

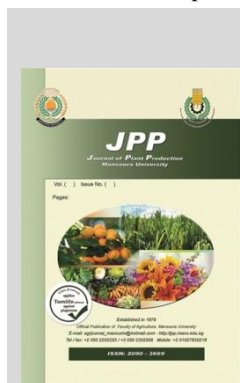
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Effect of Naphthaleneacetic acid (NAA) on Controlling of Suckers Growth on Lime Trees Grown in New Reclaimed Soil

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ABSTRACT

A field experiment was carried out during 2015/2016 and 2016/2017 seasons on Egyptian lime trees (*Citrus aurantifolia*) on orchard located at Al-kamal region, Governorate , Egypt . In this study, the effects of Naphthalene acetic acid (NAA) at different concentrations (0.50, 0.75, 1 .00, 1.25 1.50 %) for suckers growth and improve fruit quality of lime trees. As a result of the study, spraying NAA highly decreased trunk sprouts. However, the highest concentration (1.50%) recorded the lowest values of number, weight, and length of Suckers during the two growing seasons compared with the control and removal treatments. In addition, it enhanced vegetative growth parameters as leaf area and chlorophyll content in the leaves in both seasons. Moreover, Spraying NAA at 1.00% achieved the highest values of fruit weight, length, diameter, yield/tree and fruit Acidity % in the two seasons, respectively. Furthermore, NAA at 1.25% increased fruit juice %, TSS % and Ascorbic acid content in fruit juice in the two seasons of study. Peel thickness was reduced as a result of NAA at 1.50%.

Keywords: Egyptian lime, methods of sucker control, NAA, lime suckers control, removal of suckers and fruit quality.

INTRODUCTION

Citrus is one of the most important horticultural crops in Egypt due to its high economic value especially through exportation. Also, lemon is an important export crop for foreign markets and source for a highly priced fruit crop having significant importance in the fruit economy of our country. Egyptian lime (*Citrus aurantifolia*) is one of the most popular fruit among citrus in Egypt, due to its high yield, fresh consumption, consumes throughout the year. Egyptian lime occupied 55797.47 feddan, represented about 10.3% of total area of citrus (541723 feddan) according to M.A.L.R. (2015). Lime, is a medicinal fruit, good source of vitamins and minerals such as potassium, iron, phosphorus, calcium, vitamin C, niacin, riboflavin, B2, thiamin, B1, vitamin A, crude Fiber, carbohydrates, fat and protein. Lime is reach of Pectin after the extract of juice which has been used in toiletry materials (Reuther *et al* 1967). Fruits being acidic in nature, they are largely used for garnishing and flavouring several vegetarian and non-vegetarian dishes. Besides its value-added products like pickle, juice, squashetc, lime peel oil, peel powder are also of great demand in soap and cosmetic industry .Suckers are nonbearing shoots, canes, or limbs that emanate from the rootstock area of the trunk. They often grow from latent buds at the crown area of the trunk (Hellman, 2003). Sucker growth generally initiates in spring and continues until late summer requiring continuous removal during the growing season. Growth control is one of the important elements and labor-intensive in lemon orchard management. The right time for suckering is when they are not yet lignified. Waiting longer causes the suckers to become lignified, harden, which are then more difficult to remove Fregoni, *et al*,1999).

Methods of sucker control including disbudding the lower portion of the trunk, manual removal, thermal control, and chemical control. Traditionally, sucker treatment involved the hand removal of suckers growing in the area of the crown. Chemical control management technique saves labor costs and improves the value of the crop. Also, it is a popular method for farmers because it requires less time and labor than other sucker control methods (Serdar and Akuzuz 2018). Nowadays interest is mainly directed towards synthetic growth regulators to control of suckers.

Naphthaleneacetic acid and Paclobutrazol have been proven to be effective methods to control the growth of suckers inhibitor. The most common technique for control under the suckers is growth retardants. Naphthaleneacetic acid (NAA) has been shown to control trunk and crown sucker growth as a potential inhibitor in pomegranate, avocado and peach species (Fare *et al* 2005; Arpaia *et al* 2007; Salama and Elsherbeny, 2016), citrus (Nauer and Boswell, 1978), and hazelnut (Dolci *et al* 2001).

Furthermore, success with chemical control of trunk suckers has been demonstrated by several workers through the use of NAA (Ahmedullah and Wolfe, 1982), paclobutrazol (Reynolds, 1989) also, found that trunk-applied NAA and PB increased yield, several yield components, °Brix, and titratable acidity, although the effects of PB were shorter lived. Desukering can be carried out in different stages, on lignified stems. If performed early on small suckers there will be a successive regrowth and a second treatment may be required. A late season treatment on lignified suckers with chemical or physical techniques will require the hand removal of the wilted stems Tomasone *et al*,2010). Removal of suckers by hand, through the use of

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cutting tools (scissor, hatchet, hoe) requires a lot of working hours and is uncomfortable and tiring for workers.

The objectives of this study were to determine the effectiveness of Naphthalene acetic acid (NAA) spraying at different levels which can control vegetative growth and improve yield and fruit quality of lime trees.

MATERIALS AND METHODS

Experiment site

The present study was carried out during 2015/2016 and 2016/2017 seasons on 11years old Egyptian lime trees (*Citrus aurantifolia*) planted at 5x5 meters in a private orchard located Al-kamal region, Governorate , Egypt.

Forty two healthy trees were selected nearly similar in vigor and size, Naphthaleneacetic acid (NAA) was applied as spray on the hand removed suckers at rates of 0.0, 0.50, 0.75, 1.00, 1.25 and 1.50 beside hand removal of suckers.

However, the application was at approximately three weeks after full bloom during the two seasons of study. Nine years old Egyptian lime trees grown in sandy soil, under drip irrigation system from well were devoted for this study. Physical and chemical analyses of the experimental soil were done and shown in Table 1 .Experiment design and treatments

A complete randomized block design with three replicates for each treatment was done. Twenty one lime trees healthy, nearly uniform in growth vigor and productivity and received the same horticulture practices, In January 2016, the suckers were removed, then all treatments were applied directly following suckers removal on a cut surface from the point of attachment at the main trunk outward for a distance of 50 cm around the tree. The experiment involved the following seven treatment and its concentrations as follow:

1-Control (without desuckering and 0.00% NAA)

2-Hand cut of suckers only

3-Naphthaleneacetic acid (NAA) at 0.50%

4-Naphthaleneacetic acid (NAA) at 0.75%

5-Naphthaleneacetic acid (NAA) at 1.00 %

6-Naphthaleneacetic acid (NAA) at 1.25%

7-Naphthaleneacetic acid (NAA) at 1.50%

The following parameters were recorded for both seasons:

Sucker growth

(1) Number of measured and developed suckers, weigh 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) Leaf area (cm²) average leaf area of spring flushes shoots of lime trees was measured at the end of each season by using cl- 202 AREAMETER .

(3) Leaf chlorophyll of lime trees were extracted and determined according to the method described by Malik & Singh 1980.

(4)Yield tree and number of fruits /tree:-

The following parameters were considered: At harvest time (first week of September), the yield expressed in weight (kg) and number of fruits per tree was recorded.

(5) Fruit physical and chemical properties

Ten fruits were randomly collected from all sides of the trees under treatments and Physical characters, fruit dimensions [length and diameter], peel thickness ,Fruit weight and chemical characters such: total soluble solids percentage (TSS) was determined using a hand refractometer, total titratable acidity as g citric acid/100 ml of juice was determined by titration against 0.1 N sodium hydroxide in the presence of phenolphthalin as an indicator, ascorbic acid content (mg/100 ml of juice) was determined by titration against 2, 6- dichlorophenol indophenol (mg/100 ml) and juice volume (%) (AOAC, (1985).

Table 1. Physical and chemical analyses of the experimental farm which carried out according to Wilde *et al.* (1985)

Depth cm	CaCO ₃ %	E.C ds ⁻¹	Cations (mg/L)				Anions (mg/L)		N %	P %	K %	Fe ppm	Mn ppm	Zn ppm
			Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	HCO ₃ ⁻	Cl ⁻						
0-30	3.0	1.52	0.5	1.18	0.49	0.19	0.23	0.73	1.73	0.81	1.67	7.89	2.36	1.97
30-60	1.6	1.55	0.7	1.30	0.41	0.13	0.41	0.81	1.62	3.60	11.00	7.08	2.26	1.86
60-90	1.4	1.52	0.4	1.10	0.70	0.11	0.90	0.60	1.53	3.20	10.15	6.12	2.27	1.53

Statistical analysis:

Duncan's multiple range test (Duncan, 1955) at 5% level was used to compare the means.

RESULTS AND DISCUSSION

Effect of Naphthaleneacetic acid on number weight, and length of suckers .

Growth of suckers

In the present investigation, All NAA treatments inhibited Number, Weight and Length of Suckers, as

compared with the conventional control of suckers (untreated) and hand cut treatments (Table 2). NAA at 1.50 % treatment induced maximum reduction of number of suckers per tree (15.63-12.37) followed by (19.00-17.97) on 2016 and 2017seasons respectively, as compared with the control (80.53-71.90) and hand cut treatments (46.37-41.00). However, results showed that the increase in concentrations level of NAA led to progressive reduction of weight of suckers per trees (46.87- 3397) (48.97-48.97).

Table 2. Effect of spraying Naphthalene acetic acid on suckers growth developed on lime trees during 2016 and 2017 seasons.

Treatment	No. suckers/tree		Weight of suckers/tree (g)		Length of suckers/tree (cm)	
	2016	2017	2016	2017	2016	2017
Control	80.53 A	71.90 A	159.5 A	144.9 A	143.3 A	139.3 A
Hand Cut	46.37 B	41.00 B	118.3 B	116.5 B	92.63 C	88.93 C
0.50% NAA	37.70 C	26.00 D	96.20 C	86.97 C	132.6 B	129.6 B
0.75% NAA	27.73 E	23.60 E	66.37 E	37.37 F	55.20 D	51.03 D
1.00% NAA	31.47 D	30.40 C	72.00 D	69.77 D	48.70 E	46.07 E
1.25% NAA	19.00 F	17.97 F	48.97 F	47.83 E	40.80 F	40.03 F
1.50% NAA	15.63 G	12.37 G	46.87 F	33.77 G	40.27 F	38.60 G

Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

In this concern, application paclobutrazol at 2.5 ml/ tree in lemon trees achieved a decrease in canopy volume and trunk sectional area, number of new shoots, shoot length volume, and, number of fruits, and high yield per tree (Archana *et al.*,2018).

The same trend was found by Reynolds (1988), He reported that trunk application of NAA and pp33 ppm decreased the mean sucker length of Okanagna Riesling vines. In addition, the successful inhibition of suckers weight and numbers by NAA and ppm concentrations in fig and pomegranate trees.

in addition, the effect of other growth regulators, such as Naphthalene acetic acid (NAA) on regrowth control and prohexadione-calcium (GA biosynthesis inhibitor) on shoot growth will be investigated under Australian conditions (John Leonardi, 2005).

Leaf characteristics

Chlorophyll content in leaves (SPAD value):

Data Table (3) clearly show that chlorophyll content in leaves was significantly influenced. The maximum chlorophyll content (SPAD value) in leaves (76.67 and 76.93) was observed with the treatment, T6 (Cut+ 1.25 NAA) followed by treatment, T5 (Cut + 1) 75.67. The minimum Chlorophyll content (55.87 and 56.93) was found in control.

Table 3. Effect of spraying Naphthaleneacetic acid on chlorophyll and leaf area of lime trees during 2016 and 2017 seasons.

Treatments	Chlorophyll (spad value)		Leaf area (cm ²)	
	2016	2017	2016	2017
Control	55.87 E	56.93 F	17.43 A	17.13 A
Hand Cut	62.70 D	61.20 E	16.63 B	16.50 B
0.50%NAA	70.10 C	69.70 D	16.00 C	15.83 C
0.75% NAA	73.63 B	74.20 C	14.53 D	14.47 D
1.00% NAA	75.67 A	75.40 B	13.03 E	13.03 F
1.25% NAA	76.67 A	76.93 A	13.43 E	13.53 E
1.50% NAA	75.33 AB	76.27 A	12.43 F	12.10 G

Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

On the other hand, all NAA treatments decreased leaf area of lime trees and the lowest significant values of leaf area was produced from 1.50% NAA (12.43 -12.10)

Table 4. Effect of spraying Naphthalene acetic acid on fruit weight, fruit length, length and fruit diameter of lime trees during 2016 and 2017 seasons

Treatments	fruit weight (g)		fruit length (cm)		fruit diameter (cm)	
	2016	2017	2016	2017	2016	2017
Control	26.80 F	26.97 F	3.55 B	3.53 D	3.43 D	3.50 B
Hand Cut	27.67 E	27.63 E	3.87 A	3.80 BCD	3.47 CD	3.53 B
0.50% NAA	29.00 D	28.97 D	3.73 A	3.97 ABC	3.57 BCD	3.50 B
0.75% NAA	32.97 B	33.00 B	3.87 A	3.63 CD	3.73 B	3.70 B
1.00% NAA	36.00 A	35.73 A	4.00 A	4.23 A	4.00 A	3.97 A
1.25% NAA	30.80 C	30.73 C	3.87 A	3.97 ABC	3.63 BC	3.63 B
1.50% NAA	28.97 D	29.13 D	3.80 A	3.83 BCD	3.57 BCD	3.63 B

Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

Number of fruits tree :

Data presented in Table (5) showed that Number of fruits per tree was significantly increased under treatment of 1.00% NAA (471.7-490.0). As the maximum (430.7-445.7) numbers of fruits per tree were obtained whereas, the minimum number of fruits per tree (231.0) were obtained in the control. In this concern, Plant growth retardants prohexadione-Ca (ProCa), was effective in increasing the number of inflorescences per cane, and promoting the yield

during both seasons as compared with other treatments. However, the higher value was obtained with the control treatments (17.43 - 17.13) during the two studied seasons.

The growth retardant (NAA) suggested that functions by reducing the amount of energy available to developing fruit either by interference with photosynthesis or by the reduced translocation of metabolites, including photosynthates, from leaves to fruit (Stopar *et al.*, 1997). The reduced leaf area was corrected by the thicker leaves and increase of their photosynthetic capacity (Wample *et al.*, 1987). Also, Wang *et al.* (1985) showed that Paclobutrazol increased chlorophyll content on a leaf area basis, increased soluble protein in leaves and increased mineral element concentration in leaf tissue.

Naphthalene acetic acid on fruit weight, length and diameter of lime trees.

Average fruit weight, length and diameter of lime trees in both seasons were affected by naphthaleneacetic acid applications.

Fruit Weight: The maximum fruit weight (36.00 -35.73) was obtained with 1.00% NAA treatments. The minimum fruit weight (26.80 -26.97) was noted in the control treatment in both seasons. These results came in line with that obtained by Allan *et al.* (1995), who reported that paclobutrazol significantly increased yield by increasing mean fruit weight rather than the number of fruits. In addition, Reynolds *et al.* (1991) berry weight was increased by NAA in Grapevine .

Fruit size (length & diameter): It is clear from Table (4) that on Maximum fruit length (4.00 -4.23 cm) was recorded in trees treated with 1.00% NAA in the first and second seasons respectively. On the other hand, the lowest values was obtained by Control in both seasons (3.55-3.53 cm), respectively. The highest fruit diameter was obtained by 1.00% NAA as compared with the control during the two seasons. (Sekhi, 2017) found that 50% decapitation and sucker removal achieved significant increasing fruit No and size. Bound (2001) reported that late application of high concentrations of NAA and NAA has a negative effect on fruit size.

and nutritional fruit quality of the Willamette raspberry (Milena *et al.* 2012). In addition, application of paclobutrazol at 2.5 ml/ tree in lemon increased tree number of fruits, and high yield per tree (Archana *et al.* 2018).

Yield / tree (Kg):

Data revealed that fruit yield of lime trees was statistically influenced with the application of NAA treatments. The maximum fruit yield per tree was significantly increased under treatment of 1.00% NAA

(155.0 - 159.20 Kg) as compare to control and hand cut treatment under the present study. While, lowest fruit yield (61.75 – 63.82 Kg) was obtained in the control. In the literature, application of PBZ has consistently been found to increase tree yield (Burondkar & Gunjate 1993). In addition, the effect of other growth regulators, such as naphthalene acetic acid (NAA) on regrowth control and prohexadione-calcium (GA biosynthesis inhibitor) on yield will be investigated under Australian conditions (John Leonardi, 2005).

Peel thickness The peel thickness of fruit had significantly influenced with the application of

Naphthaleneacetic acid treatments. The maximum peel thickness (0.28 -0.28 cm) was recorded with hand Cut treatments. On the other hand, the minimum peel thickness (0.18 - 0.18 cm) was obtained with the application of 1.50% NAA. The previous significant influence of NAA on yield, yield components, and fruit composition may be attributable to similar movement throughout the vine and into the fruit (Reynolds, 1988). In addition, the effect of other growth regulators, such as naphthalene acetic acid (NAA) on regrowth control and prohexadione-calcium (aGA biosynthesis inhibitor) on fruit quality will be investigated under Australian conditions (Rademacher 2000).

Table 5. Effect of spraying Naphthalene acetic acid on No. fruit/ tree, Yield/ tree and Peel thickness of lime trees during 2016 and 2017 seasons

Treatments	No. fruit/ tree		Yield / tree (kg)		Peel thickness (cm)	
	2016	2017	2016	2016	2016	2017
Control	231.0 F	236.7 F	61.75 F	63.82 E	0.26 B	0.27 AB
Hand Cut	219.0 G	231.7 F	60.59 F	64.02 E	0.28 A	0.28 A
0.50% NAA	295.0 E	303.3 E	85.56 E	87.87 D	0.19 CD	0.18 D
0.75% NAA	355.0 C	361.3 C	117.1 C	134.3 B	0.26 B	0.26 AB
1.00% NAA	471.7 A	490.0 A	155.0 A	159.2 A	0.25 B	0.25B
1.25% NAA	322.7 D	350.3 D	99.14 D	107.7 C	0.20 C	0.21 C
1.50% NAA	430.7 B	445.7 B	136.6 B	142.8 B	0.18 D	0.18 D

Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

Effect of NAA application on juice chemicals constituents of Lime fruits:

Total soluble solids (TSS %):-

Data tabulated in Table (6) revealed that Naphthaleneacetic acid had significant effect on TSS % of lime fruits. Maximum TSS % (10.60 and 10.50) was noticed in 1.00% NAA treatment whereas, minimum TSS% (6.36 and 6.37) was observed in the control in both seasons. Reynolds (1988, 1989) also found that trunk-applied NAA and paclobutrazol (PB) increased several yield components,

°Brix, and titratable acidity .Similar results have been reported by Ghosh *et al.* (2009) in pomegranate, and Jagtap *et al.* (2013) in acid lime. Hoda *et al.* (2001) also reported that paclobutrazol(PBZ)treatments improved fruit quality.

Titratable Acidity (%):-

The results revealed that acidity % significantly reduced with NAA sprays in both seasons. The found that trunk-applied NAA and PB increased °Brix, and titratable acidity,

Table 6. Effect of spraying Naphthaleneacetic acid on Titratable acidity%, Ascorbic acid and T.S.S of lime trees during 2016 and 2017 seasons.

Treatments	T.S.S. %		acidity %		Ascorbic acid (mg/100 ml juice)		Juice %	
	2016	2017	2016	2017	2016	2017	2016	2017
Control	6.36 F	6.37 F	6.71 E	6.82 F	33.93 E	33.47 E	57.46 ABC	54.49 AB
Hand Cut	6.52 F	6.51 F	7.40 C	7.38 D	34.53 E	34.10 E	57.85 AB	57.78 A
0.50% NAA	6.97 E	6.97 E	7.18 D	7.18 E	37.27 D	36.67 D	54.94 BC	55.02 BC
0.75% NAA	8.70 C	8.47 C	8.18 B	8.16 B	41.83 C	41.33 C	56.04 ABC	54.15 C
1.00% NAA	10.60 A	10.50 A	7.34 C	7.53 C	43.37 B	43.30 B	56.59 ABC	57.01 AB
1.25% NAA	9.60 B	9.67 B	8.37 A	8.38 A	45.60 A	45.13 A	58.54 A	58.49 A
1.50% NAA	7.63 D	7.60D	8.35 A	8.35 A	41.27 C	41.67 C	54.32 C	54.12 C

Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

Ascorbic acid (mg/100 g pulp):-

Data of table (6) proved that spraying lime trees with NAA at 1.25% significantly increased ascorbic acid content to the greatest level (45.60 - 45.13 %) in both seasons as compared with other studied treatments . Such results could be confirmed with the finding of Ramirez *et al.* (2010) showed that ProCa increased the content of vitamin C in apple fruits. Reynolds *et al.* (1991) also found that trunk-applied NAA and PB increased several yield components in *Vitis vinifera* .

Fruit juice (%):-

Data clearly indicate that fruits harvested from trees sprayed with 1.25 NAA showed maximum juice content (58.54 - 58.49 %) in lemon fruits. compared to the Control. Habib *et al.* (2004) reported that paclobutrazol (cultural) application on mango trees improved fruit quality

CONCLUSION

The results of the present study proved that using NAA at different levels as foliar spray to the suckers developed on the adult lime trees gained beneficial effects for controlling suckers growth on the tree trunk as well as improving yield and fruit quality.

However, NAA spraying at 1.50% achieved the lowest number, weight and length of the developed suckers and chlorophyll content and leaf area of lime trees. Meanwhile, NAA spraying at 1.00% resulted in the greatest number of fruit / tree, fruit weight, length, diameter and juice TSS %. On the other hand, NAA spraying at 1.25% resulted in the highest acidity % , ascorbic acid content and fruit juice % .Results also revealed that manual and hand cut of suckers caused the lowest peel thickness of lime fruit.

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تأثير حمض نفتالين حمض الخليك على التحكم في نمو السرطانات النامية على اشجار الليمون البلدى فى الأراضي حديثة الاستصلاح مايسه السيد يس مركز بحوث الصحراء – القاهرة – مصر

أجريت هذه التجربة خلال موسمين متتاليين 2016 , 2017 على أشجار الليمون البلدى عمر 11 سنوات التي تروى بالتنقيط بمياه ترعه الإسماعيلية بمزرعة الكمال – محافظه الإسماعيلية جمهورية مصر العربية. وكان الهدف دراسة تأثير نفتالين حمض الخليك على التحكم فى نمو السرطانات والمحصول وصفات جودة ثمار اشجار الليمون البلدى. من خلال رش نفتالين حمض الخليك بتركيزات مختلفة فى شهر فبراير حيث يتم ازالة جميع السرطانات يدويا من على جميع اشجار التجربة لبدء تطبيق معاملات الرش على النحو التالى: 1- الكنترول (بدون ازالة للسرطانات وبدون رش) 2- قطع السرطانات باليد فقط وبدون رش 3- رش نفتالين حمض الخليك بتركيز 0,50% 4- رش نفتالين حمض الخليك بتركيز 0,75% 5 - رش نفتالين حمض الخليك بتركيز 1,00% 6- رش نفتالين حمض الخليك بتركيز 1,25% 7- رش نفتالين حمض الخليك بتركيز 1,50%. تم اجراء المعاملات مرة واحدة فى شهر فبراير وقد اشارت النتائج الى ان معاملة رش نفتالين حمض الخليك بتركيز 1,50% اعطت أفضل النتائج وحدث انخفاض بالنسبة لعدد السرطانات واوزانها وطوالها واقل سمك لقشرة الثمرة وذلك بالمقارنة بالقطع اليدوى والكنترول. كما اظهرت نفس المعاملة افضل النتائج فى مساحة الورقة ومحتوى الأوراق من الكلوروفيل فى حين اظهرت معاملة رش نفتالين حمض الخليك بتركيز 1,00% اعلى عدد ووزن وطول الثمرة واعلى حموضة ومحصول للشجرة . كما اظهرت معاملة نفتالين حمض الخليك بتركيز 1,25% 0% زيادة فى نسبة العصير ونسبة المواد الصلبة الذائبة الكلية وحمض الاسكوربيك عن اشجار الكنترول.