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# Alleviating Air Pollutants Impact by Some Chemicals and Planting Distance off the Freeway and Their Effect on Pears Productivity and Fruit Quality

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Abstract

The goal of this study was to determine the effectiveness of exogenous application of some chemicals [Salicylic acid (SA; 200 and 400 mg/l), Ascorbic acid (AA; 1000 and 2000 mg/l), Proline (Pro; 100 and 200 mg/l), and Sodium hydrosulfide (NaHS; 250 and 500 M)] as well as planting distances (10 and 50 meters off the freeway) in alleviating air pollutants stress on "Le Conte" productivity and fruit quality of pears. During the 2019 & 2020 seasons, a study was accomplished at the 6th of October Agriculture Company. SA, AA, proline, and NaHS had a positive effect on reducing the fruit heavy metal content for the pear trees under stress. Also, SA (400 mg/l), AA, Pro (100 mg/l), and NaHS (500 µM) treatments were very helpful in increasing the tolerance index for air pollution (APTI) in pear leaves. Exogenous application of Pro, SA (200 mg/l), and AA (2000 mg/l) increased Pro in leaves. Pear trees' yield, fruit firmness, TSS, TSS/acid, V.C., total sugars, total phenolics, antioxidants, peroxidase, and superoxide dismutase were increased. Fruit from trees planted at 10 m deferred in ripening and had higher total phenolics, antioxidants, peroxidase, and superoxide dismutase.

Keywords: Pears, Salicylic acid, Ascorbic acid, Proline, Sodium hydrosulfide, Air pollutants

## Introduction

In terms of production, pears are the world's third most important deciduous fruit tree after apples and grapes. Le Conte (*Pyrus communis x Pyrus pyrifolia*) pear cultivar is widely grown in newly reclaimed lands in Egypt. Fruitful area of pear crop reached 11772 feddan in 2019/2020 compared to 11687 feddan in 2018/2019, an increase of 0.7% and the production reached 79206 tons in 2019/2020 compared to 68407 tons in 2018/2019, an increase of 15.8%. Nubaria City occupied the first rank, where production reached 33696 tons at a rate of 28.6% **(CAPMS, 2022)**. Fruit trees can be injured when exposed to concentrations of various air pollutants. Injuries to the tree can result in visible markings on the foliage, reduced growth and yield, or the tree dying prematurely. The development and severity of the injury are determined by a number of factors other than the pollutant concentration. These factors include the exposure period and stage of tree development, as well as the environmental factors that promote pollutant buildup. Variable impacts on vegetation can only be seen after a brief period of exposure to high levels of air pollution. Additionally, they have chronic effects after prolonged exposure at low concentrations (**Saborit, 2009**).

Heavy metals are used in a variety of industries and, as a result, are released into the environment. There are about twenty metals that are known to be toxic, and half of them, such as cadmium (Cd), silver (Ag), lead (Pb), copper (Cu), mercury (Hg), nickel (Ni), and zinc (Zn), are discharged into the environment in proportions that are harmful to human health. Cadmium toxicity can disrupt plant metabolism, causing disturbances with mineral nutrient uptake and translocation **(Nazar *et al.*, 2012).** The increase in Pb in the environment has an effect on plant growth and metabolism **(Sharma and Dubey, 2005).** Lead stress has various effects on plant physiological stages. This stress increases the production of reactive oxygen species (ROS), alters plant growth, nitrogen metabolism, and phytohormone biosynthesis, and reduces photosynthesis efficiency **(Souza *et al.*, 2014, and Bharwana *et al.*, 2014).**

In plants, salicylic acid (SA) is a phenolic phytohormone that is involved in photosynthesis, transpiration, nutrient absorption, and growth and development. Additionally, it alters the chloroplast's structure as well as the leaf's anatomy. It promotes growth and enhances defense against biotic and abiotic stress. Salicylic acid has been shown to cause hormonal changes associated with the transient accumulation of Indole acetic acid (IAA) and Abscisic acid (ABA), both of which have no negative effects and improve the expression of dehydrin genes and proline accumulation **(Hayat and Ahmad, 2007).** Ascorbic acid (AA) influences differentiation and cell division. It takes part in a variety of critical processes, including photodefense, photosynthetic control, and antioxidant activity **(El-Badawy *et al.*, 2017b).** Proline is an important determinant of many cell-wall proteins. It is progressively becoming evident that proline modulates a wide array of activities like cell wall elongation and modifications, xylogenesis, stem elongation, and root and shoot growth **(Kavi Kishor *et al.*, 2015).** Plants accumulate proline when subjected to harsh environmental conditions on a regular basis. Interestingly, proline metabolism may also contribute to the formation of reactive oxygen species in mitochondria, which play a notably important role in hypersensitive responses in plants **(Rejeb *et al.*, 2014).** Many plants accumulate free proline in response to a variety of biotic and abiotic stresses, such as heavy metals. Proline has been shown to play an important role in correcting the adverse effects of environmental stress in plants, including heavy metal stress **(Siripornadulsil *et al.*, 2002).** By acting as an H2S donor (NaHS), toxic metal stress can be reduced. This increases the fixation of toxic metal ions, which is strongly related to cell wall function, transporter regulation, plant chelator cooperation, and other signals. Similar to this, higher plants' H2S donors (NaHS) may operate as a defense mechanism against environmental stress. Additionally, exogenous administrations of H2S to plants appear to offer additional protection against stresses such as heavy metals, drought, salinity, and severe temperatures, primarily through the stimulation of antioxidant mechanisms to mitigate oxidative cellular damage **(Corpas and Palma, 2020)**. Additionally, sodium hydrosulfide functions as a signaling molecule to prevent oxidative stress by scavenging reactive oxygen species (ROS) as a result of an increase in the activity of antioxidative enzymes **(Li, 2013; Shi *et al.*, 2014)**. In addition, SA, AA, proline, and H2S increased relative water content, chlorophyll concentration, proline content, and activity of antioxidant enzymes when applied to different crops (pear, barley, corn, basil, olive, and strawberry plants) (**Abdelaal *et al.*, 2020; Tatari *et al.*, 2020; Darvishan *et al.*, 2013; Khalil *et al.*, 2010; Ahmed *et al.*, 2011; Christou *et al.*, 2013)**. Further, increasing leaf total proline content was achieved on squash plants, olive trees, and sweet pepper when treated with salicylic acid, AA, proline, and $H_2S$ (**Abd El-Mageed *et al.*, 2016; El-Sayed *et al.*, 2014; Ahmed *et al.*, 2011; Kaya *et al.*, 2018)**.

The major goal of this research was to ascertain the effectiveness of exogenous applications of salicylic acid, ascorbic acid, proline, sodium hydrosulfide, and plant distance from the freeways in reducing the stress of air pollution on the production and fruit quality of "Le Conte" pear trees.

## Materials and Methods

The present study was conducted throughout two successive growing seasons (2019 and 2020) on 12-year-old "Le Conte" pear trees *(Pyrus communis x Pyrus pyrifolia*) budded on *Pyrus betulaefolia* rootstock. The trees were planted at 3*4 meters apart and grown in sandy soil at the $6^{th}$ October Company Orchard, Ismailia Governorate, Egypt. Fifty-four trees that were identical in growth, vigour, and physical condition (9 treatments× 3 replicates× 2 distances) were chosen to be distributed at various distances from the freeway as follows:

1- Twenty-seven trees were chosen at a distance of ten meters from the freeway.

2- The other twenty-seven trees were located fifty meters from the freeway.

The experiment had nine treatments as follows: Salicylic acid (SA; 200& 400 mg/l), ascorbic acid (AA; 1000& 2000 mg/l), proline (Pro; 100& 200 mg/l), sodium hydrosulfide (NaHS; 250& 500 µM) and control (only water). The trees were selected and labeled for the treatment application at three times: at bud dormancy stage (on $30^{th}$ January), at full bloom (FB), and thirty days after full bloom (DAFB). A single spray of a 5-liter solution was applied per tree in the early morning using a handgun sprayer **(Ali and El-Zayat, 2019).**

The following parameters were studied in two seasons:

**1- Vegetative Growth**

On the 15th of May in the 2019 and 2020 seasons, at four directions of each tree, twelve new growing shoots per tree were randomly chosen and labeled for estimating average shoot length (cm) and shoot diameter (cm) in mid-October. Leaf area on average ($cm^2$) on a weight basis was determined by collecting 20 fully grown leaves from each treated tree, according to the mathematical relation between the known area ($1cm^2$) and the weight by balance of the discs and leaves as subsequent formula:

$$\textbf{Leaf area cm2} = \frac{(\textbf{LDW})}{(\textbf{DDW})}\ x\ DA$$

**Where**, LDW= total leaf dry weight (g); DDW= disks dry weight; DA= disks area.

**Determination of heavy metals in leaves and fruit**

For leaf analysis, 20 mature leaves from each tree's spring flush branches were collected in the middle of July of each season. Leaves were carefully cleaned, rinsed with distilled water, and dried at 70˚C until they reached constant weight. After that, 0.5 g of each sample was treated with 10 ml of concentrated nitric acid ($HNO_3$). The mixture was gently simmered for 45 minutes to oxidise all readily oxidizable components. Following cooling, 5 ml of 70% perchloric acid ($HClO_4$) was added, and it was gently heated until a dense white fume appeared. Twenty millilitres of deionized water were added once the mixture had cooled, and the liquid was then further heated to expel any odours. After being cooled, the sample was filtered through #11 Whatman filter paper, then transferred to a 25 ml capacity flask, and diluted to volume (**AOAC 1990**). The atomic absorption (thermo-electron, S Series, GE 711838) was used to determine lead (Pb) and cadmium (Cd) elements spectrophotometrically at wavelengths 217 nm and 228.8 nm, respectively. Results were given as µg g-1 of dry leaf weight. The same procedures were applied for the determination of heavy metals in fruits using 0.5g dried fruit flesh (**Shallari et al., 1998**).

**2- Air pollution tolerance index (APTI):**

From the treated trees, mature leaves were gathered, cleaned, and washed with distilled water. The biochemical characteristics of an extract of leaves as mentioned above (pH, relative water content, total chlorophyll, and ascorbic acid) were measured. The air pollution tolerance index was estimated using the method described by **Singh and Rao (1983)**, and the following equation was used:

APTI = [AA (TChl + P) + RWC]/10

**Where:** AA = ascorbic acid content (mg/g) **(Pearson, 1976);** TChl = total chlorophyll (mg/g) (**Kamble *et al.*, 2015)**; P = pH of leaf extract (**Cornelissen *et al.*, 2011**); RWC = relative water content of leaf (%) (**Yamasaki and Dillenburg, 1999).**

**3- Determination of proline content:**

Proline was estimated according to **Bates *et al.* (1973)**. A sample of 0.1 g of dry mature leaf (dried at 70˚C, until constant weight) was digested with 10 ml of 3% aqueous sulfosalicylic acid. Through Whatman filter paper, the homogenate was filtered. For estimation, 2 ml of the filtrate was added to 2 mL of glacial acetic acid and 2 mL of acid ninhydrin (1.25 g of ninhydrin was warmed in 30 ml of glacial acetic acid and 20 ml of 6 M phosphoric acid with agitation till dissolved). For one hour, the mixture was boiled in a bath of boiling water. The tubes were submerged in an ice bath to stop the reaction. The reaction mixture received 4 ml of toluene, which was thoroughly mixed for 20–30 sec. The toluene layer was warmed to room temperature after being divided. At 520 nm, the red color's intensity was evaluated in comparison to a toluene blank. The proline content was calculated as follow:

**Proline (mg/100g) = ((absorbance sample solution (mg/l) x volume extraction solution (ml)x dilution)/ (10x sample wt. (g)x estimated sample solution volume (ml))**

**4- Fruit set and fruit retention**

The first fruit set and fruit retention percentages for each treatment were calculated on roughly 180±3 spurs from each tree. The spurs were tagged at random during full bloom stage **(Ali *et al*., 2005).** Number of flowers on such spurs was recorded at full bloom. The number of fruitlets and sequent fruit on their spurs were counted at 15-day intervals up to 110 days from full bloom. The following equation was used.

Initial fruit set or fruit retention (%) = No. of fruitlets or No. of fruits x 100 / No. of flowers at full bloom or No. of fruitlets (**Westwood, 1978**).

**5- Fruit production**

At the time of harvest, when fruit firmness and TSS reached 43.79 N and 12.25% respectively, the average fruit weight (g) and fruit number per tree were both estimated. The yield was then computed and expressed as kg per tree.

**6- Fruit quality**

Ten sound fruit samples were randomly selected by hand from each tree. Fruits were packed in polyethylene bags and transported at ambient temperature within one hour to the lab, Horticulture Dept., Fac. of Agriculture, SCU, Ismailia. A total of 30 fruits were used for each treatment. The selected fruits were washed and sterilized with 0.2% of Sodium hypochlorite (NaOCl) for one minute, were air-dried (held for one hour at room temperature). After that, fruits were used to estimate physico-chemical properties at harvest: firmness (Newton), total soluble solids (TSS%), titratable acidity (TA%), and ascorbic acid (V.C as mg/100 g). Each replicate's 20 g of fruit pulp was homogenized in 50 ml of 80% ethanol for two minutes. The resultant slurry was heated for 15 minutes, cooled, and filtered through Whatman No. 4 paper before being diluted with 80% ethanol to a final volume of 100 ml. Total sugars were determined according to **Stewart (1974**), while total phenolics were determined by the Folin-Ciocalteu method (**William *et al*., 1965**).

**7-1- Determination of antioxidant enzyme activity**

Enzymes extract was prepared according to **Urbanek *et al.* (1991).**

**7-1-1-Total protein**

According to **Bradford (1976)**, the amount of soluble protein was measured in fruit samples. Two ml of Bradford solution were added to 0.2 ml of fruit extract. Bradford reagent (100 mg of Coomassie brilliant blue G-250 was dissolved in 50 ml of 95% ethanol and 100 ml of 85% phosphoric acid (w/v), and the solution was completed to one liter with distilled water). A wavelength of 595 nm was used to measure the color blue. Using the Bovine Serum Albumin Standard Curve and a correction factor of 0.00233, the concentration of solubilized protein was determined in various samples as mg g-1 FW of the extracted fruit. Fruit extract was prepared by homogenizing 0.2 g of fruit in a pre-chilled mortar with 1 ml of 0.1 M phosphate buffer (pH 7). The resulting suspension centrifuged at 18,000× g for 15 min at 4ºC after being filtered through one layer of muslin cloth (**Urbanek *et al*., 1991).** The concentration of soluble proteins and the activity of the enzymes were measured in the supernatant.

**7-1-2- Peroxidase (POD, E.C.: 1.11.1.7) activity**

It was estimated with 0.1% O-dianisidine and 0.2 M hydrogen peroxide at 430 nm **(Urbanek *et al*., 1991).** One unit of peroxidase activity was defined as a change in optical density of 1.0 unit per $mg^{-1}$ protein min. The reaction mixture consisted of 2.5

ml of 0.1 M phosphate buffer (pH 6.5), 0.2 ml of 0.1% O-dianisidine solution, 0.2 ml of enzyme extract, and 0.2 ml of 0.2 M hydrogen peroxide solution.

### 7-1-3- Superoxide dismutase (SOD, E.C.: 1.15.1.1) activity

It was evaluated using **Beauchamp and Fridovich's method (1971)**, which involves assessing the substance's capacity to prevent the reduction of nitro blue tetrazolium (NBT) at 560 nm. The amount of enzyme required for 50% inhibition of NBT reduction is equal to one unit of enzyme activity. Each set of the reaction mixture's various enzyme extracts received a total of 3.0 ml of buffer, which was made up of 13 mM methionine, 80 µM NBT, and 0.1 mM EDTA for each set. Then, each set received 0.25 ml of 50 µM riboflavin. The tubes were shaken and positioned 30 cm from the light source. After allowing the reaction to continue for 20 minutes, the light was turned off to end the process.

### 7-2- Determination of total antioxidants activity

The antioxidant activity of the sample extract was determined by the DPPH (2,2-diphenyl-1-picryhydrazyl radical) method described by **Lee *et al.* (2003).**

Methanol extracts (0.1 ml) from the sample were mixed for 30 sec with 3.9 ml of freshly prepared DPPH solution (6x $10^{-5}$ M) and left to react for 30 min; the absorbance of the mixture was measured at 515 nm, and the DPPH solution without extract was used as a blank. Following is a calculation of antioxidant activity:

DPPH radical–scavenging activity (%) = $[(A_{blank} - A_{sample})/ A_{blank}] \times 100$

**Where:** $A_{blank}$ and $A_{sample}$ are the absorbance values of the control and test samples, respectively. Changes in samples absorbance were measured at 515 nm.

Statistical Analysis:

The analysis of variance (ANOVA) was performed using the computer program CoStat version 6.303 (1998-2004 CoHort software, 798 Lighthouse Ave PMP 320, Monterey, CA, 93940, USA) as a factorial experiment with a randomized complete block design. According to **Steel and Torrie (1980)**, mean comparisons were determined using Duncan's test at p 0.05.

## Results and discussion

### 1-Effect of treatments and planting distances on vegetative growth

The interaction effect of treatments and planting distances was significant (Table 1). All the parameters measured (concerning the vegetative growth) were significantly better for the trees planted at 50 m off the freeway in comparison with those planted at 10 m off the main road in both seasons. The number of leaves, number of shoots, and diameter of shoot did not significantly change in the second season. As for the improvement in vegetative growth, it was noticed that the improvements occurred at the low concentrations of the compounds (Pro, AA, SA, and NaHS), so there is no need to use the high concentrations (money can be saved). Trees planted at 10 m off the freeway were under stress from the pollutants coming from the freeway (heavy metals and gases), which affected the trees' growth. All treatments improved the vegetative growth, but the best effect was more pronounced at the 50-m planting distances. AA, Pro, and NaHS treatments had better effects over the other treatments at both distances. In accordance with the data reported here, **Abdel Aziz *et al.* (2017)** found that treatments with salicylic acid (SA) at 50-200 mg/l on "Manfalouty" pomegranate trees significantly enhanced the number of new shoots per tree, shoot length, number of leaves per shoot, and total leaf area per tree in comparison with the control. Similarly, **El-kenawy (2017)** reported that single applications of SA were effective in improving shoot length, leaf area, and total chlorophyll of "Thompson seedless" grapevines.

In the same direction, on olives, **Hassan *et al.* (2019)** investigated the influence of foliar application of SA (200 and 300 mg/l) and ascorbic acid (2000 and 3000 mg/l). They indicated that shoot length, number of leaves per shoot, and leaf area were significantly increased. On "Washington navel" oranges (**El Khayat, 2018)**, on Valencia oranges (**Aly *et al.*, 2015),** and on "Fagri kalan" mangoes (**El-Hosieny, 2015),** leaf area, shoot number, and thickness were increased by spraying SA and AA. As for the proline effect, **Abdallah *et al.* (2017)** showed that foliar sprays of proline at 50 and 100 mM increased leaf area and numbers in "Washington" navel orange. **El Sayed *et al.* (2014)** on "Manfalouty" pomegranate and **Aly *et al.* (2015)** on Valencia orange found that proline increased leaf area, shoot number, and shoot thickness. On the other hand, as for the NaHS outcome, **Kondo (2021)** indicated that foliar spraying of NaHS at 500 µM had significantly increased vine height and leaf number of passion fruit under chilling stress as compared with that of the control.

**Table 1: Effect of salicylic acid (SA), ascorbic acid (AA), proline (Pro), and sodium hydrosulfide (NaHS) and planting distances off the freeway on shoot length, leaf area, Leaf area/shoot, and shoot diameter of "Le Conte" pear trees in 2019 and 2020 seasons**

| **Studied factor** | | **Shoot length (cm)** | | **Leaf area (cm$^2$)** | | **Leaf area/shoot (m$^2$)** | | **Shoot diameter (mm)** | |
|---|---|---|---|---|---|---|---|---|---|
| | | **2019** | **2020** | **2019** | **2020** | **2019** | **2020** | **2019** | **2020** |
| **Distance off the freeway (meter)** | | | | | | | | | |
| 10 m | | 91.1 B | 100.8 B | 23.42 B | 25.67 B | 8.45 B | 10.98 B | 9.61 B | 10.34 A |
| 50 m | | 97.7 A | 104.7 A | 27.17 A | 29.32 A | 10.85A | 12.50 A | 9.96 A | 10.25 A |
| **Chemicals application** | | | | | | | | | |
| SA 200 mg/l | | 98.3 bc | 107.50 b | 26.46 bc | 28.30 c | 10.14 ab | 12.00 bc | 10.10 bc | 10.91 ab |
| SA 400 mg/l | | 95.0 cd | 100.83cd | 25.08 bc | 27.32 c | 9.30 b | 11.28 c | 11.05 a | 11.59 a |
| AA 1000 mg/l | | 105.0 ab | 115.00 a | 25.24 bc | 28.35 c | 10.08 ab | 13.42 ab | 9.26 d | 10.04 b |
| AA 2000 mg/l | | 87.3 d | 96.50 de | 30.95 a | 34.09 a | 10.84 a | 13.27 ab | 10.08 bc | 10.17 b |
| Pro 100 mg/l | | 110.8 a | 118.50 a | 24.44 c | 27.72 c | 10.69 a | 13.63 a | 10.26 bc | 10.78 ab |
| Pro 200 mg/l | | 101.7 bc | 106.67bc | 24.30 c | 24.73 d | 9.59 ab | 11.13 c | 10.57 ab | 10.75 ab |
| NaHS 250 µM | | 98.0 bc | 106.50bc | 27.29 b | 31.25b | 10.78 a | 13.60 a | 9.28 d | 9.85 b |
| NaHS 500 µM | | 86.8 d | 94.33 e | 25.60 bc | 26.70 cd | 9.71 ab | 10.58 c | 9.74 cd | 10.02 b |
| Control | | 66.7e | 79.00 f | 18.35 d | 18.99 e | 5.73 c | 6.75 d | 7.75 e | 8.52 c |
| CEOT$^{Z}$ | | **94.40 B** | **102.76 A** | **25.30 A** | **27.49 A** | **9.65 A** | **11.74 A** | **9.79 A** | **10.29 A** |
| **Interaction** | | | | | | | | | |
| 10 m | SA 200 mg/l | 91.7 def | 103.7d-g | 24.62def | 26.37 ef | 9.02 def | 11.57d-g | 10.11abc | 10.53abc |
| | SA 400 mg/l | 90.0 def | 100.0fgh | 23.70 ef | 26.46 ef | 7.83 f | 10.77efg | 10.91 a | 11.58 a |
| | AA 1000 mg/l | 110.0 ab | 120.0 b | 24.64def | 29.81cde | 8.71 ef | 14.43 bc | 9.37 bc | 10.30a-d |
| | AA 2000 mg/l | 87.7 ef | 98.3 fgh | 28.81 bc | 32.17 bc | 9.99 cde | 12.73cde | 9.73 bc | 10.06a-d |
| | Pro | 101.7bcd | 107.0 c-f | 21.30 fg | 21.39 h | 8.74 ef | 9.97 g | 10.33 ab | 11.55 a |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 100 mg/l | | | | | | | | |
| | Pro 200 mg/l | 95.0 c-f | 100.3fgh | 21.18 fg | 23.01 gh | 7.64 f | 10.53efg | 10.07 ab | 11.07abc |
| | NaHS 250 µM | 98.3 b-e | 110.0cde | 24.45def | 28.22def | 9.29 def | 12.27c-g | 9.04 c | 9.56 cde |
| | NaHS 500 µM | 83.7 f | 95.0 gh | 24.17def | 25.51 fg | 9.43 def | 10.23 fg | 9.44 bc | 10.14a-d |
| | Control | 61.7 g | 73.3 j | 17.93 h | 18.07 i | 5.44 g | 6.33 h | 7.50 d | 8.24 e |
| 50 m | SA 200 mg/l | 105.0 bc | 111.3bcd | 28.29 bc | 30.22 cd | 11.26abc | 12.43c-f | 10.12abc | 11.29 ab |
| | SA 400 mg/l | 100.3b-e | 101.7e-h | 26.45cde | 28.18def | 10.77bcd | 11.80d-g | 11.18 a | 11.60 a |
| | AA 1000 mg/l | 100.4b-e | 110.0cde | 25.84cde | 26.88def | 11.46abc | 12.40c-f | 9.15 c | 9.77 bcd |
| | AA 2000 mg/l | 87.0 ef | 94.7 gh | 33.09 a | 36.00 a | 11.69abc | 13.80bcd | 10.42 ab | 10.28a-d |
| | Pro 100 mg/l | 120.0 a | 130.0 a | 27.57bcd | 34.04 ab | 12.64 a | 17.30 a | 10.18abc | 10.01a-d |
| | Pro 200 mg/l | 108.3 ab | 113.3 bc | 27.41bcd | 26.46 ef | 11.55abc | 11.73d-g | 11.07 a | 10.42a-d |
| | NaHS 250 µM | 97.7 b-e | 103.0d-g | 30.12 ab | 34.28 ab | 12.28 ab | 14.93 b | 9.52 bc | 10.14a-d |
| | NaHS 500 µM | 90.4 def | 93.7 h | 27.02b-e | 27.89def | 9.98 cde | 10.93efg | 10.04abc | 9.90 bcd |
| | Control | 71.7 g | 84.7 i | 18.77 gh | 19.91 hi | 6.01 g | 7.17 h | 7.99 d | 8.80 de |

Means values followed by the same letter within a column are not significantly different at the $P < 0.05$ level. CEOT[z]= composite effect of treatments.

**2- Effect of treatments and planting distances on concentrations of Pb and Cd in leaves and fruits and proline in leaves:**

The interaction effect of treatments and planting distances on Pb and Cd concentrations in leaves and fruits was significant in both seasons (Table 2). The untreated trees (control) planted at 10 m and 50 m off the freeway had significantly higher Pb and Cd concentrations in leaves and fruits in both seasons as compared with the other treatments. On the other hand, trees planted at 10 m had significantly higher Pb and Cd in their leaves and fruits than those planted at 50 m off the main road. All treatments decreased Pb and Cd concentrations in leaves and fruits in comparison with those of the control in both seasons.

Proline (200 mg/l) was effective in reducing leaf and fruit Pb and Cd in both seasons at 10 m and 50 m off the freeway. Besides, proline (100 mg/l) was more effective in reducing both metals in the fruit in both seasons and at both planting distances. Additionally, NaHS was more effective in reducing Cd in the fruits and leaves in both seasons and at both planting distances. Furthermore, in both seasons and at both planting distances, NaHS reduced Pb concentration in the fruit. All treatments reduced Pb and Cd in the fruits better at 50 m planting distance than at 10 m distance.

It can be concluded that SA, AA, proline, and NaHS had a positive effect on reducing heavy metals under stress conditions, and this positive effect of these substances was more prominent in the fruits. In an explanation of how the plant cells can, as affected by the prementioned treatments, mitigate for the harmful effect of heavy metals, according to **Popova *et al.* (2012),** SA reduces cadmium (Cd) toxicity by promoting a broad anti-stress response in plants, which likely involves controlling the antioxidant system and lipid metabolism to maintain membrane integrity.

Overproduction of reactive oxygen species (ROS) in plants under stress, such as heavy metal stress, is a common occurrence. Usually, plants produce ROS-neutralizing chemicals as a response to this problem (non-enzymatic and enzymatic antioxidants). In this respect, AA is an all-purpose non-enzymatic antioxidant with substantial potential for both scavenging ROS and regulating a number of essential activities in plants under both stress and non-stress situations (**Akram *et al.*, 2017**). It has been demonstrated that proline is crucial for reducing environmental stress in plants, particularly heavy metal stress (**Szabados and Savoure, 2010; Siripornadulsil *et al.*, 2002**).

Regarding the H2S donor (NaHS) function, H2S works through a mechanism that reduces toxic metal stress and promotes the fixation of toxic metal ions. This mechanism is strongly related to cell wall function, transporter control, plant chelator cooperation, and other signals. To reduce Cd toxicity, plant cell walls can bind and fix Cd ions from the extracellular environment. Brassica roots' pectin content and pectin methylesterase activity can both be greatly increased by exogenous H2S, which also increases the retention of Cd in pectin fractions (**Liu *et al.*, 2021**). Similar to this, using $H_2S$ donors (NaHS) has proved useful in reducing the effects of heavy metals on plants by enhancing their biochemical and physiological processes. A dedicated approach to treating $H_2S$ results in improvements in plant growth, photosynthetic pigments, biomass, nutritional uptake, gas exchange parameters, and antioxidant enzymes (**Arif *et al.*, 2020**). Higher plants' $H_2S$ production may function as a defense mechanism against environmental stressors. Additionally, exogenous H2S applications to plants appear to boost their resistance to environmental challenges such as heavy metals, drought, salinity, and severe temperatures, mostly through inducing antioxidant mechanisms to mitigate oxidative cellular damage (**Corpas and Palma, 2020**).

In order to combat the oxidative stress caused by heavy metals (HM), plants have developed a variety of adaptation methods. These processes include the buildup of enzymatic and non-enzymatic antioxidants, as well as osmolytes like proline, which control normal growth and increase plant survival in urban and sub-urban environments with high metal contamination. (**Paul *et al.*, 2018**). The interaction effect of treatments and planting distances on leaf proline concentrations was significant in both seasons (Table 2).

Proline treatment increased proline concentrations in pear leaves at both distances over the other treatments in both seasons. Proline concentrations in leaves were significantly higher for trees planted 10 m off the freeway in comparison with those planted 50 m off the freeway in both seasons.

In line with the information provided here, **El-Sayed *et al.* (2014)** found that applying AA at 2000 and 3000 mg/l to “Manzanillo” olive trees produced a statistically significant positive effect on leaf total proline content as compared with that of the control. The negative effects of salt stress caused by proline buildup were effectively mitigated by ascorbic acid treatment in both durum wheat and barley plants **(Azzedine *et al.*, 2011).** Also, **Ahmed *et al.* (2011)** found that proline at 25 and 50 mM enhanced proline contents in aged and young leaves from "Chemlali" olive plants. As for the application of NaHS, **Kaya *et al.* (2018)** found that NaHS at 200 µM increased proline content in sweet pepper.

**Table 2: Effect of salicylic acid (SA), ascorbic acid (AA), proline (Pro), and sodium hydrosulfide (NaHS) and planting distances off the freeway on minimizing concentrations of Pb and Cd in leaves and fruits and Proline conc. In leaves of "Le Conte" pear in 2019 and 2020 seasons.**

| Studied factor | | Leaves | | | | | | Fruits | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pb (µg/kg dry wt.) | | Cd (µg/kg dry wt.) | | Proline (mg/100g DW) | | Pb (µg/kg dry wt.) | | Cd (µg/kg dry wt.) | |
| | | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| **Distance off the freeway (meter)** | | | | | | | | | | | |
| 10 m | | **329 A** | **346 A** | **65 A** | **68 A** | **56.96 A** | **57.26 A** | **33 A** | **33 A** | **19 A** | **20 A** |
| 50 m | | **195 B** | **204 B** | **41 B** | **40 B** | **52.83 B** | **53.51 B** | **21 B** | **22 B** | **14 B** | **14 B** |
| **Chemicals application** | | | | | | | | | | | |
| SA 200 mg/l | | 283 bc | 301 bc | 46 cd | 46 cd | 56.81 c | 58.44 c | 22 b | 23 b | 19 b | 20 b |
| SA 400 mg/l | | 243 cd | 236 de | 41 def | 41 cd | 55.23 c | 54.47 d | 18 b | 18 cd | 15 c | 14 cd |
| AA 1000 mg/l | | 299 b | 314 b | 58 b | 58 b | 50.43 d | 51.00 e | 21 b | 21 bc | 17 c | 16 c |
| AA 2000 mg/l | | 253 cd | 261 cd | 53 bc | 50 bc | 55.98 c | 55.93 d | 16 b | 16 de | 12 d | 12 cd |
| Pro 100 mg/l | | 171 ef | 201 e | 46 cde | 49 bc | 61.08 b | 61.10 b | 14 b | 14 de | 12 d | 11 cd |
| Pro 200 mg/l | | 142 f | 161 f | 38 ef | 38 cd | 62.71 a | 64.81 a | 14 b | 12 e | 11 d | 11 d |
| NaHS 250 µM | | 239 cd | 236 de | 43 de | 45 cd | 55.80 c | 56.37 d | 16 b | 16 de | 12 d | 13 cd |
| NaHS 500 µM | | 211de | 221 de | 34 f | 35 d | 56.26 c | 55.57 d | 15 b | 15 de | 11 d | 13 cd |
| Control | | 513 a | 547 a | 116 a | 122 a | 39.80 e | 40.83 f | 110 a | 115 a | 42 a | 43 a |
| CEOT[z] | | **26 A** | **28 A** | **54 A** | **53 A** | **54.90A** | **55.39 A** | **27A** | **28A** | **17 A** | **17 A** |
| Interaction | | | | | | | | | | | |
| 10 m | SA 200mg/l | 394 bc | 414 b | 57 de | 57 def | 61.59bc | 61.91 b | 26 c | 28 c | 25 c | 23 c |
| | SA 400mg/l | 336 cd | 321 c | 52 ef | 51 d-h | 59.43cde | 58.28cd | 28 cd | 20 de | 19 d | 17 de |
| | AA1000 mg/l | 380 bc | 392 b | 73 c | 75 c | 50.88 g | 51.68fg | 26 c | 25 cd | 20 d | 18 cd |
| | AA2000 mg/l | 294 de | 319 c | 65 cd | 62 cde | 57.10 ef | 56.62de | 20 cd | 18 e | 13 efg | 13 def |
| | Pro 100 mg/l | 241 e-h | 263 cde | 60 de | 66 cd | 63.13 ab | 62.18 b | 15 cd | 14 ef | 12 efg | 12 ef |
| | Pro 200 mg/l | 177 hij | 190 fgh | 50 ef | 53 d-g | 64.74 a | 67.97 a | 14 cd | 14 ef | 11 g | 12 ef |
| | NaHS250µM | 278 def | 290 vd | 52 ef | 54 def | 56.96 ef | 57.25cde | 17 cd | 17 ef | 13 efg | 14 def |
| | NaHS500µM | 250 efg | 276 cd | 42 fgh | 45 e-i | 57.05 ef | 56.58de | 16 cd | 14 ef | 10 g | 13 def |
| | Control | 609 a | 650 a | 134 a | 144 a | 41.79 h | 42.89 h | 144 a | 151 a | 51 a | 55 a |
| 50 m | SA 200 mg/l | 171 ij | 188 fgh | 36 ghi | 34 g-j | 52.02 g | 54.97 e | 17 cd | 18 e | 14 ef | 17 def |
| | SA 400 mg/l | 149 jk | 151 gh | 30 hi | 31 ij | 51.03 g | 50.65 g | 14 cd | 15 ef | 11 fg | 10 f |
| | AA1000 mg/l | 220 g-j | 236 def | 44 fg | 41 f-j | 49.98 g | 50.31 g | 17 cd | 16 ef | 14 ef | 13 def |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| AA2000mg/l | 211 g-j | 203 efg | 40 fgh | 39 f-j | 54.85 f | 55.23de | 12 d | 13 ef | 12 efg | 11 ef |
| Pro 100 mg/l | 101 k | 140 gh | 32 ghi | 33 hij | 59.02 de | 60.01bc | 12 d | 13 ef | 11 efg | 11 ef |
| Pro 200 mg/l | 108 k | 132 h | 25 i | 23 j | 60.69 cd | 61.64 b | 14 cd | 11 ef | 10 g | 11 f |
| NaHS250µM | 201g-j | 181fgh | 34 ghi | 35 g-j | 54.64 f | 55.48 de | 14 cd | 16 ef | 11 efg | 12 def |
| NaHS500µM | 173 ij | 166 gh | 26 i | 24 j | 55.46 f | 54.55 ef | 14 cd | 15 ef | 11 efg | 12 def |
| Control | 418 b | 443 b | 98 b | 99 b | 37.81 i | 38.76 i | 77 b | 80 b | 33 b | 32 b |

Means values followed by the same letter within a column are not significantly different at the $P < 0.05$ level. CEOT$^{Z}$= composite effect of treatments; Pb = lead; Cd = Cadmium.

### 3- Effect of treatments and planting distances on APTI and its components:

The interaction effect of treatments and planting distances on APTI and its components was significant in both seasons (Table 3). All the treatments demonstrated improvements of APTI and its components over the control in both seasons and at the two different planting distances off the main road. Again, salicylic acid (400 mg/l), AA, and NaHS (500 µM) increased positively APTI and its components at the 10 m distance in both seasons when compared to the other treatments. However, SA (400 mg/l), AA, Pro (100 mg/l), and NaHS (500 µM) had a better and more pronounced effect on the same parameters in both seasons at the 50-m distance. Proline was not that effective under much stress at a 10-meter distance. For the composite effect of planting distance, the trees at 10 m off the freeway showed significantly better APTI and its components over those at 50 m in both seasons. An important screening technique for plants is the air pollution tolerance index, which measures how sensitive or tolerable a plant is to various air pollutants.

Generally, SA (400 mg/l), AA, Pro (100 mg/l), and NaHS (500 µM) were very effective in increasing APTI in pear leaves at both planting distances. However, SA (400 mg/l), AA, and NaHS (500 µM) were more effective in increasing APTI for the trees planted 10 m off the freeway in comparison with the effect of proline. Consequently, and comparable to the data stated here, **Abdelaal *et al.* (2020)** found that SA at 0.5 mM led to significant increases in relative water content, chlorophyll concentration, and activity of antioxidant enzymes in both seasons compared with stressed, untreated barley plants. Spraying “Washington navel” orange trees with SA at 400 mg/l enhanced chlorophyll a and b, which affect the APTI positively (**El-Khayat, 2018**). Moreover, **Tatari *et al.* (2020)** stated that the response of pear trees to drought stress was improved by significantly increasing the RWC and proline content compared with the control. Likewise, the highest levels of chlorophyll a, b, and total chlorophylls were obtained after treating "Manfalouty" pomegranate plants three times with SA at 200 mg/l (**Abdel Aziz *et al*., 2017**).

Moreover**, Abo-Ogiala (2018)** found that applications of AA at 10 mM increased leaf total chlorophyll and ascorbic acid in "Manfalouty" pomegranate trees under environmental stresses. Likewise, **Aly *et al.* (2015)** found that foliar application of AA (0, 250, 500, and 750 mg/l) and SA (0, 100, 200, and 300 mg/l) on “Valencia” orange increased total chlorophyll compared to the control. Additionally, foliar sprays of AA at 75 and 150 mg/l on grape cv. Rash-Mew under non-irrigated conditions and 750 mg/l on HojiBlanca olive cv. significantly increased the amount of chlorophyll in leaves **(Nerway, 2011; Ibrahim, 2013).** For the proline effect, **Abdelaal *et al.* (2020)** found that proline at 10 mM led to significant increases in relative water content, chlorophyll concentration, and activity of antioxidant enzymes compared with stressed, untreated barley plants. In addition, **Abo-Ogiala (2018)** found that the application of proline increased leaves' total chlorophyll and ascorbic acid in "Manfalouty" pomegranate trees under environmental stresses. Exogenous application of NaHS increased chlorophyll content in strawberry plants **(Kaya and Ashraf, 2019)**. Also, NaHS at 100 µM had the highest chlorophyll concentration in soybean seedlings **(Chen *et al.*, 2018).** Besides, **Kaya *et al.* (2018)** indicated that applying NaHS at 0.2 mM improved chlorophyll contents and RWC in sweet pepper.

**Table 3: Effect of salicylic acid (SA), ascorbic acid (AA), proline (Pro), and sodium hydrosulfide (NaHS) and planting distances off the freeway on relative water content (RWC), total chlorophyll (TChl), pH, ascorbic acid (AA), and air pollution tolerance index (APTI) of "Le Conte" pear leaves in 2019 and 2020 seasons**

| Studied factor | | RWC (%) | | TChl (mg/g) | | pH | | AA (mg/g) | | APTI value | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| **Distance off the freeway (meter)** | | | | | | | | | | | |
| 10 m | | **85.82 A** | **86.12 A** | **2.64 A** | **2.65 A** | **7.61 A** | **7.61 A** | **0.79 A** | **0.81 A** | **9.39 A** | **9.45 A** |
| 50 m | | **82.44 B** | **83.57 B** | **2.27 B** | **2.36 B** | **7.43 B** | **7.40 B** | **0.60 B** | **0.57 B** | **8.83 B** | **8.92 B** |
| **Chemicals application** | | | | | | | | | | | |
| SA 200 mg/l | | 85.39 ab | 86.93 a | 2.37 d | 2.46 cd | 7.54abc | 7.55a-d | 0.58 e | 0.58 f | 9.12bc | 9.28bcd |
| SA 400 mg/l | | 85.33 ab | 86.44 a | 2.68 ab | 2.66abc | 7.60 ab | 7.51bcd | 0.85bc | 0.70cd | 9.42ab | 9.36bcd |
| AA 1000 mg/l | | 86.17 ab | 85.42 a | 2.62abc | 2.70 ab | 7.59 ab | 7.58abc | 0.91ab | 0.94 b | 9.55 a | 9.52 ab |
| AA 2000 mg/l | | 87.06 a | 86.13 a | 2.49bcd | 2.50bcd | 7.41 c | 7.43 d | 1.01 a | 1.04 a | 9.71 a | 9.65 a |
| Pro 100 mg/l | | 84.69 ab | 86.20 a | 2.56bcd | 2.66abc | 7.58 ab | 7.62 ab | 0.61de | 0.60 f | 9.09bc | 9.24 cd |
| Pro 200 mg/l | | 83.76 b | 85.36 a | 2.40 cd | 2.55bcd | 7.50 bc | 7.46 cd | 0.59de | 0.66de | 8.96 c | 9.20 d |
| NaHS 250 µM | | 85.09 ab | 86.86 a | 2.48bcd | 2.42 d | 7.65 ab | 7.65 a | 0.62de | 0.62 ef | 9.13bc | 9.31bcd |
| NaHS 500 µM | | 87.82 a | 87.31a | 2.85 a | 2.87 a | 7.66 a | 7.62 ab | 0.73cd | 0.72 c | 9.55 a | 9.49abc |
| Control | | 71.89 c | 72.94 b | 1.65 e | 1.73 e | 7.17 d | 7.11 e | 0.34 f | 0.34 g | 7.48 d | 7.59 e |
| CEOT$^{z}$ | | **84.13A** | **84.84A** | **2.456A** | **2.506A** | **7.52 A** | **7.50 A** | **0.693A** | **0.689A** | **9.112A** | **9.182A** |
| **Interaction** | | | | | | | | | | | |
| 10 m | SA 200mg/l | 88.42 ab | 89.06 a | 2.61b-e | 2.71bcd | 7.64a-d | 7.64a-d | 0.62b-e | 0.73 ef | 9.48abc | 9.66 ab |
| | SA 400mg/l | 86.70a-d | 87.64abc | 2.92 ab | 2.80 bc | 7.76 ab | 7.62bcd | 1.09 a | 0.84 cd | 9.84 ab | 9.64 ab |
| | AA1000mg/l | 87.25a-d | 86.79abc | 2.86abc | 2.89 ab | 7.63a-d | 7.69abc | 1.06 a | 1.15 b | 9.84 ab | 9.89 a |
| | AA2000mg/l | 88.03abc | 87.10abc | 2.68bcd | 2.57b-e | 7.46c-f | 7.51c-f | 1.18 a | 1.23 a | 10.00 a | 9.95 a |
| | Pro 100 mg/l | 86.54a-d | 87.30abc | 2.71bcd | 2.76bcd | 7.67abc | 7.70abc | 0.63b-e | 0.73 ef | 9.31b-e | 9.50 b |
| | Pro 200 mg/l | 85.67a-d | 86.62abc | 2.52cde | 2.67b-e | 7.54b-e | 7.55cde | 0.66b-e | 0.77d-e | 9.23c-f | 9.45 bc |
| | NaHS250µM | 86.70a-d | 88.10ab | 2.57b-e | 2.51c-f | 7.74 ab | 7.77 ab | 0.68b-e | 0.67 fg | 9.37b-e | 9.50 b |
| | NaHS500µM | 89.72 a | 88.15ab | 3.10 a | 3.13 a | 7.79 a | 7.82 a | 0.82 bc | 0.81cde | 9.82 ab | 9.66 ab |
| | Control | 73.37 e | 74.30 d | 1.76 g | 1.84 g | 7.26 fg | 7.17 g | 0.37 fg | 0.37 jk | 7.67 h | 7.76 g |
| 50 m | SA 200 mg/l | 82.36 cd | 84.80 bc | 2.13 f | 2.21 f | 7.43def | 7.46def | 0.54b-e | 0.43 ij | 8.75 fg | 8.90 f |
| | SA 400 mg/l | 83.96bcd | 85.23 bc | 2.43def | 2.51c-f | 7.43def | 7.39 ef | 0.61cde | 0.56 h | 9.00c-g | 9.08def |
| | AA1000mg/l | 85.10a-d | 84.05 c | 2.38def | 2.51c-f | 7.54b-e | 7.47def | 0.76bcd | 0.74 ef | 9.26c-f | 9.15c-f |
| | AA2000mg/l | 86.08a-d | 85.15 bc | 2.29def | 2.44def | 7.35 ef | 7.34 f | 0.84 b | 0.85 c | 9.42bcd | 9.35bcd |
| | Pro 100 mg/l | 82.83bcd | 85.10 bc | 2.41def | 2.56b-e | 7.49cde | 7.54c-f | 0.59 de | 0.47 i | 8.86efg | 8.99 ef |
| | Pro 200 mg/l | 81.84 d | 84.10 c | 2.28 ef | 2.43def | 7.46c-f | 7.36 ef | 0.52 ef | 0.56 h | 8.70 g | 8.96 f |
| | NaHS250µM | 83.47bcd | 85.61abc | 2.39def | 2.34 ef | 7.56b-e | 7.53c-f | 0.55def | 0.56 h | 8.89d-g | 9.11c-f |
| | NaHS500µM | 85.91a-d | 86.47abc | 2.59b-e | 2.61b-e | 7.54b-e | 7.41 ef | 0.64b-e | 0.64 g | 9.27c-f | 9.32b-e |
| | Control | 70.40 e | 71.59 d | 1.53 g | 1.61 g | 7.08 g | 7.05 g | 0.30 g | 0.30 k | 7.30 h | 7.42 h |

Means values followed by the same letter within a column are not significantly different at the $P < 0.05$ level. CEOT$^{z}$= composite effect of treatments.

### 4- Effect of treatments and planting distances on initial fruit set and fruit retention:

The interaction effect of treatments and planting distances on initial fruit set and fruit retention was significant in both seasons (Table 4). When compared to the control, all treatments significantly increased initial fruit set and fruit retention of trees planted 10 and 50 m off the freeway over both seasons. Salicylic acid was superior to the other treatments in significantly increasing both parameters at either 10 m or 50 m off the freeway in both seasons. As for the distance effect, initial fruit set and retention were significantly higher for trees planted 50 m off the freeway in comparison with the trees planted 10 m away through both seasons.

**Table 4: Effect of salicylic acid (SA), ascorbic acid (AA), proline (Pro), and Sodium hydrosulfide (NaHS) and planting distances off the freeway on initial fruit set and fruit retention of “Le Conte” pear trees in 2019 and 2020 seasons**

| Studied factor | | Initial fruit set (%) | | | | Fruit retention (%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 15 DAFB | | 21 DAFB | | 30 DAFB | | 110 DAFB | |
| | | **2019** | **2020** | **2019** | **2020** | **2019** | **2020** | **2019** | **2020** |
| **Distance off the freeway (DoF)** | | | | | | | | | |
| 10 meter (m) | | **44.96 B** | **45.34 B** | **16.30 B** | **16.52 B** | **13.90 B** | **14.59 B** | **5.12 B** | **5.42 B** |
| 50 meter (m) | | **46.31 A** | **46.87 A** | **17.11 A** | **17.38 A** | **14.75 A** | **15.33 A** | **5.61 A** | **5.91 A** |
| **Chemicals application (CA)** | | | | | | | | | |
| SA 200 mg/l | | 51.50 a | 52.98 a | 19.96 a | 19.93 a | 17.23 a | 18.25 a | 6.93 a | 7.38 a |
| SA 400 mg/l | | 51.35 a | 52.07 a | 20.13 a | 20.08 a | 17.69 a | 18.65 a | 6.97 a | 7.66 a |
| AA 1000 mg/l | | 44.67 c | 44.23 d | 15.63 c | 16.28 cd | 12.83 d | 13.40 d | 4.77 c | 4.94 d |
| AA 2000 mg/l | | 45.68 c | 45.69 bc | 16.22 bc | 16.08 cd | 14.15 c | 14.64 bc | 5.21 bc | 5.23 cd |
| Pro 100 mg/l | | 45.54 c | 46.09 bc | 16.35 bc | 17.16 bc | 13.65 c | 14.45 c | 5.20 bc | 5.17 cd |
| Pro 200 mg/l | | 46.70 b | 46.88 b | 17.05 b | 18.05 b | 15.27 b | 15.26 b | 5.33 b | 5.56 bc |
| NaHS 250 µM | | 42.74 e | 44.26 d | 15.48 c | 16.54 cd | 13.51 cd | 14.22 c | 5.03 bc | 5.33bcd |
| NaHS 500 µM | | 44.28 d | 45.20 cd | 16.69 b | 15.65 d | 13.81 c | 14.48 c | 5.34 b | 5.90 b |
| Control | | 38.28 f | 37.58 e | 12.84 d | 12.78 e | 10.75 e | 11.31 e | 3.52 d | 3.82 e |
| CEOT$^{z}$ | | **45.64A** | **46.11 A** | **16.71 A** | **16.95 A** | **14.32 A** | **14.96 A** | **5.37 A** | **5.67 A** |
| **Interaction (DoF×CA)** | | | | | | | | | |
| 10 m | SA 200mg/l | 51.45 a | 53.63 a | 19.71 a | 18.67bcd | 17.17 a | 18.43 a | 6.68 bc | 7.26 a |
| | SA 400mg/l | 51.53 a | 50.65 bc | 20.52 a | 19.96 ab | 17.97 a | 18.68 a | 6.28 cd | 7.45 a |
| | AA1000 mg/l | 43.41 ef | 42.41 i | 15.41 fg | 16.32 ef | 11.98 fg | 12.57 gh | 4.66 h | 4.25 ef |
| | AA2000 mg/l | 45.21 cd | 46.39 de | 15.51efg | 14.84 f | 13.60b-e | 14.05 ef | 5.13e-h | 4.61 de |
| | Pro 100 mg/l | 43.09 fg | 44.07f-i | 15.32 fg | 16.52 ef | 12.56 ef | 13.32 fg | 4.82 gh | 5.07 cd |
| | Pro 200 mg/l | 44.00def | 43.37ghi | 15.75d-g | 16.85def | 13.48cde | 14.05 ef | 4.92fgh | 5.27bcd |
| | NaHS250µM | 43.76def | 45.26e-h | 15.77d-g | 16.86def | 13.85bcd | 14.23def | 4.94fgh | 5.33bcd |
| | NaHS500µM | 44.67cde | 45.38efg | 16.75cde | 16.11 ef | 14.34 bc | 15.05cde | 5.20e-h | 5.67 bc |
| | Control | 37.52 i | 36.92 j | 11.96 i | 12.54 g | 10.11 h | 10.95 i | 3.45 i | 3.88 ef |
| 50 m | SA 200 mg/l | 51.54 a | 52.34 ab | 20.20 a | 21.18 a | 17.29 a | 18.08 a | 7.17 ab | 7.50 a |
| | SA 400 mg/l | 51.16 a | 53.50 a | 19.73 a | 20.19 ab | 17.40 a | 18.61 a | 7.65 a | 7.87 a |
| | AA1000 mg/l | 45.93 c | 46.04 ef | 15.85d-g | 16.24 ef | 13.68b-e | 14.22def | 4.88fgh | 5.64 bc |
| | AA2000mg/l | 46.15 c | 44.98e-h | 16.92 cd | 17.33 de | 14.69 b | 15.23 cd | 5.28e-h | 5.81 bc |
| | Pro 100 mg/l | 47.99 b | 48.11 d | 17.38 bc | 17.79cde | 14.75 b | 15.58 bc | 5.58 ef | 5.26bcd |
| | Pro 200 mg/l | 49.39 b | 50.39 c | 18.34 b | 19.24 bc | 17.05 a | 16.46 b | 5.75 de | 5.85 bc |
| | NaHS250µM | 41.72 g | 43.26 hi | 15.18 g | 16.22 ef | 13.17 de | 14.20def | 5.12e-h | 5.32bcd |
| | NaHS500µM | 43.88def | 45.02e-h | 16.63c-f | 15.19 f | 13.28cde | 13.90 f | 5.48efg | 6.12 b |
| | Control | 39.05 h | 38.23 j | 13.71 h | 13.02 g | 11.40 g | 11.67 hi | 3.59 i | 3.75 f |

Means values followed by the same letter within a column are not significantly different at the $P < 0.05$ level. CEOT$^{z}$= composite effect of treatments.

### 5- Effect of treatments and planting distances on fruit weight, number, and yield:

The interaction effect of treatments and planting distances on fruit weight, number, and yield was significant in both seasons (Table 5). All treatments significantly increased fruit weight, number, and yield of trees planted 10 and 50 m off the freeway compared with those of the control in both seasons. For the treatments' effect on fruit weight, number, and yield at both distances, all the treatments improved the measured parameters, and the improvements were more pronounced by the SA, AA (2000 mg/l), pro (200 mg/l), and NaHS (500 µM). As for the distance effect, fruit weight, number, and yield were significantly higher for trees planted 50 m off the freeway in comparison with the trees planted 10 m in both seasons.

**Table 5: Effect of salicylic acid (SA), ascorbic acid (AA), proline (Pro), and Sodium hydrosulfide (NaHS) and planting distances off the freeway on "Le Conte" pear fruit weight, fruit number/tree and yield in 2019 and 2020 seasons**

| Studied factor | | Fruit weight (g) | | Fruit No./tree | | Yield (kg/tree) | |
|---|---|---|---|---|---|---|---|
| | | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| **Distance off the freeway (DoF)** | | | | | | | |
| 10 meter (m) | | **216.5 B** | **221.6 B** | **287.1 B** | **295.8 B** | **62.3 B** | **65.7 B** |
| 50 meter (m) | | **270.1 A** | **275.9 A** | **355.2 A** | **362.0 A** | **96.9 A** | **101.2 A** |
| **Chemicals application (CA)** | | | | | | | |
| SA 200 mg/l | | 280.5 a | 287.0 a | 298.8 e | 306.0 f | 87.3 c | 91.2 c |
| SA 400 mg/l | | 247.0 c | 252.8 c | 321.3 d | 326.8 e | 79.8 e | 83.1 d |
| AA 1000 mg/l | | 237.5 d | 242.0 cd | 267.2 f | 271.0 g | 64.2 g | 66.3 f |
| AA 2000 mg/l | | 266.7 b | 268.6 b | 431.7 a | 455.5 a | 115.0 a | 122.4 a |
| Pro 100 mg/l | | 262.8 b | 271.1 b | 265.8 f | 272.3 g | 71.2 f | 75.0 e |
| Pro 200 mg/l | | 232.1 d | 242.4 cd | 362.2 c | 374.3 c | 84.0 d | 90.8 c |
| NaHS 250 µM | | 235.8 d | 243.8 cd | 324.2 d | 336.0 d | 78.0 e | 83.2 d |
| NaHS 500 µM | | 230.7 d | 237.8 d | 409.2 b | 415.0 b | 95.5 g | 99.8 b |
| Control | | 196.4 e | 193.2 e | 210.0 g | 202.8 h | 41.2 h | 39.2 g |
| CEOT$^{z}$ | | **243.28 A** | **243.96A** | **323.95A** | **331.71A** | **78.61 A** | **82.48 A** |
| **Interaction (DoF×CA)** | | | | | | | |
| 10 m | SA 200mg/l | 226.0 f | 233.8 e | 237.7 ij | 242.7 i | 53.72 i | 56.74 gh |
| | SA 400mg/l | 224.3 fg | 231.5 e | 297.7 h | 305.3 g | 66.77 h | 70.68 f |
| | AA1000 mg/l | 221.0fgh | 226.9 e | 217.7 k | 222.0 j | 48.11 j | 50.37 h |
| | AA2000 mg/l | 218.3fgh | 219.7 e | 435.0 b | 453.7 b | 94.96 d | 99.68 cd |
| | Pro 100 mg/l | 225.7 f | 234.5 e | 235.0 j | 242.0 i | 53.04 i | 56.75 gh |
| | Pro 200 mg/l | 214.3 gh | 218.0 ef | 361.0 de | 372.7 d | 77.36 f | 81.25 e |
| | NaHS250µM | 216.7fgh | 224.0 e | 251.7 i | 272.0 d | 54.54 i | 60.93 g |
| | NaHS500µM | 211.7 hi | 220.6 e | 343.3 f | 351.7 e | 72.68 g | 77.56 e |
| | Control | 190.4 j | 185.2 g | 205.0 k | 200.0 k | 39.03 l | 37.04 i |
| 50 m | SA 200 mg/l | 335.0 a | 340.2 a | 360.0 de | 369.3 d | 120.60b | 125.64 b |
| | SA 400 mg/l | 269.7 d | 274.8 c | 345.0 ef | 348.3 e | 93.05de | 95.71 d |
| | AA1000 mg/l | 254.0 e | 257.1cd | 316.7 g | 320.0 f | 80.44 f | 82.27 e |
| | AA2000mg/l | 315.0 b | 317.5 b | 428.3 b | 457.3 b | 135.07a | 145.19 a |
| | Pro 100 mg/l | 300.0 c | 307.7 b | 296.7 h | 302.7 g | 89.01 e | 93.14 d |
| | Pro 200 mg/l | 249.9 e | 266.8cd | 363.3 d | 376.0 d | 90.79 e | 100.32cd |
| | NaHS250µM | 255.0 e | 263.7cd | 396.7 c | 400.0 c | 101.16c | 105.48 c |
| | NaHS500µM | 249.7 e | 255.1 d | 475.0 a | 478.3 a | 118.61b | 122.01 b |
| | Control | 202.3 i | 201.2 fg | 215.0 k | 205.7 k | 43.49 k | 43. 24 i |

Means values followed by the same letter within a column are not significantly different at the $P < 0.05$ level. CEOT$^{z}$= composite effect of treatments.

### 6- Effect of treatments and planting distances on Flesh firmness, fruit TSS, acidity, TSS/acid ratio, and vitamin C:

In both seasons, the interaction effect of treatments and planting distances on fruit firmness was significant (Table 6). All treatments resulted in significantly higher fruit firmness over that of the control at both planting distances in both seasons. In addition, fruit firmness was significantly higher as affected by Pro (100 mg/l) in both seasons and at both planting distances. However, fruit firmness was significantly lower, as affected by the 50-meter distance off the freeway. The interaction effect of treatments and planting distances on fruit TSS, acidity, TSS/acid ratio, and V.C. were significant in both seasons (Table 6). The effect of the different treatments was more prominent on fruit taken from trees planted 50 m off the freeway. Generally, fruit taken from trees planted 50 meters off the freeway had higher TSS, TSS/acid ratio, and V.C. and lower titratable acidity in both seasons than the fruits from trees planted 10 m.

**Table 6: Effect of salicylic acid (SA), ascorbic acid (AA), proline (Pro), and sodium hydrosulfide (NaHS) and planting distances on "Le Conte" pear fruit firmness, fruit TSS, acidity, TSS/acid ratio, and vitamin C in 2019 and 2020 seasons**

| Studied factor | | Flesh firmness (N) | | TSS (%) | | Acidity (%) | | TSS/acid ratio | | Vitamin C (mg/100g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Distance off the freeway (meter) | | | | | | | | | | | |
| 10 m | | **44.30 A** | **43.07 A** | **11.74 B** | **12.08 B** | **0.22 A** | **0.27 A** | **56.47 B** | **45.91 B** | **1.10 A** | **1.16 B** |
| 50 m | | **41.31 B** | **40.93 B** | **12.59 A** | **12.71 A** | **0.20 B** | **0.25 B** | **66.28 A** | **51.05A** | **1.12 A** | **1.30 A** |
| Chemicals application | | | | | | | | | | | |
| SA 200 mg/l | | 42.29cde | 40.96d | 12.13 a | 12.58 a | 0.23b | 0.26cd | 52.78d | 49.19cd | 1.00de | 1.17de |
| SA 400 mg/l | | 43.25cd | 43.25b | 12.38 a | 12.67 a | 0.19cd | 0.27bc | 68.23bc | 47.01de | 1.07cd | 1.10e |
| AA 1000 mg/l | | 46.59b | 41.92bcd | 12.15 a | 12.35 a | 0.18d | 0.26bcd | 70.79ab | 46.86de | 1.33b | 1.37b |
| AA 2000 mg/l | | 44.42bc | 42.68bc | 12.27 a | 12.52 a | 0.24b | 0.23e | 52.07d | 53.53b | 1.57a | 1.60a |
| Pro 100 mg/l | | 51.53a | 48.26a | 12.03 a | 12.28 a | 0.23bc | 0.27bcd | 54.73d | 46.23de | 1.23bc | 1.33bc |
| Pro 200 mg/l | | 41.02de | 42.10bcd | 12.50 a | 12.60 a | 0.20bcd | 0.25d | 63.24c | 50.17c | 1.00de | 1.20cde |
| NaHS 250 µM | | 39.73e | 41.44cd | 12.37 a | 12.47 a | 0.17d | 0.28b | 74.70a | 45.31e | 1.03d | 1.27bcd |
| NaHS 500 µM | | 42.74bc | 41.04d | 12.43 a | 12.60 a | 0.17d | 0.20f | 75.88a | 62.25a | 0.93de | 1.13de |
| Control | | 33.67f | 36.35e | 11.22 b | 11.52 b | 0.28a | 0.32a | 39.96e | 35.80f | 0.83e | 0.93f |
| CEOT[z] | | **42.80 A** | **42.00 A** | **12.16 A** | **12.40 A** | **0.21 A** | **0.26 A** | **61.38 A** | **48.48 A** | **1.11 A** | **1.23 A** |
| Interaction | | | | | | | | | | | |
| 10 m | SA 200mg/l | 43.64c-f | 42.11c-h | 11.50def | 12.43a-e | 0.25abc | 0.27 cd | 47.16 hi | 46.49e-h | 0.93 d | 1.07fgh |
| | SA 400mg/l | 42.17d-g | 44.13 bc | 12.00b-e | 12.43a-e | 0.20bcd | 0.27 cd | 61.81def | 45.79fgh | 0.87 d | 1.00gh |
| | AA1000mg/l | 48.54 b | 42.37c-g | 11.83c-f | 12.10d-g | 0.20bcd | 0.27 cd | 64.01def | 44.43 gh | 1.27 bc | 1.33b-e |
| | AA2000mg/l | 46.09cde | 42.81cde | 11.77c-f | 12.13d-g | 0.26abc | 0.24 fg | 45.70 hi | 50.42 de | 1.53 a | 1.53 ab |
| | Pro 100 mg/l | 56.15 a | 51.23 a | 11.80c-f | 12.20c-f | 0.24a-d | 0.27 cd | 51.90 gh | 44.78 gh | 1.53 a | 1.47abc |
| | Pro 200 mg/l | 41.68efg | 43.76bcd | 12.00b-e | 12.03d-g | 0.20bcd | 0.26cde | 60.20efg | 45.70fgh | 1.07 cd | 1.13efg |
| | NaHS250µM | 38.90 gh | 42.09c-h | 11.70c-f | 11.93efg | 0.17 e | 0.28 c | 67.91c-f | 42.47 h | 1.07 cd | 1.07fgh |
| | NaHS500µM | 44.62cde | 41.99c-h | 11.90c-f | 12.03d-g | 0.18 de | 0.20 h | 70.88bcd | 58.62 b | 0.87 d | 1.00 gh |
| | Control | 36.94 h | 37.16 i | 11.17 f | 11.43 g | 0.29 a | 0.33 a | 38.63 i | 34.50 i | 0.80 d | 0.87 h |
| 50 m | SA 200 mg/l | 40.94efg | 39.81 h | 12.77 ab | 12.73a-d | 0.22b-e | 0.25efg | 58.39 fg | 51.88 cd | 1.07 cd | 1.27c-f |
| | SA 400 mg/l | 44.32c-f | 42.37c-h | 12.77 ab | 12.90abc | 0.17 e | 0.27 cd | 74.65abc | 48.22d-g | 1.27 bc | 1.20d-g |
| | AA1000mg/l | 44.64cde | 41.46d-h | 12.47abc | 12.60a-e | 0.16 e | 0.26def | 77.57 ab | 49.30def | 1.40 ab | 1.40bcd |
| | AA2000mg/l | 42.75d-g | 42.55c-f | 12.77 ab | 12.90abc | 0.22b-e | 0.23 g | 58.44 fg | 56.63 b | 1.60 a | 1.67 a |
| | Pro 100 mg/l | 46.91 bc | 45.29 b | 12.27a-d | 12.37b-e | 0.21cde | 0.26def | 57.57 fg | 47.67d-g | 0.93 d | 1.20d-g |
| | Pro 200 mg/l | 40.36fgh | 40.44fgh | 13.00 a | 13.17 a | 0.20cde | 0.24 fg | 66.27c-f | 54.64 bc | 0.93 d | 1.27c-f |
| | NaHS250µM | 40.56e-h | 40.79e-h | 13.03 a | 13.00 a | 0.16 e | 0.27 cd | 81.49 a | 48.15d-g | 1.00 cd | 1.47abc |
| | NaHS500µM | 40.86efg | 40.10 gh | 12.97 a | 13.17 a | 0.16 e | 0.20 h | 80.87 a | 65.88 a | 1.00 cd | 1.27c-f |
| | Control | 30.40 i | 35.53 i | 11.27 ef | 11.60 fg | 0.27 ab | 0.31 b | 41.28 i | 37.10 i | 0.87 d | 1.00 gh |

Means values followed by the same letter within a column are not significantly different at the P < 0.05 level. CEOTZ= composite effect of treatments.

### 7- Effect of treatments and planting distances on fruit total sugars, phenolics, antioxidants, peroxidase (POD), and superoxide dismutase (SOD):

The interaction effects of treatments and planting distances on fruit total sugars, phenolics, antioxidants, peroxidase, and superoxide dismutase were significant in both seasons (Table7). The results of the study suggest that treatments were more effective on trees planted 50 m away from the main road due to reduced exposure to environmental contaminants. Again, as mentioned formerly, AA (2000 mg/l) and NaHS (500 µM) were more effective in both seasons in comparison with the other treatments. As for the distance effect, fruits taken from trees planted 50 m off the main road had significantly higher total sugars content than the fruits from trees planted 10 m away. However, the fruits taken from trees planted 10 m off the main road had higher phenolic content, antioxidants, peroxidase, and superoxide dismutase activities in both seasons. Fruits taken from trees planted 10 m off the freeway were under stress, which is why phenolics, antioxidants, peroxidase, and superoxide dismutase were high.

**Table 7: Effect of salicylic acid (SA), ascorbic acid (AA), proline (Pro), and sodium hydrosulfide (NaHS) and planting distance off the freeway on total antioxidants, peroxidase (POD), and superoxide dismutase (SOD) of "Le Conte" pear fruits in 2019 and 2020 seasons**

| Studied factor | | Total sugars (mg/g FW) | | Total phenolics (mg/100g FW) | | Total antioxidants (%) | | POD (unit/mg protein) | | SOD (units/mg protein) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Distance off the freeway (meter) | | | | | | | | | | | |
| 10 m | | **134.79 B** | **141.8 B** | **211.7 A** | **220.5 A** | **58.99A** | **59.10 A** | **4.74A** | **4.85A** | **1.92A** | **1.94A** |
| 50 m | | **155.19A** | **163.1 A** | **203.7 B** | **210.2 B** | **56.59B** | **57.22 B** | **4.50 B** | **4.45 B** | **1.60 B** | **1.73 B** |
| Chemicals application | | | | | | | | | | | |
| SA 200 mg/l | | 151.5 ab | 154.0 bc | 190.3 e | 187.9 f | 62.04a | 62.23 a | 4.89 d | 4.88 d | 1.84 b | 1.85 d |
| SA 400 mg/l | | 142.4 b | 151.6 bc | 226.1 c | 227.3c | 56.98e | 57.39 ef | 3.76 f | 3.72 f | 1.56 c | 1.60 e |
| AA 1000 mg/l | | 142.5 b | 147.9 c | 231.8 c | 240.1b | 57.99d | 59.74 c | 5.35 c | 5.98 c | 1.58 c | 1.63 e |
| AA 2000 mg/l | | 162.8 a | 174.1 a | 250.3 b | 260.8a | 60.61b | 60.74 b | 3.97 e | 3.92 e | 1.84 b | 1.83 d |
| Pro 100 mg/l | | 147.5 b | 162.8 b | 176.9 f | 192.4e | 56.83e | 57.09 f | 3.49 g | 3.46 g | 1.90 b | 1.93 c |
| Pro 200 mg/l | | 150.6 ab | 157.4 bc | 184.5ef | 196.6e | 56.39e | 57.73 ef | 3.52 g | 3.52 g | 1.61 c | 1.61 e |
| NaHS 250 µM | | 142.8 b | 147.3 c | 216.9 d | 219.9d | 58.00c | 57.98 e | 6.34 b | 6.32 b | 2.18 a | 2.22 b |
| NaHS 500 µM | | 147.1 b | 152.1 bc | 262.8 a | 262.9a | 58.96c | 58.73 d | 8.50 a | 8.29 a | 2.20 a | 2.75 a |
| Control | | 117.7 c | 124.8 d | 129.5 g | 149.8g | 52.34f | 51.80 g | 1.76 h | 1.75 h | 1.13 d | 1.12 f |
| CEOT$^{Z}$ | | **144.99A** | **152.44A** | **207.68A** | **215.30A** | **57.79A** | **58.16A** | **4.62A** | **4.65A** | **1.76A** | **1.84A** |
| Interaction | | | | | | | | | | | |
| 10 m | SA 200mg/l | 125.6 fg | 133.2gh | 193.0 g | 192.2i | 65.23a | 65.18 a | 4.39 e | 4.36 f | 2.05cd | 2.03 e |
| | SA 400mg/l | 125.7 fg | 134.3f-h | 230.0de | 233.9de | 58.21ef | 58.72def | 4.27 e | 4.22 f | 1.70 f | 1.74 fg |
| | AA1000 mg/l | 141.3 def | 145.0d-g | 236.1cd | 242.7c | 59.81cd | 60.34 c | 6.34 c | 7.66 b | 1.63fg | 1.67gh |
| | AA2000 mg/l | 157.5 bcd | 163.7b-d | 255.0ab | 264.9a | 61.40b | 61.83 b | 4.34 e | 4.30 f | 1.82 e | 1.85 f |
| | Pro 100 mg/l | 140.1 def | 152.0cde | 180.0gh | 195.1hi | 57.52 f | 57.84 f | 3.21hi | 3.18jk | 2.15 c | 2.19 d |
| | Pro 200 mg/l | 148.9 b-e | 154.8cde | 187.0gh | 202.2h | 57.31 f | 57.62 f | 3.03 i | 3.04 k | 1.40 h | 1.43 i |
| | NaHS250µM | 127.0 fg | 132.6 gh | 225.0de | 226.3ef | 58.32ef | 58.17 ef | 6.38 c | 6.48 c | 2.33 b | 2.35 c |
| | NaHS500µM | 130.8 efg | 137.7 e-h | 266.8 a | 272.7a | 60.08 c | 59.60cd | 9.11 a | 8.88 a | 2.58 a | 2.62 b |
| | Control | 116.1 g | 123.0 h | 132.3 i | 154.0k | 53.06 h | 52.61 h | 1.54 k | 1.53m | 1.64fg | 1.61 h |
| 50 m | SA 200 mg/l | 177.4 a | 174.9 ab | 187.5gh | 183.6j | 58.85de | 59.28cd | 5.40 d | 5.40 e | 1.63fg | 1.66gh |
| | SA 400 mg/l | 159.0a-d | 168.9a-c | 222.1 e | 220.7fg | 55.74 g | 56.07 g | 3.25 h | 3.22 j | 1.43 h | 1.45 i |
| | AA1000 mg/l | 143.7c-f | 150.9c-f | 227.6de | 237.5cd | 56.18 g | 59.13de | 4.36 e | 4.30 f | 1.54 g | 1.59 h |
| | AA2000mg/l | 168.1 ab | 184.5 a | 245.6bc | 256.6b | 59.81cd | 59.66cd | 3.59 g | 3.54 i | 1.86 e | 1.81 f |
| | Pro 100 mg/l | 154.9bcd | 173.5 ab | 173.78h | 189.7ij | 56.14 g | 56.34 g | 3.77 g | 3.74 h | 1.64fg | 1.67gh |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Pro 200 mg/l | 152.3bcd | 159.9bcd | 182.1gh | 191.1ij | 55.47 g | 57.85 f | 4.00 f | 4.00 g | 1.82 e | 1.79 f |
| NaHS250µM | 158.5a-d | 162.1bcd | 208.7 f | 213.4g | 57.68 f | 57.80 f | 6.29 c | 6.16 d | 2.02 d | 2.08de |
| NaHS500µM | 163.4abc | 166.4 bc | 258.8 a | 253.2b | 57.84 f | 57.86 f | 7.89 b | 7.71 b | 1.83 e | 2.87 a |
| Control | 119.3 g | 126.7 h | 126.7 i | 145.7l | 51.62 i | 50.98 i | 1.99 k | 1.97 l | 0.61 i | 0.62 j |

Means values followed by the same letter within a column are not significantly different at the P < 0.05 level. CEOT$^{Z}$= composite effect of treatments.

Pear tree yield was increased by 112–133% (SA; 200 mg/l), 180–212% (AA; 2000 mg/l), 105–133% (Pro; 200 mg/l), and 134–156% (NaHS; 500 µM) in the first and second seasons, respectively, as compared with the control. The other treatments increased yield over that of the control, but not as much as the increments stated above. The same treatments (SA; 200 mg/l), (AA), (Pro) and (NaHS) increased fruit height, firmness, TSS, TSS/acid, V.C., total sugars, phenolics, antioxidants, peroxidase, and superoxide dismutase activities. However, titratable acidity was reduced by the treatments. Ascorbic acid (2000 mg/l) and NaHS (500 µM) were more effective than the other treatments. Similarly, **Mahmoud *et al.* (2020)** reported that 3 or 4 mM foliar sprays of SA and AA on "Golden Japan" plums increased total soluble solids and total phenolic content while decreasing titratable acidity and antioxidant activity. In addition, **Ali and El Zayat (2019)** reported that "Washington navel" orange trees sprayed with SA at 200 or 400 mg/l increased fruit number per tree and fruit yield. On the other hand, **Abo-Ogiala (2018)** indicated that application of AA at 10 mM increased fruit weight, tree yield, TSS, and total sugar. Under environmental stress, the acidity of "Manfalouty" pomegranate decreased. Similarly, **Hafez *et al.* (2018)** indicated that fruit weight and number of "Le Conte" Pears were significantly increased by using 20 mg/l of SA and, therefore, produced a higher yield than untreated trees. Besides, **Abdel Aziz *et al.* (2017)** showed that the number of fruits per tree as well as the gross and marketable yield of "Manfalouty" pomegranate trees were positively affected by varying concentrations and frequencies of SA application.

**Al Barzinji *et al.* (2017)** sprayed pear trees with 0.5, 1.0, and 1.5% SA. The treatments increased fruit weight, firmness, TSS, and total sugars compared to the control. in the same direction, **Ahmed *et al.* (2015)** applied SA at 50-200 mg/l on "Sukkary" mango trees and reported significant enhancements in yield and fruit quality. While on "Valencia" oranges, **El-Sayed and Habasy (2015)** revealed that spraying SA at 100 to 400 mg/l considerably enhanced all growth characters, including initial fruit set, fruit retention, yield, and fruit quality over the rest of the treatments. While on "Florida King" peaches, **Ali *et al.* (2014)** reported that foliar application of SA improved fruit weight and yield compared to the control. All treatments increased fruit firmness and ascorbic acid content over the control. Besides, **Ngullie *et al.* (2014)** revealed that foliar application of SA at 2000 mg/l on "Kesar" mango at flower bud initiation resulted in significantly higher total soluble solids, total sugar, and minimum acidity. Further, **El-Khayat (2018)** sprayed "Washington navel" orange trees with SA and AA at 400 mg/l. They reported an increase in fruit yield. In the same way, **Hagagg *et al.* (2020)** applied SA (200 and 300 mg/l) and AA (2000 and 3000 mg/l) on "Picual" olive trees. They stated that the yield per tree was increased in comparison with that of the control. Additionally, "Hollywood" and "Golden Japanese" plum trees were treated with 50 mg/l of AA. The treatment significantly increased fruit set and yield. To improve the quality and yield of "Early Grand" and

“Florida King” peaches, four levels of AA (200, 400, 600, and 800 mg/l) were used **(Sajid *et al.*, 2017)**. The foliar application of AA at 800 mg/l significantly increased fruit weight, yield, total soluble solids, firmness, titratable acidity, and antioxidant activity as compared to the rest of the treatments. Equally, **El-Hosieny (2015)** showed that AA at 1.0 mM and SA at 2.0 mM on “Fagri Kalan” mango trees enhanced fruit set and total fruit number per tree compared with that of the control. The same compounds were sprayed at 1000 mg/l of AA and 200 mg/l of SA on “Le Conte" pears **(Fayek *et al.*, 2014)**. When compared to the control, the treatments increased average yield per tree, fruit weight, and TSS significantly. In addition, treatment increased fruit firmness, total soluble solids, the fruit TSS/acid ratio, and fruit juice acidity as compared with the untreated trees **(Nabil *et al.*, 2013)**. Therefore, **Samra *et al.* (2012)** demonstrated that mandarin trees that were sprayed with both AA and SA at 500 or 1000 mg/l had a better yield per tree (kg) than the untreated trees. Applications significantly improved the total number of fruits per tree at harvest time. In this respect, the best results in yield were recorded from trees sprayed with AA at 500 mg/l. This treatment resulted in a higher yield and number of fruit per tree. AA sprayed at 200, 300, and 400 mg/l increased yield, fruit weight, firmness, total soluble solids, total sugars, and total phenols of "Alphonse" and "Badami" mango fruits **(Awad, 2006)**. **Abo-Ogiala (2018)** indicated that the application of proline increased fruit weight, tree yield, TSS, and total sugar. Whereas, "Manfalouty" pomegranate fruit acidity was decreased under environmental stress. In addition, **El Sayed *et al.* (2014)** reported that three concentrations of proline-50, 75, and 100 mg/l on Manfalouty pomegranate produced a higher number of fruits, improved tree yield, and had a higher positive effect on fruit weight as compared with the control. It was found that $H_2S$ donor (NaHS) treatment increased the contents of titratable acids and vitamin C in kiwifruit, grape, and mulberry fruit **(Liu *et al.*, 2021)**. **Li *et al.* (2021)** indicated that exogenously applied NaHS (800 µM) led to higher soluble sugar, soluble protein, and ascorbic acid levels.

## Conclusion

Spraying ascorbic acid (2000 mg/l) and NaHS (500 µM) on "Le Conte" pear trees three times had a better effect on vegetative growth and increased APTI at both planting distances (10 m and 50 m off the freeway). Also, the treatments were more effective in pear trees' yield (180-212% for AA and 134-156% for NaHS), firmness, TSS, TSS/acid, V.C, total sugars, phenolics, peroxidase, and superoxide dismutase. The ascorbic acid and NaHS treatments had superior effects in increasing peroxidase and superoxide dismutase activities in "Le Conte" pear fruit. Moreover, pear tree's treated with SA (400 mg/l) had higher APTI values and resulted in the best improvement of fruit setting and retention, and the highest content of antioxidants. In addition, the use of NaHS and proline showed the best results in reducing Cd and Pb contents in pears followed by ascorbic acid and salicylic acid compared with the control.

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