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Impact of Using Some Antioxidants on Improving Yield and Fruit Quality of Le-Conte Pear Trees

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Abstract: This study aims to evaluate the effects of spraying some antioxidants on improving growth , fruit set, yield and fruit quality of Le-Conte pear trees during the two successive seasons of 2018 and 2019. Trees were 35- years- old budded on *Pyrus communis* rootstock and grown on clay soil in El-Pharoania village at El-Monufia Governorate. Anti-oxidants such as Hydrogen peroxide (H_2O_2) at 1 & 2%, Salicylic acid at 250 & 500 PPm, Succinic acid at 250 & 500 ppm and Ascopein at 250 & 500 PPm. Trees were sprayed at four dates: first date at the start of bud burst stage (first week of March), second date at full bloom (75% flowering at mid March), third date after fruit set at (May) and fourth date after fruit set at (June). The results show that all studied antioxidants improved fruit set%, yield (Kg/tree) and fruit quality especially higher concentration in both seasons. Ascopein treatment at 500ppm recorded significantly the highest leaf area, chlorophyll, N, P, K, carbohydrates content, C/N ratio, fruit set and yield as well as improved significantly fruit quality and monetary value as compared to all other treatments, while the lowest values obtained with unsprayed trees (control) during the period of study.

Key words: Antioxidants · Hydrogen peroxide (H_2O_2) · Salicylic acid · Succinic acid · Ascopein · Fruit set · Yield · Ffruit quality · "Le-Conte ' pear trees

INTRODUCTION

Pear is considered an economically important fruit among other deciduous fruit trees and one of the most important fruits grown in the world [1]. In Egypt, productivity of “Le Conte”, the main pear cultivar, significantly varies from one year/location to another [2].

Antioxidants play an important role in protecting the cell from senescence as well as improving productivity of organic fruits. Antioxidants are safe to human, environment and prevent the free radicals produced during plant metabolism from oxidation of lipids, the components of plasma membrane which accompanied with the loss of permeability and the death of cells. Moreover, antioxidants with their protect and properties play an important role in plant defense against oxidative stress as well as the biosynthesis of most organic foods and activation of cell division process [3-5].

Hydrogen Peroxide (H_2O_2), plays a duplicate role as a toxic by product of normal cell metabolism and as a regulatory molecule in stress perception and signal transduction [6, 7]. Moreover, it may be enhanced flowering and fruit growth [8-11]. Also, increased the photosynthetic rates, stomata conductance, transpiration, chlorophyll and dry matter content of the leaves and total soluble solids and total sugar content of the fruits of wax apple [12]. In addition, trees treated by hydrogen peroxide resulted larger fruit size, higher fruit set, fruit number, fruit biomass, yield and may be promote the ripening process compared to the control [13-15].

Salicylic acid is a phenolic phytohormone, it plays an important role in plant growth and development, photosynthesis, transpiration, ion uptake and transport [16-18]. Salicylic acid (SA) beneficial effect is accelerating the biosynthesis, translocation of sugars, plant pigments and hastening peel coloration of fruits. Also, Xu and Tian [19] and Babalar *et al*. [20] cleared that SA treatment stimulated the activities of antioxidant enzymes (catalase, glutathione peroxidase, chitinase and ß-1, 3- glucanase) in sweet cherry fruit. On the other hand, many others cleared that spraying salicylic acid at 50 to 400 ppm once, twice, or three times was very effective in improving growth,

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yield and fruit quality in most evergreen fruit crops and interactions between SA and other natural stress management compounds [21-31].

Succinic acid known as SADH or B 9 is a plant growth regulator, a chemical sprayed on fruit to regulate growth , plays a role in the citric acid cycle, an energy-yielding process and concerned one of the intermediary metabolites in the citric acid cycle. It may be participated in the net synthesis of glucose, other sugars, fatty acids normally found in plant and dicarboxylic acids. Also, catalyses by the enzyme succinct dehydrogenase (or complex II of the mitochondrial ETC). Intermediate electron carriers are FAD and three 2Fe-2S clusters part of subunit B [32]. Succinic acid is an important platform molecule in the synthesis of a number of commodities, specialty chemicals and important biochemical intermediate that occurs in all living creatures [33]. Also, Sherif and Samia [34] cleared that fruit set (%) and fruit quality increased by spraying Succinic acid150 & 250ppm.

Moreover, Ascopein concerned as natural and organic antioxidant compounds has auxinic action, since it contains 13% citric acid (CA) and 25% ascorbic acid (AA) respectively, provided diseases control against most fungi infections on different fruit trees [35-37]. And increased yield, fruit weight, total soluble solids and total sugars, while reduced the total acidity on "Anna" apple trees [38]. In addition, many others cleared that spraying AA and /or CA significantly enhanced quality and properties of 'Red Spur' apples. Also, improved vegetative growth traits such as shoot length, leaves/shoot ratio, leaf area index as well as fruit characteristics [39-41]. It has been shown that both AA and CA have substantial roles in many metabolic and physiological processes such as cell enlargement and division, resulting in increased biomass and increased photosynthesis rate.

Increasing fruit quality and properties can be important for enhancing economic production [44, 45]. Hence, this study aimed to evaluate foliar application of different nature antioxidants substances on fruit set, yield, fruit quality and net profit of "Le-Conte ' pear trees.

MATERIALS AND METHODS

The present study was conducted in two successive seasons of 2018 and 2019 on "Le-Conte" pear trees grown under clay loamy soil conditions in a private orchard at El- Pharonia Village El–Mounifia Governorate, Egypt. Selected trees were 35 years-old grafted on commuins rootstocks, at 5x6m apart; nearly similar in growth vigor and fruiting, free from any visual infections and received regularly the recommended horticultural practices. Trees were applied as foliar spray four times at the start of growth bud burst stage (first week of March), full bloom (75% flowering at mid March), after fruit set at (May) and two months later after fruit set at (June).

The experimental design was complete randomized block design, with nine treatments in three replicates consisting of three trees. The applied treatments were as follows:

- Spraying with tap water only (Control).
- Spraying with 1% or 2% Hydrogen peroxide (H_2O_2)
- Spraying with 250 or 500 ppm Salicylic acid (SA).
- Spraying with 250 or 500 ppm Succinic acid (SU).
- Spraying with 250 or 500 ppm Ascopein (AS) contained 38% organic acids (Ascorbic &citric acids) and 62% organic substances. (Ascopein is a trade name for plant growth activator, Registered under No.12624 -Ministry of Agriculture).

All treatments were applied with a hand-held spray bottle until runoff. Salicylic acid was dissolved in distilled water and the pH was adjusted at 6.5 with NaOH. The control trees were sprayed with tap water. Furthermore, to evaluate the efficiency of the tested treatments on tree fruiting and fruit quality .Four branches were selected and labeled to calculate the following measurements:

Vegetative Growth Measurements

Leaf Area: On late August during both two seasons, ten mature leaves were collected at random from each studied tree to determine the average leaf area (cm^2) by using Leaf Area meter model (1203, CID, Inc, USA).

Chlorophyll Reading: On late August, samples of 20 leaves /tree were taken at random from the middle leaves from the previously tagged shoots of each tree. Leaf chlorophyll reading was recorded by Minolta chlorophyll Meter SPAD-502 (Minolta camera .Co, LtD Japan) at the field [46].

Leaves Mineral Content: Leaf minerals contents were determined in August (after harvest) in both seasons. Samples of twenty leaves from the middle part of shoots were selected according to Chuntanaparb and Cummings [47] at random from each replicate to determine their content of C, N, P and K according to Evenhuis [48]. Leaf samples were washed with tap water and distilled water twice, dried at 70°C to a constant weight and then ground. The ground samples were digested with sulphoric acid and hydrogen peroxide according to Evenhuis and

Dewaard [49]. Total nitrogen and Phosphorus were determined calorimetrically according to Evenhuis [48] and Murphy and Riley [50], respectively. Potassium was determined by a flame Photometer model E.E/L [51]. Total carbohydrates were determined according to Smith *et al*. [52]. Carbohydrates / nitrogen ratio calculated as follows:

$$\text{C/N ratio} = \frac{\text{Total carbohydrates}}{\text{Total nitrogen}}$$

Crude Protein = N (%) × 6.25

Flowering and Fruiting

Fruit Set (%): Four branches, in the different sides of each tree were tagged for determining the fruit set percentage. Fruit set was calculated in relation to the total number of flowers, on May and then the percentages were calculated as follow:

$$\text{Fruit set (\%)} = \frac{\text{No. of developing fruitlets}}{\text{Total No. of flowers}} \text{x100}$$

Yield and Fruit Quality

Yield (Kg/tree): Fruits were collected at maturity stage late of July from each tree of various replicates and yield weight (kg/tree) was estimated by multiplying the number of fruits with average fruit weight.

Fruit Physical Properties: Twenty fruits from each tree under study were chosen for determining the following:

- Average fruit weight (gm).
- Average fruit volume (ml^3).
- Average fruit length (cm).
- Average fruit diameter (cm).
- Average fruit shape index (length/ diameter) was estimated.
- Fruit firmness was estimated as $Ib/inch^2$ using the pressure tester of 5/16 inch plunger [53].

Chemical Properties:

- Total soluble solids (T.S.S)was determined by a hand refractometer,
- Acidity of fruit juice was determined (as malic acid) by titration with 0.1 normal sodium hydroxide with phenolphthalein as an indicator, according to(A.O.A.C.) [54].
- TSS/acidity ratio was assessed.
- Total sugars % content were determined according to Malik and Singh [55].

Net Profit (LE): Fruit yield were used in estimating crop monetary value considered a farm-gate price of 7 *LE*/Kg for the first season and 8 *LE*/Kg for the second season, control treatment cost % /fed had considered equal 12000LE. In considered that the price of antioxidants used in addition to the cost of agricultural practices for trees (as well as, fertilizers, irrigation, pests control, workers and breaking dormancy agents…. etc). Whereas , the prices were Hydrogen peroxide 80 LE/liter , Salicylic acid 200 LE/ kg , succinic acid 150 LE/ 100 g and Ascopein 50 LE/400 g .The cost % is counted by adding total agricultural practices cost (12, 000 LE /Fed.) plus the various antioxidants cost multiply by 100. Herein, counted the net profit /Fed. which led to count the net profit % and Investment return rate (LE) according to [56].

Net profit LE/ fed for treatments were calculated as follows:

Net profit = Yield price (LE/fed) - Treatments cost (LE/Fed).

Net profit % = 100 - Treatment cost (%)

Investment return rate (LE) = Net profit (LE) / fed / treatment - Net profit (LE) / fed /control ÷ Net profit (LE) / fed /control

Statistical Analysis: Data were statistically analyzed with split plot A.N.O.V.A. table according to the method of Duncan multiple range tests [57] were used for comparison between means of each treatment.

RESULTS AND DISCUSSION

Vegetative Growth

Leaf Area (cm^2): The effect of applied various antioxidants (hydrogen peroxide (H_2O_2), Salicylic acid (SA), Succinic acid (SU), Ascopein (AS)), on average of leaf area (cm^2) are shown in Table 1. Data revealed that there was a significant difference between all treatments under study compared with the control. Also, it noticed that higher concentration increased leaf area than lower concentration. In this respect, spraying Ascopein at 250 & 500 ppm enhanced the leaf area followed by hydrogen peroxide at 1&2% in both seasons under study. The present results are in agreement with Khandaker *et al*. [58], Ahmed *et al*. [59] and El-Abbasy *et al*. [18] who cleared the role of hydrogen peroxide (H_2O_2), Ascopein and salicylic acid in enhancing vegetative growth of apple.

Table 1: Effect of spraying various antioxidants on Chlorophyll reading and Leaf area (cm^2) of Le-Conte pear trees in seasons 2018 and 2019

Treatments		Leaf area (cm^2)	Mean (A)	Chlorophyll reading	Mean (A)
Antioxidant substances (A)	Con.(B)		First season (2018)		
Hydrogen peroxide (H2O2)	1%	29.03e	30.72B	49.13f	50.28B
	2%	32.40a		51.43ab	
Salicylic acid (SA)	250ppm	26.77g	28.19D	50.63d	51.13A
	500ppm	29.60d		51.63a	
Succinic acid (SU)	250ppm	28.47f	29.04C	51.13c	51.16A
	500ppm	29.60d		51.20bc	
Ascopein (AS)	250ppm	30.20c	31.14A	49.80e	50.32B
	500ppm	32.07b		50.83d	
Control	Tap water	19.43h	19.43E	47.07g	47.07C
	Tap water	19.43h		47.07g	
Mean (B)		26.78B	28.62A	49.55B	51.90B
			Second season (2019)		
Hydrogen peroxide (H2O2)	1%	31.00e	32.04B	50.90g	51.33D
	2%	33.07a		51.77f	
Salicylic acid (SA)	250ppm	27.27g	29.30D	55.50b	55.64A
	500ppm	31.33d		55.77a	
Succinic acid (SU)	250ppm	30.40f	30.37A	52.87d	52.52C
	500ppm	30.33f		52.17e	
Ascopein (AS)	250ppm	32.47b	32.37A	51.87f	52.74B
	500ppm	32.27c		53.60c	
Control	Tap water	21.60h	21.60E	48.37h	48.37E
	Tap water	21.60h		48.37h	
Mean (B)		28.55B	29.72A	50.43A	52.34A

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

Table 2: Effect of spraying antioxidant substances on N, P and K in leaves of Le-Conte pear trees in seasons 2018 and 2019

Treatments		N (%)	Mean (A)	P (%)	Mean (A)	K (%)	Mean(A)
Antioxidant substances (A)	Con.(B)			First season (2018)			
Hydrogen peroxide (H_2O_2)	1%	2.33bc	2.42A	0.360b	0.370A	1.020de	1.045C
	2%	2.50a		0.380a		1.070cd	
Salicylic acid (SA).	250ppm	2.26c	2.33B	0.340cd	0.350B	1.030de	1.170B
	500ppm	2.40b		0.360b		1.310ab	
Succinic acid (SU	250ppm	2.31bc	2.42A	0.300e	0.315C	1.200bc	1.022C
	500ppm	2.52a		0.330d		0.843f	
Ascopein (AS)	250ppm	2.11d	2.23C	0.330d	0.340B	1.370a	1.363A
	500ppm	2.34bc		0.350bc		1.357ab	
Control	Tap water	1.12e	1.12D	0.240f	0.240D	0.900ef	0.900D
	Tap water	1.12e		0.240f		0.900ef	
Mean (B)		2.03B	2.18A	0.314B	0.332A	1.104A	1.096A
				Second season (2019)			
Hydrogen peroxide (H_2O_2)	1%	2.54d	2.64B	0.360de	0.395A	1.030c	1.060C
	2%	2.74c		0.430a		1.090c	
Salicylic acid (SA).	250ppm	2.25e	2.48D	0.340f	0.360B	1.050c	1.050C
	500ppm	2.70c		0.380bc		1.050c	
Succinic acid (SU	250ppm	2.33e	2.58C	0.350ef	0.370B	1.300b	1.310B
	500ppm	2.83b		0.390b		1.320b	
Ascopein (AS)	250ppm	2.85b	2.92A	0.370cd	0.405A	1.890a	1.930A
	500ppm	2.99a		0.440a		1.970a	
Control	Tap water	2.32e	2.32E	0.260g	0.260C	0.900d	0.900D
	Tap water	2.32e		0.260g		0.900d	
Mean (B)		2.46B	2.72A	0.336B	0.380A	1.234A	1.266A

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

Chlorophyll Reading: The results presented in Table (1) indicated that chlorophyll reading of Le-Conte pear leaves was significantly affected by the spraying of various antioxidants than untreated trees. Trees sprayed with higher concentration of various antioxidants had recorded higher leaf chlorophyll readings value followed by lower concentration in two seasons understudy. Also, it noticed that both of Salicylic acid and Succinic acid gave the highest chlorophyll reading at both concentrations in both seasons under study. Results are in harmony with Shaaban *et al.* [22] those who reported that using antioxidants regulating photosynthesis and growth. Also Uzunova and Popova, [60] and Fariduddin *et al.* [61] suggests that SA is an important regulator of photosynthesis because it affects leaf and chloroplast structure, chlorophyll and carotenoid contents.

Leaves Mineral Content: The effect of various antioxidants treatments on N, P and K leaves content of Le-Conte pear trees during the two seasons under study are shown in Table (2). As regard, it is clear from the obtained data that spraying various antioxidants was significantly effective in enhancing percentages of N, P and K in the leaves compared with the untreated. Also, it noticed that the highest concentration recorded the highest values compared with the lowest ones. First season, Ascopein and Succinic acid treatments increased N, P while Ascopein and salicylic acid recorded high value of K leaf contents as compared with the other antioxidants and untreated trees. Furthermore, in the second season hydrogen peroxide (H_2O_2) and Ascopein gave high values for N and P but the best K leaves content found from Ascopein and Succinic acid treatments. The present results are in agreement with El-Sayed *et al*. [62] who suggested that antioxidants, like ascorbic acid and citric acid, have auxinic action and synergistic effect on leaf mineral contents. Recently, antioxidants are used rather than auxins and other chemicals for enhancing the expansion of varied fruit trees. Ghazijahani *et al.,* [63] indicated that there's a clear effect by sprayed organic acids, which might be transferred to the root and affect the uptake of mineral nutrients from the medium. The physiological mechanism behind this effect might not be the identical for various nutrients.

Total Carbohydrates, C/N Ratio and Crude Protein: Table (3) shows the effect of various antioxidants on "Le-Conte" pear trees during the two experimental seasons (2018 and 2019). It is noticed that Hydrogen peroxide (H_2O_2) followed by Succinic acid gave the highest average values from carbohydrates in first season compared with the control. Meanwhile, in the second season, both Salicylic acid and Succinic acid recorded the best carbohydrates content. In addition, the highest concentration gave the highest values than the lowest ones. Herein, C/N ratio showed the same trend with carbohydrate contents. Meanwhile, Crude Protein recorded higher value with Hydrogen peroxide (H_2O_2) followed by Succinic acid in both seasons under study.

In this respect, Slesak *et al.* [64] and Ismail *et al.* [11] cleared that during photosynthesis, the plants used carbon dioxide (CO_2) and water (H_2O) and produced carbohydrate ($C_6H_{12}O_6$) and released oxygen (O_2) as byproduct, while, during respiration, the carbohydrate are converted into energy where, the energy is used in the process of building new tissues.

Flowering and Fruiting

Fruit Set (%) and Yield (Kg/tree): Regarding the effect of various antioxidants on fruit set% and yield (Kg/tree), Table (4) revealed that they had significantly positive effect in both seasons, it was found that the highest fruit set (%) and yield(Kg/tree) were obtained from spraying Ascopein followed by Hydrogen peroxide (H_2O_2), Salicylic acid and Succinic acid whereas, untreated ones resulted the lowest fruit set in both seasons under study. It was noticed that there was a positive relation between the concentration of antioxidants and the yield. Data in Table (4) also revealed that second season has higher significant results (fruit set % and fruit yield Kg/ tree) than the first one and that may be as a result of the accumulated effect of the treatments.

The present results are in agreement with those of Abdou [37] working on “Le-Conte” pear, Shaaban *et al*. [22] on "Anna" apple, Aly [65] on “Costata” persimmon and El-Abbasy *et al.* [18] on apple. Moreover application of antioxidant treatments have auxinic action and also synergistic effect on flowering and fruit trees; therefore they are used instead of auxins and other chemicals for enhancing fruiting of various fruit trees [62, 42]. Also, Khandaker *et al*. [12] and Ismail *et al.* [11] referred to the effects of H_2O_2 on germination of seedling until maturation, flowering, fruit set and fruiting stage and fruit quality.

Fruit Quality

Fruit Physical Properties

Fruit Weight (G): Data presented in Table (5) reveal that there was a positive response of fruit weight to the different antioxidants treatments. Hence, the highly positive response of fruit weight was detected with those

Table 3: Effect of spraying antioxidant substances on Total carbohydrates, C/N ratio and Crude Protein in leaves of Le-Conte pear trees in seasons 2018 and 2019

Treatments		Total carbohydrates (C) %	Mean (A)	C/N ratio	Mean (A)	Crude Protein	Mean (A)
Antioxidant substances (A)	Con.(B)			First season (2018)			
Hydrogen peroxide (H_2O_2)	1%	26.67b	30.93A	11.45c	12.76B	14.56c	15.13A
	2%	35.19a		14.08b		15.63a	
Salicylic acid (SA).	250ppm	21.76g	23.24C	9.63ef	9.96CD	14.13d	14.56B
	500ppm	24.71d		10.30de		15.00b	
Succinic acid (SU)	250ppm	21.29h	23.89B	9.22f	9.86D	14.44c	15.13A
	500ppm	26.49c		10.51d		15.75a	
Ascopein (AS)	250ppm	22.91f	23.28C	10.86cd	10.48C	13.19e	13.94C
	500ppm	23.64e		10.10de		14.63c	
Control	Tap water	19.46i	19.46D	17.38a	17.38A	7.00f	7.00D
	Tap water	19.46i		17.38a		7.00f	
Mean (B)		22.42B	25.90A	11.70B	12.47B	12.69B	13.63A
				Second season (2019)			
Hydrogen peroxide (H2O2)	1%	30.27g	34.87C	11.92d	13.16C	15.88e	16.50B
	2%	39.47c		14.41b		17.13c	
Salicylic acid (SA).	250ppm	39.38d	39.55A	17.50a	16.10A	14.06g	15.50D
	500ppm	39.71b		14.71b		16.88d	
Succinic acid (SU	250ppm	30.77f	36.20B	13.21c	13.96B	14.56f	16.13C
	500ppm	41.62a		14.71b		17.69b	
Ascopein (AS)	250ppm	26.67h	28.93D	9.36f	9.89D	17.81b	18.25A
	500ppm	31.18e		10.43e		18.69a	
Control	Tap water	23.63i	23.63E	10.19e	10.19D	14.50f	14.50E
	Tap water	23.63i		10.19e		14.50f	
Mean (B)		30.14B	35.12A	12.43A	12.89A	12.69B	16.18A

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

Table 4: Effect of spraying various antioxidants on Fruit set (%) and Yield (Kg/tree) of Le-Conte pear trees in seasons 2018 and 2019

Treatments		Fruit set (%)	Mean	Yield (kg/tree)	Mean
Antioxidant substances (A)	Con.(B)		First season (2018)		
Hydrogen peroxide (H_2O_2)	1%	6.4c	6.3B	43.33d	43.67B
	2%	6.2b		44.00c	
Salicylic acid (SA)	250ppm	5.5g	5.6C	37.67h	39.50D
	500ppm	5.8e		41.33g	
Succinic acid (SU)	250ppm	5.4h	5.5D	41.67f	42.17C
	500ppm	5.7f		42.67e	
Ascopein (AS)	250ppm	5.9d	6.2A	45.33b	46.83A
	500ppm	6.5a		48.33a	
Control	Tap water	3.9 i	3.9E	30.00i	30.00E
	Tap water	3.9i		30.00i	
Mean (B)		5.3B	5.6A	39.60B	41.27A
			Second season (2019)		
Hydrogen peroxide (H_2O_2)	1%	6.5c		48.00d	
	2%	6.6a	6.6A	49.33c	48.67B
Salicylic acid (SA).	250ppm	5.9f	6.1B	45.67f	47.67C
	500ppm	6.3d		49.67b	
Succinic acid (SU)	250ppm	6.1e	6.1B	42.33h	43.50D
	500ppm	6.1e		44.67g	
Ascopein (AS)	250ppm	6.5c	6.6A	46.33e	49.50A
	500ppm	6.6b		52.67a	
Control	Tap water	4.3g	4.3C	32.67i	32.67E
	Tap water	4.3g		32.67i	
Mean (B)		5.9B	6.0A	43.00B	45.80A

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

Table 5: Effect of spraying antioxidant substances on fruit weight, fruit volume and fruit firmness of Le-Conte pear trees in seasons 2018and 2019

Treatments		Fruit weight (g)	Mean (A)	Fruit volume (ml^3)	Mean (A)	Fruit firmness ($Ib/inch^2$)	Mean (A)
Antioxidant substances (A)	Con.(B)			First season (2018)			
Hydrogen peroxide (H_2O_2)	1%	156.0h	165.9D	159.6f	168.9D	17.70b	18.72A
	2%	175.7g		178.3e		19.73a	
Salicylic acid (SA)	250ppm	192.4e	200.1B	195.5c	201.9B	15.02d	16.01B
	500ppm	207.8b		208.2b		17.00c	
Succinic acid (SU)	250ppm	186.5f	190.8C	191.9d	193.3C	13.13f	14.05D
	500ppm	195.1d		194.7c		14.97d	
Ascopein (AS)	250ppm	203.7c	207.6A	206.7b	210.4A	14.07e	15.53C
	500ppm	211.4a		214.1a		17.00c	
Control	Tap water	144.3i	144.3E	136.3g	136.3E	12.70g	12.70E
	Tap water	144.3i		136.3g		12.70g	
Mean (B)		176.6B	186.9A	178.0B	186.3A	14.52B	16.28A
				Second season (2019)			
Hydrogen peroxide (H_2O_2)	1%	196.1e	198.4C	203.4f	210.6C	19.50d	19.61B
	2%	200.7d		217.8d		19.73cd	
Salicylic acid (SA)	250ppm	193.9e	200.9B	208.2e	212.1B	18.40ef	19.53B
	500ppm	207.8c		215.9d		20.67a	
Succinic acid (SU)	250ppm	186.5f	193.3D	183.1g	208.7D	18.47e	19.20C
	500ppm	200.1d		234.3a		19.93bc	
Ascopein (AS)	250ppm	212.1b	217.9A	222.0c	226.4A	19.77cd	19.97A
	500ppm	223.7a		230.8b		20.17b	
Control	Tap water	146.3g	146.3E	136.3h	136.3E	18.13f	18.13D
	Tap water	146.3g		136.3h		18.13f	
Mean (B)		187.0B	195.7A	190.6B	207.0A	18.85B	19.73A

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

trees which treated with Ascopein and Salicylic acid at 250 & 500 ppm in the two seasons of the study (Table 5). Fruit weight ranged (207.6 & 217.9 g) and (200.1& 200.9 g) during 2018 and 2019 seasons, respectively. While, untreated trees were recorded (144.3 g and 146.3 g) in both seasons, respectively. These results are in harmony with those reported by Shaaban *et al.* [22] they indicated that spraying salicylic acid once, twice, three and four times at 50 to 400 ppm were very effective in stimulating fruit weight of "Anna" apple trees.

Fruit Volume (ml^3): It is appeared from Table (5) .that the effect of spraying antioxidants had significantly affected fruit volume of 'Le-Conte' pear fruits in both seasons under study. It was noticed that fruit volume goes in the same trend with fruit weight in both seasons. Results are in accordance with Geros *et al*. [66] who cleared that Hydrogen peroxide may enhance cellular development during initial cell division at phase I or modulate cell expansion at phase II by its cell wall loosening effect. Moreover, Khandaker *et al*. [14] show that treated wax apple fruit with 5 mM H_2O_2 showed larger fruit size, increased fruit set, fruit number, fruit biomass and yield compared to the control.

Fruit Firmness: Foliar application with antioxidants significantly increased firmness of "Le-Conte" pear (Table 5). The highest firmness was recorded in fruit harvested from trees treated with Hydrogen peroxide followed by Ascopein, Salicylic acid and Succinic acid in both seasons respectively. Meanwhile, higher concentrations recorded higher values compared with lower concentrations during 2018 and 2019 seasons respectively. Results show that spraying with Hydrogen Peroxide (H_2O_2) at 1 & 2% and Salicylic acid at 250 & 500 ppm followed by Ascopein and Succinic acid at 250 & 500 ppm recorded the highest fruit firmness, whereas, the lowest values were obtained from control trees in both seasons. Moreover, in the second one Ascopein at 250 & 500 ppm gave the highest value followed by the other antioxidants. These results are agreed with others who said that Salicylic acid delays the increase in soluble pectin and maintained insoluble pectin and delays the modification of cell wall components of "Anna" apple fruits [22, 67, 18].

Fruit Diameter and Length: Data presented in Table (6) indicate that fruit diameter and length were significantly responded to the different studied treatments in the both

Table 6: Effect of spraying antioxidant substances on fruit length, diameter and fruit shape index of Le-Conte pear trees in seasons 2018 and 2019

Treatments		Fruit length (cm)	Mean (A)	Fruit diameter (cm)	Mean (A)	Fruit shape index (L/D)	Mean (A)
Antioxidant substances (A)	Con.(B)			First season (2018)			
Hydrogen peroxide(H_2O_2)	1%	8.00cd	8.22A	6.27c	6.40B	1.276a-c	1.283A
	2%	8.43a		6.53b		1.291a	
Salicylic acid (SA).	250ppm	7.80e	8.04B	6.13d	6.35B	1.272bc	1.266B
	500ppm	8.27ab		6.57b		1.259cd	
Succinic acid (SU)	250ppm	8.07cd	8.10AB	6.47b	6.59A	1.247de	1.230C
	500ppm	8.13bc		6.70a		1.213f	
Ascopein (AS)	250ppm	7.93de	8.18A	6.47b	6.52A	1.226e	1.254B
	500ppm	8.43a		6.57b		1.283ab	
Control	Tap water	7.23f	7.23C	5.83e	5.83C	1.240e	1.240C
	Tap water	7.23f		5.83e		1.240e	
Mean (B)		7.81B	8.10A	6.23B	6.44A	1.252A	1.257A
				Second season (2019)			
Hydrogen peroxide(H_2O_2)	1%	8.27e	8.44B	6.73d	6.83B	1.229a	1.235AB
	2%	8.60bc		6.93bc		1.241a	
Salicylic acid (SA).	250ppm	7.90f	8.09C	6.30e	6.67C	1.254a	1.215B
	500ppm	8.27e		7.03ab		1.176b	
Succinic acid (SU)	250ppm	8.37de	8.44B	6.80d	6.82B	1.231a	1.238A
	500ppm	8.50cd		6.83cd		1.245a	
Ascopein (AS)	250ppm	8.73ab	8.75A	6.97b	7.04A	1.253a	1.244A
	500ppm	8.77a		7.10a		1.235a	
Control	Tap water	7.50g	7.50D	6.37e	6.37D	1.177b	1.177C
	Tap water	7.50g		6.37e		1.177b	
Mean (B)		8.15B	8.33A	6.63B	6.85A	1.229A	1.215A

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

seasons. Furthermore, longer fruits were found from trees which treated by Hydrogen peroxide and Ascopein followed by Succinic acid and Salicylic acid compared with untreated trees. While, the highest values of fruit diameter were recorded from Ascopein and Succinic acid followed by H_2O_2 and Salicylic acid in both seasons under study. In addition, the highest concentrations were more effective than the lowest ones. It is noticed that there is a positive significant increasing between treatments in both seasons under study due to the increment in fruit weight.

Shape Index: There is a significant effect on the fruit shape index of 'Le-Conte' pear in the second season. A significant effect was noticed between effect of various antioxidants and their concentrations. Also, results go in the same trend with fruit length in both seasons under study (Table 6).

This increase in fruit weight, length and diameter are ascribed to the high level of potassium in "Le-Conte" pear leaves. Potassium improves fruit quality by enhancing the formation and translocation of carbohydrates from the shoot to storage organs (fruits) and carbohydrate enzymes .The present results agree with the previous results of Fayed [43] working on "Manfalouty" pomegranate and Fayek *et al.* [5] on Le-Conte pear. Many others explained the role of antioxidants in regulation of cell division and elongation, protection against oxidative stress, act as co-factor for many enzymes and play a role in signal transduction system and thereby regulation of trees [62, 42].

Fruit Chemical Properties

Fruit Juice TSS: Data tabulated in Table (7) refer that total soluble solids (TSS) was significantly responded to the studied treatments. These results are in accordance with those found by Sahain *et al.* [68] on "Anna" apple and Ahmed and Abd El-All [69] on "Sewy" dates, they found that application of antioxidants namely ascorbic acid and citric acid each at 500 ppm and vitamin B complex at 25 ppm either alone or at possible combinations increased fruit TSS content. The increment in TSS as a result of ascorbic and citric acids sprays may be due to their influence in increasing photosynthetic pigment which reflected on photosynthesis process and led to increase in carbohydrate content of "Anna" apple fruits Fayed, [43], Fayek *et al.* [5] on Le-Conte pear and El-Abbasy *et al.* [18].

Table 7: Effect of spraying antioxidant substances on fruit chemical characteristics of Le-Conte pear trees in seasons 2018 and 2019

Treatments		TSS %	Mean (A)	Acidity %	Mean (A)	TSS/acid ratio	Mean (A)	Total sugars (%)	Mean(A)
Antioxidant substances (A)	Con.(B)				First season (2018)				
Hydrogen peroxide (H_2O_2)	1%	11.27b	11.30B	0.210b-d	0.210B	53.67c	53.81B	12.90b	12.73A
	2%	11.33b		0.210b-d		53.95c		12.57c	
Salicylic acid (SA).	250ppm	9.83e	10.08D	0.200c-e	0.210B	49.15d	48.05D	11.80f	11.90C
	500ppm	10.33d		0.220a-c		46.95e		12.00e	
Succinic acid (SU)	250ppm	10.33d	11.75A	0.230ab	0.235A	44.91f	49.89C	12.33d	12.48B
	500ppm	13.17a		0.240a		54.88c		12.63c	
Ascopein (AS)	250ppm	10.83c	10.86C	0.170f	0.175C	63.71a	62.13A	12.13e	12.62A
	500ppm	10.90c		0.180ef		60.56b		13.11a	
Control	Tap water	8.33f	8.33E	0.190d-f	0.190C	43.84f	43.84E	10.19g	10.19D
	Tap water	8.33f		0.190d-f		43.84f		10.19g	
Mean (B)		10.12B	13.11B	0.200A	0.195B	51.06B	66.46A	11.87B	12.47B
					Second season (2019)				
Hydrogen peroxide (H_2O_2)	1%	13.58c	14.04A	0.200cd	0.205BC	67.90a-c	68.47A	13.25d	14.39A
	2%	14.50a		0.210bc		69.05ab		15.52a	
Salicylic acid (SA)	250ppm	13.00e	13.16D	0.220b	0.235A	59.09e	56.21D	11.95g	12.14D
	500ppm	13.33d		0.250a		53.32f		12.32f	
Succinic acid (SU)	250ppm	12.33f	12.91E	0.180d	0.215B	68.50bc	61.25C	12.81e	13.15C
	500ppm	13.50cd		0.250a		54.00f		13.49c	
Ascopein (AS)	250ppm	13.33d	13.58B	0.190cd	0.195C	70.16a	69.65A	13.47c	13.99B
	500ppm	13.83b		0.200cd		69.15ab		14.51b	
Control	Tap water	13.33d	13.33C	0.200cd	0.200C	66.65d	66.65B	10.85h	10.85E
	Tap water	13.33d		0.200cd		66.65d		10.85h	
Mean (B)		10.81A	13.70A	0.208A	0.222A	52.04A	62.43B	12.10A	

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

Table 8: Effect of various antioxidants on the net profit (LE) of "Le-Conte" Pear trees during 2018 and 2019 seasons

Treatments		Productivity (Ton/fed.)	Agricultural practices cost (LE/fed)	Yield price (LE) /fed	Cost(%)/ fed	Net profit(LE/ fed)	Net profit%	Investment return rate(LE)
Antioxidant substances (A)	Con.				First season (2018)			
Hydrogen peroxide (H_2O_2)	1%	6.066	12100	42462	28.50	30362	71.5	0.75
	2%	6.160	12200	43120	28.29	30920	71.71	0.78
Salicylic acid (SA).	250ppm	5.274	12050	36918	32.64	24868	67.36	0.43
	500ppm	5.786	12100	40502	29.88	28402	70.12	0.63
Succinic acid (SU)	250ppm	5.834	12375	40838	30.30	28463	69.7	0.64
	500ppm	5.974	12750	41818	30.49	29068	69.51	0.67
Ascopein (AS)	250ppm	6.346	12050	44422	27.13	32372	72.87	0.86
	500ppm	6.766	12100	47362	25.55	35262	74.45	1.03
Control	Tap water	4.200	12000	29400	40.82	17400	59.18	-
					Second season (2019)			
Hydrogen peroxide (H_2O_2)	1%	6.720	12100	53760	22.55	41660	77.45	0.69
	2%	6.906	12200	55248	22.08	43048	77.92	0.75
Salicylic acid (SA).	250ppm	6.394	12050	51152	23.56	39102	76.44	0.59
	500ppm	6.954	12100	55632	21.75	43532	78.25	0.77
Succinic acid (SU)	250ppm	5.926	12375	47408	26.10	35033	73.9	0.43
	500ppm	6.254	12750	50032	25.48	37282	74.52	0.52
Ascopein (AS)	250ppm	6.486	12050	51888	23.22	39838	76.78	0.62
	500ppm	7.374	12100	58992	20.51	46892	79.49	0.91
Control	Tap water	4.574	12000	36592	32.79	24592	67.21	-

Acidity Percentage: With regard to the specific effect of various antioxidants treatments, Table (7) displays obviously that data go in the same trend with other properties was concerned. Herein, fruit juice acidity% was significantly increased by investigated antioxidants treatments. Total acidity % was increased with increase various antioxidants concentrations. In this concern, our results are confirmed by El-Abbasy *et al.,* [18] who found that the antioxidants increased acidity of Anna apple fruits.

TSS/Acid Ratio: TSS /Acid ratio significantly increased with increase various antioxidants concentrations. The highest TSS/Acid ratio was observed from foliar

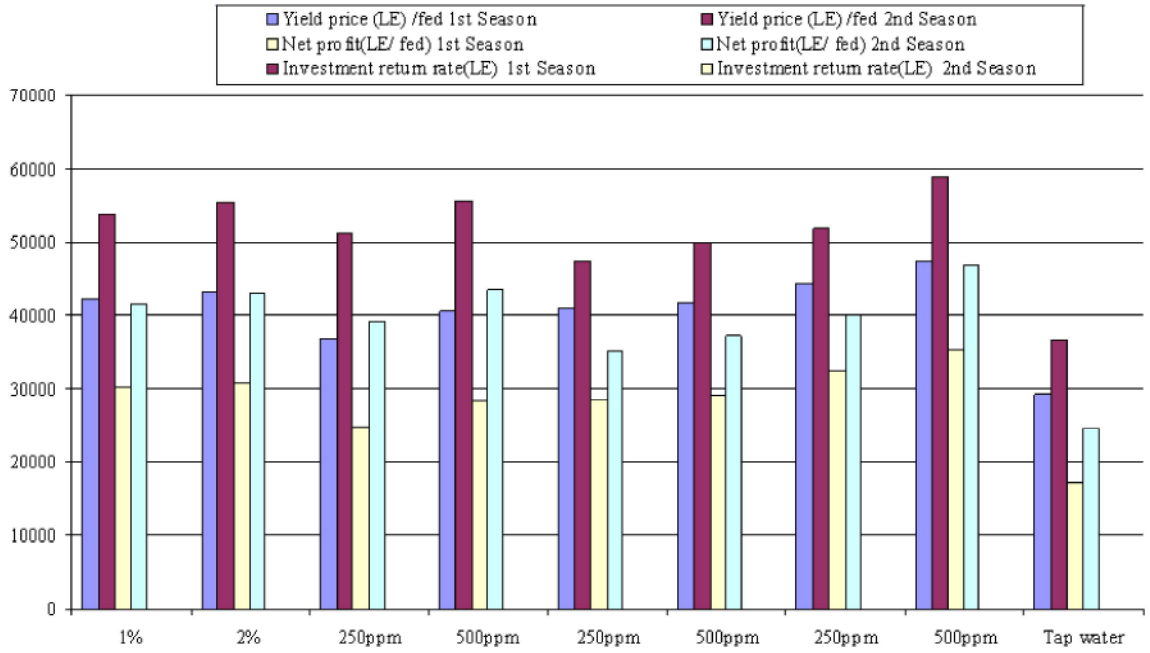

Fig. 1: Effect of various antioxidants on the yield price (LE), net profit (LE)and investment return rate (LE) of "Le-Conte" Pear trees during 2018 and 2019 seasons

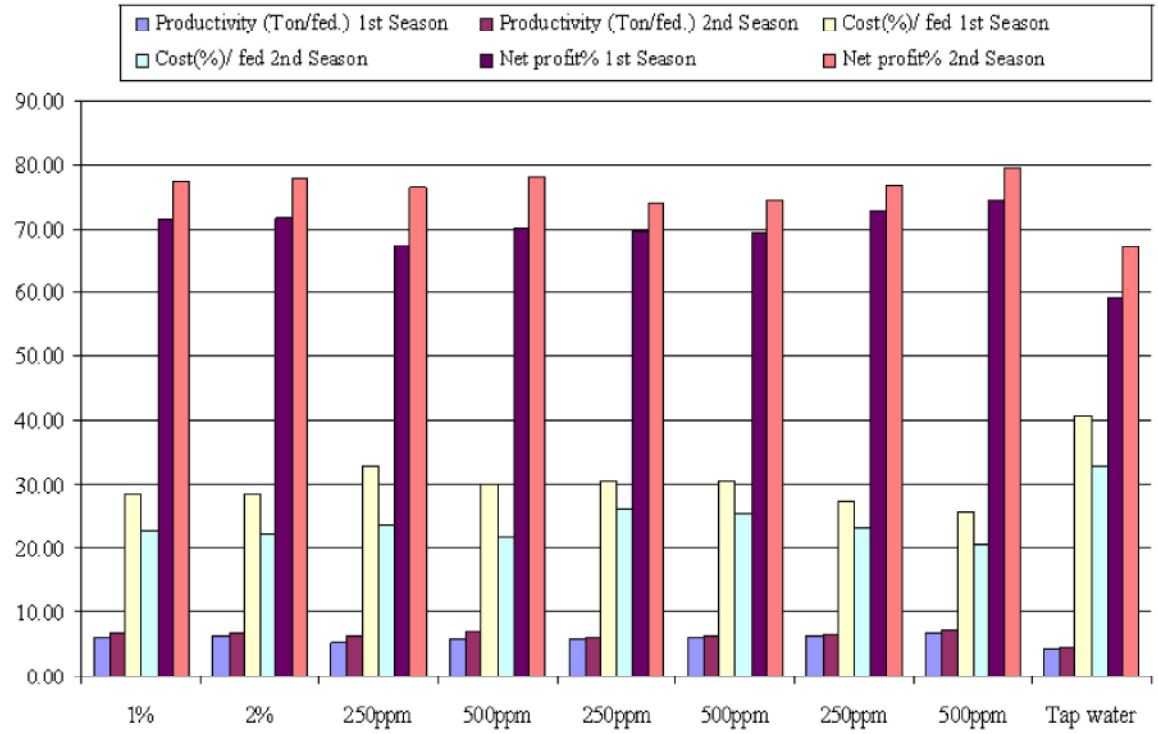

Fig. 2: Effect of various antioxidants on the Productivity (Ton/Fed.), Cost (%) and Net profit (%) of "Le-Conte" Pear trees during 2018 and 2019 seasons

application 250 & 500 ppm Ascopein followed by hydrogen peroxide, whereas lowest TSS/Acid ratio were recorded in untreated trees during 2018 and 2019 seasons (Table 7). The present results are agreed with the previous results of Abdou [37] on “Le-Conte” pear and Shaaban *et al.* [22] on "Anna" apple. The enhancement

effect of antioxidant may be due to their essential roles in signal transduction system, membrane stability and functions, activating transporter enzymes, metabolism and translocation of carbohydrates in "Anna" apple fruits [18].

Total Sugars: It is clear from the obtained data in Table (7) that varying antioxidants and concentrations were significantly enhanced total sugars content compared with untreated ones in both seasons under study. Moreover, foliar application of hydrogen peroxide at 1 & 2% gave the highest total sugars% followed by Ascopein at 250 & 500ppm, whereas the lowest total sugars% were recorded in untreated trees during 2018 and 2019 seasons.

In this concern, Fawzi *et al*. [70] mentioned that fertilization by bio-organic substances improved "Le-Conte" pear fruit sugar content. Mansour *et al.* [71] found that the combined application between some nutrients and citric acid was very effective in stimulating TSS and total sugar content of le-Conte pear fruit.

Crop Monetary Value (LE/Fed.): Data in Table (8) show the effect of some various antioxidants on the net profit (LE / fed) for treatments during the two seasons of study (2018 & 2019).It noticed that all treatments gave better net profit compare with untreated ones. Moreover, the highest net profit % and the lowest cost % were obtained from Ascopein in the two concentrations followed with Hydrogen peroxide, Salicylic acid and Succinic acid in a comparison with the untreated one in the two seasons under study. Also, it noticed that Ascopein treatments gave the highest investment rate per control costs (LE).

CONCLUSION

The target of this study was examining the effect of the various antioxidants such as Hydrogen peroxide (H_2O_2), Salicylic acid (SA), Succinic acid (Su) and Ascopein (As) on counteracting the adverse effects on yield and fruit quality of Le-Conte pear trees grown on clay soil. It is cleared that application of antioxidants gave a promising influence on the productivity of Le-Conte pear trees. Herein, according to these results it can be concluded that usage of various antioxidants are preferred to improve the yield and fruit quality of "Le-Conte" pear trees , especially , it is cleared from the accumulated effect of the treatments in the 2nd season. Moreover, it is noticed that Ascopein treatment at 500ppm recorded significantly the highest leaf area, chlorophyll, N, P, K, carbohydrates content, C/N ratio, fruit set and yield as well as improved significantly fruit quality and monetary value as compared to all other treatments, while the lowest values obtained with unsprayed trees (control) during the period of study.

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