth retardant that inhibits gibberellin biosynthesis which caused reduction in suckers growth reflected on yield and fruit quality (Graebe, 1982).

However, Maleic hydrazide acts as an anti-auxin or a regulator of auxin metabolism which inhibited sucker growth and which reflected on tree yield and fruit quality (Hoffman and Parups, 1964).

The obtained results regarding the effect of NAA, paclobutrazol and maleic hydrazide on yield and fruit quality go in line with the findings of Ahmedullah and Wolfe (1982) who illustrated that NAA at 1.0% treatment of grapevines had no deleterious effects on yield and fruit quality. Moreover, Reynolds (1988) demonstrated that trunk-applied NAA gave linear increases in several yield components with increasing NAA level. As well as, enhance sugar accumulation and titratable acidity in 'Okanagan Riesling'.

In addition, Reynolds et al. (1991) reported that NAA treatments increased berry weight. Moreover, Aly et al. (1999) reported that 20000 ppm NAA treatment increased the mean number of fruits as well as yield per tree and total sugar percentage in fig but reduced TSS percentage slightly in pomegranate.

On the other hand, Gaash (1986) stated that 1000-4000 ppm of paclobutrazol on Canino apricot cultivar increased the yield. However, Blanco (1988) stated that paclobutrazol increased the average fruit size and yield of "Crimsongold" nectarines. Moreover, fruit maturity was advanced in "Okanagan Riesling" by trunk-applied paclobutrazol (Reynolds, 1988). However, Aly et al. (1999) mentioned that paclobutrazol treatments increased TSS percentage and vitamin C of fig and pomegranate fruits.

In addition, Maleic hydrazide (MH) is a retardant of shoot growth in grape (Kamuro, 1995).

Briefly, 1500 ppm PP_{333} treatment gave a maximum reduction of the number of suckers, length of suckers and weight of suckers as compared with hand removal treatment (control) but gave an intermediate values on yield and fruit quality. Meanwhile, 1500 ppm NAA treatments gave high positive effect on yield and fruit quality but gave less reduction than PP_{333} and MH treatments for the number of suckers, length of suckers and weight of suckers. Furthermore, MH treatments gave an intermediate values between PP_{333} and NAA treatments.

3.4. Economic study

3.4.1. The cost of hand cut method to remove suckers (control)

Suckers can be removed by hand during the growing season or at the end of growing season by using sharp knife. This practice is a temporary solution to the problem; also, periodic removal of suckers from trunk during the growing season is laborious job and consumes a lot of labour and time. Table, 7 shows the total cost of hand cut method (control), which costs about 2680 L.E / feddan.

Table 7. The cost of the hand cut method to remove suckers during (2012 and 2013).

items	workers/feddan	wage of worker per day(L.E)	total number of workers	Cost (L.E)	Total cost of Hand cut (L.E)
removal suckers	11	100	22	2200	2680
removal wastes	3	80	6	480	

Source: calculated by using field study data during (2012-2013) .

3.4.2. The cost of using experimental treatments to remove suckers

Table, 8 shows that all experimental treatments had negative values when estimated difference cost between it and hand cut (control) method except PP_{333} at 500 ppm, PP_{333} at 1000 ppm , PP $_{333}$ at 1500 ppm and NAA at 5000 ppm.

Table, 8 presents that the treatment PP $_{333}$ at 500 ppm came in ranked first with L.E 2194 on the other hand, the treatment PP $_{333}$ at 1000 ppm ranked second with L.E 1708 the treatment PP_{333} at 1500 ppm came in the third rank with L.E1250.5, whereas the treatment NAA at 5000 ppm came in the fourth rank with L.E 736.

The estimation results of the cost analysis led to choose four treatments. They had positive difference cost NAA at 5000 ppm, PP_{333} at 500, PP_{333} at 1000, PP_{333} at 1500 to determine the best treatment to the economic point of view.

3.4.3. Technological efficiency

Table, 9 revealed the economic difference (or the difference between productivity by using treatments (kg/tree) and productivity by using hand cut) was found to be positively in the estimation . These results used to calculated the production per feddan from using each treatment (tons/feddan) by multiply the difference with the density of trees per feddan (324 tree), then technological efficiency for using each treatments estimated . Table, 9 shows that all treatments had technological efficiency and the treatment PP_{333} at 500 ppm came in ranked first on the other hand, the treatment PP_{333} at 1000 ppm ranked second, the treatment PP_{333}, at 1500 ppm came in the third rank, whereas the treatment NAA at 5000 ppm came in the fourth rank.

3.4.4. Total revenue per feddan

Data in Table, 10 shows that total revenue per feddan kidney in case of using chemical treatments NAAat5000ppm, PP_{333} at 500 ppm, PP_{333} at1000ppm, and PP_{333} at 1500ppm were 68778.72, 64278.36, 57892.32, 55967.76 L.E/ feddan, respectively. While, it was 45048.96 L.E/ feddan with control treatment.

Table 8. The cost of chemical treatments to remove suckers during (2012 and 2013).

Treatments	liter concentration (gram/liter)	package weight (gram)	The required weight from treatment per feddan (gram)	The required number of package per feddan	Cost (L.E)	Difference cost compare with traditional method (L.E)	The rank according to the difference cost
NAA at 5000 ppm	5	500	1620	3.24	1944	736	4
NAA at 10000 ppm	10		3240	6.48	3888	-1208	-
NAA at 15000 ppm	15		4909	9.818	5890.8	-3210.8	-
PP_{333} at 500 ppm	0.5	25	162	6.48	486	2194	1
PP_{333} at 1000 ppm	1		324	12.96	972	1708	2
PP_{333} at 1500 ppm	1.5		476.5	19.06	1429.5	1250.5	3
MH at 500 ppm	0.5	10	162	16.2	3240	-560	-
MH at 1000 ppm	1		324	32.4	6480	-3800	-
MH at 1500 ppm	1.5		463	46.3	9260	-6580	-

Source: calculated by using field study data and Table, 7.

Table 9. The technological Efficiency for using the Chemical treatments to remove suckers on Manfalouty pomegranate in average the two study seasons (2012 and 2013).

Treatments	productivity kg/tree	difference in productivity by using treatments (kg/tree)	production per feddan from using treatments (ton/feddan)	The required weight from treatment per feddan (gram)	Technological Efficiency
Hand cut (control)	25.28	0	0	0	0
NAA at 5000 ppm	35.38	10.1	3.27	1620	2018.5
PP_{333} at 500 ppm	33.065	7.785	2.52	162	15555.5*
PP_{333} at 1000 ppm	29.78	4.5	1.45	324	4475.3
PP_{333} at 1500 ppm	28.79	3.51	1.13	476.5	2371.4

Source: calculated by using field study data and Table 6,7and 8.

3. 4.5. Net revenue per feddan for each treatment

Table, 10 shows the Net revenue per feddan in case of using experimental treatments NAA at 5000 ppm, PP $_{333}$ at 500 ppm, PP_{333} at 1000 ppm, and PP_{333} at 1500 ppm were 23729.76, 19229.4, 12843.36, and 10918.8, respectively. The PP_{333}at 500ppm achieves the best value of economic efficiency 39.65, then the PP_{333} at1000 ppm, it achieves 13.2, eventually NAA at 5000 ppm achieves 12.2. These results indicated that the PP_{333} at 500 ppm was the best treatment according the value of economic efficiency.

Table 10. The Economic Efficiency indicators for using the Chemical treatments to remove suckers on Manfalouty pomegranate in average the two study seasons (2012 and 2013).

Treatments	Average productivity kg/tree	Average production per feddan (ton/feddan)	Average* selling price	total revenue/ feddan (L.E/ton)	Net revenue from using treatments (L.E/feddan)	Economic Efficiency
Hand cut (control)	25.28	8.19072	5500	45048.96	0	0
NAA at 5000 ppm	35.38	11.46312	6000	68778.72	23729.76	12.2
PP_{333} at 500 ppm	33.065	10.71306	6000	64278.36	19229.4	39.56*
PP_{333} at 1000 ppm	29.78	9.64872	6000	57892.32	12843.36	13.2
PP_{333} at 1500 ppm	28.79	9.32796	6000	55967.76	10918.8	7.63

*calculated at harvest time during (2012 and 2013).
Source: calculated by using field study data and Table 6,7 and 8.

IV. Conclusion

Briefly, 1500 ppm PP_{333} treatment gave a maximum reduction of the number of suckers, length of suckers and weight of suckers as compared with hand removal treatment (control) but gave an intermediate values on yield and fruit quality. Meanwhile, 1500 ppm NAA treatments gave high positive effect on yield and fruit quality but gave less reduction than PP_{333} and MH treatments for the number of suckers, length of suckers and weight of suckers. Furthermore, MH treatments gave an intermediate values between PP_{333} and NAA treatments. Moreover, Economic efficiency, and technological efficiency recommended that the Paclobutrazol PP_{333} at 500 ppm is the best treatment to improve the "Manfalouty" pomegranate fruit quality and raising the net income farmer which reflect positively on pomegranate in El-Maghara, North Sinai governorate, Egypt.

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