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Alternative Natural Chelating Means for Iron as Compared With EDDHA on Le-Conte Pear Trees Budded on Calleryana Rootstock

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ABSTRACT

To overcome the problem of iron deficiency in the rootstock of *Pyrus calleryana*, due to its susceptibility to chlorosis caused by lime, to improve Le-Conte pear trees grafted on this rootstock, some natural materials were used to chelate iron and artificial chelated iron (EDDHA 6%). These materials were 1- Ascorbic acid (3.8g/tree) + ferrous (6.2 g/tree) 2- Humic acid (2.7g/tree) + ferrous (7.3g/tree) 3- Amino acids (3.6 g/tree) + ferrous (6.4g) 4- EDDHA (10 g/ tree) 5- Control. These treatments were added as ground additives under the trees in three doses at the beginning and middle of the growing season and a month before harvest. The most important results were: Ground application of ascorbic acid + ferrous, followed by Humic acid + ferrous iron treatment, led to a significant increase in the quantity of the crop as a result of an increase in the fruit set of the trees and an increase in the weight and size of the fruits and the dimensions of the fruits and increased the iron available to trees and increased the zinc and copper content of the leaves for ascorbic acid + ferrous. The best treatments for increasing hardness, TSS, and reducing the acidity of the fruits were as a result of the ground treatments with amino acids + ferrous iron as a result of the increased potassium, Fe and Mn content of the leaves.The humic acid + ferrous treatment showed an increase in the vegetative growth rate as a result of an increase in the nitrogen content of the leaves. The positive effects of these materials + ferrous are due to the increase in iron available in the soil compared to the control.

KEYWORDS: pear, *Pyrus calleryana*, Ascorbic acid, ferrous, Humic acid, Amino acids, yield and rhizosphere.

1. INTRODUCTION

Le-Conte pears are one of the most important deciduous fruit crops in Egypt. Its' acreage reached 12989 Fedanns, producing 82746 tons, according to the Agriculture Statistics (2021) of the Egyptian Ministry of Agriculture for the year 2021. Le-conte cultivar is susceptible to infection with Fire Blight bacterial disease. The majority of trees grown in Egypt are grafted on *Pyrus communis* rootstock. It blooms from mid-March to beginning of April where prevailing weather conditions are suitable for severe infection with this disease (Shakweer, 2017).

One of the means to prevent infection of fire blight is to graft trees onto *Pyrus calleryana* rootstock, as it is characterized by resistance to infection with the bacteria causing fire blight, and trees grafted on it are 10 days earlier in flowering compared to other rootstocks, thus escaping from weather conditions suitable for infection (Li Xuan *et al.,* 2011).

However, grafting on *Pyrus calleryana* rootstock is criticized for being sensitive to iron deficiency(lime induced chlorosis) , due to the high percentage of calcium carbonate in most Egyptian lands, the high soil pH of the soil, and deficit organic materials in it (Asaad *et al.*, 2014). Thus it is important to reduce the problem of the sensitivity of *Pyrus calleryana* rootstock to iron deficiency, which has important physiological roles and affects the growth, production and quality of the fruits of the Le-Conte pear variety (Hamouda *et al*., 2015; Murgia *et al*., 2022) Fertilization with iron is carried out by ferrous sulfate ($FeSO_4.7H_2O$) which is a cheap source. The available iron as ferrous (II) will be transformed into ferric (III) which is not available for the trees to absorb due to the high pH(Shirsat and Suthindhiran 2023).

To overcome the high pH of Egyptian soils, artificial iron chelates are used, (Hansen, 2006) but they are expensive, and these products are lost through filtration or adsorption to soil particles due to the high percentage of calcium carbonate and its' association with calcium and magnesium because they are positively charged and may be attracted to the negative charges created by the chelates (Ferreira *et al*., 2019).

Thus, some additives can be used for ferrous iron to improve its' availability to trees and increase the absorption of iron. These additives are characterized by their ability to be biodegradable, environmentally friendly, and of low cost compared to artificial chelates (Liñán, 2007; Chakraborty *et al.,* 2016). These materials include Ascorbic acid + ferrous; Humic acid + ferrous; Amino acids + ferrous and EDDHA (ethylene diamine-di-ortho-hydroxy phenyl acetic acid).

Ascorbic acid is a chemically defined compound, having the empirical formula $C_6H_8O_6$ and a molecular weight of 176.13 (Roche Vitamins 2000). The role of Ascorbic acid as a reducing agent and oxygen scavenger explains some of its biological functions (Teucher and Cori 2004). Enhancing translocation by combining some additives such as Ascorbic acid (Fe transporters in the plants), some positive responses were reported, but they seemed to be species-dependent and not sufficiently substantiated (Shenker, and Chen, 2005). One of Ascorbic acid main attributes is its ability to reduce ferric to ferrous. Ascorbic acid undergoes a reversible two-stage redox process with a free radical intermediate. The latter reacts preferably with it, thus preventing the propagation of free radical reactions (Herbert *et al*., 1996). At the same time, Ascorbic acid maintains a transition metal, such as Fe (III), in its reduced form Fe (II) and can promote the reaction of these ions with hydrogen peroxide to form highly reactive hydroxyl radicals in the Fenton reaction (Nappi *et al.,* 2002).

Humic large organic molecules with a complex and stable chemical structure (Schnitzer, 2000; Sutton and Sposito, 2005) improves iron nutrition because humic binds to iron via Binding could occur through: 1) A water bridge; 2) electrostatic attraction to a charged COO- group; 3) formation of coordinate linkages with a single donor group; and 4) formation of chelate structures, such as those with COO- and phenolic OH- site combinations (Shenker, and Chen, 2005)., which acts as a chelator, providing a stable compound for a wide range of pH (Nikoosefat *et al*., 2023). Homic acid also converts iron (III) into soluble forms due to its photocatalytic and redox properties, which leads to an increase in soluble iron and enhances the transfer of iron from the roots to the leaves (Yang *et al*., 2021). It also reduces phosphorus deficiency in calcareous soils (Jalali and Jalali 2022; Zhao *et al.*, 2023) and works on the bio-balance of nutrients through soluble complexes with minerals and increases nutrient absorption

(Olego *et al.*, 2022; Sun *et al.*, 2020;Massimi *et al.*, 2023; Sharma *et al.* 2023)..

Free amino acids binds to iron via steric arrangement of free amino acid binding sites around iron, as occurred in synthetic chelators. Fe forms stable complexes with cysteine and glutamic acid (Lucena, 2009).

Synthetic Fe chelates such as ethylene diamine-di-ortho-hydroxy phenyl acetic acid (EDDHA) have been shown to be effective for application to soils in which Fe deficiency is a problem (Hansen, 2006). Iron chelates aid in the movement of iron to plant roots, but they are neither absorbed to any great extent nor do they raise the activity of $Fe3+$ or $Fe2+$ in the bulk soil solution (Zhou *et al.*, 2021).

The goal of research is to overcome the problem of iron deficiency in the rootstock of Pyrus calleryana, due to its susceptibility to chlorosis caused by lime, to improve Le-Conte pear trees grafted on this rootstock, some natural materials were used to chelate iron (Ascorbic acid, Humic acid, Amino acids) and artificial chelated iron EDDHA (6%).

2. MATERIALS AND METHODS

The present investigation was performed during 2020, 2021 and 2022 seasons in Horticultural Research Institute orchard, Agriculture Research Center, Giza, Egypt. Seventeen years old Le-Cont pear trees budded on Pyrus calleryana rootstock uniform in vigor and spur load were considered. Trees were spaced at 3.5*4 m vase trained and grown in clay silty soil and flood irrigated. All trees received the same cultural practices recommended by the Ministry of Agriculture.

The present research study was initiated in 2020 and extended for three successive growing seasons. The first season was considered to be a preliminary season to eliminate the residual effects of the previously used fertilizer treatments.

Each three trees (with each tree acting as a replicate) were subjected to a specific ground addition under the canopy of the tree into 3 doses per season, the first at the beginning of the growing season (March), the second in the middle of the growing season (May), and the third a month before harvest (July)

.. The considered treatments were as follows;

1- 10g per tree (3.8g Ascorbic acid + 6.2 g ferrous sulfate ($FeSo_4$).

2- 10g per tree (2.7g Humic acid + 7.3g ferrous sulfate).

3- 10g per tree (3.6g Amino acids + 6.4g ferrous sulfate).

4- EDDHA (10 g/ tree).

5- Control (without ground additives).

- The amounts of ferrous iron vary according to the molar quantities according to the specialist Dr. Mahmoud Al-Bordini, Department of Lands and Water, Faculty of Agriculture - Ain Shams University.

For each of the considered seasons the following parameters were assessed: **Fruit set percentage:** 4 branches with nearly same load of spurs around the circumference were chosen and labeled. Fruit set percentage was calculated 3 weeks after full bloom according to Westwood (1978).: Fruit set % = (Total No. of fruitlets/Total No. of flowers) x 100)

Yield (Kg/tree): At maturity according to El-Azzouni *et al.* (1975) average fruit weight of 10 fruits per replicate were measured and number of fruits per tree were counted and yield was estimated as follows: average fruit weight* number of fruits per tree

Yield attributes:

a) Physical attributes: At maturity, a representing sample of 20 fruits per tree were harvested from trees dedicated to sampling. The following characteristics were assessed Fruit weight (g.), fruit volume(cm3), fruit length (cm.), width (cm.) and unpeeled fruit firmness (Lb. /inch2) by Lfra texture analyzer.

b) Chemical attributes: Total soluble solids percentage (TSS %) were determined in fruit juice by Abbe hand refractometer. Total acidity percentage (TA %) as malic acid was determined in fruit juice according to A.O.A.C. (1995), and TSS/acidity.

Vegetative growth attributes):-at growth cessation for each considered tree ten of current season's shoots were selected at random from each replicate for determining the following parameters; average shoot length (cm) by using a ruler, shoot diameter (cm) by using a vernier caliper and number of leaves/shoot.

Chemical determinations:

a) Foliar macro-nutrients: On mid-August, after harvest a sample of fifty mature leaves were taken from the mid region of current year's shoots from trees dedicated for sampling of each replicate. For the determination of N and K. Nitrogen % was estimated by microkjeldahl Gunning method (A.O.A.C. 1995). Potassium % was estimated by flame photometer as Jackson (1973). Ca , Mg (%) Fe, Zn, Mn and Cu (ppm) by using Atomic Absorption Spectrophotometer, Pye Unican SP1900, According to Brandifeld and Spincer (1965).

Feasibility study: To assess the applicability of promising treatments the following simple feasibility study was carried out

Cost/Feddan (LE)= Cost of material per for one tree for 3 times* number of tree/Feddan (300 tree).

Yield/Feddan (Ton) = Fruit yield kg/tree * No. of tree/Feddan (300 tree).

Net profit = Gros income.- (cost of treatment+cost of remaing horticultural practices)

Gros income/Feddan (LE) = Price of one ton in farm*tree yield ton/ Feddan*yield per fedan

The price of one ton = the price at farm gate was 10000 and 12000 for both seasons respectively.

Net profit = Gros income – (cost of treatment + cost of remaing horticultural practices).

Statistical analysis : The experiment was arranged as a randomized complete blocks design with three replicates and each replicate consisted of one tree and the collected data were statistically analyzed according to Snedecor and Cochran (1990). Means of treatments were compared using least significant difference (LSD) test at $P < 0.5$.

3. RESULTS AND DISCUSSION

The results in Table 1 show the effect of various ground additions of chelating agents on percentages of fruit set and yield. The Significant increases in fruit set measurements and pear crop quantity compared to the control were detected. The best chelating agents were ascorbic + ferrous sulfate treatment gave the highest percentage of fruit set and yield per tree, followed by the humic acid + ferrous sulfate treatment during the two seasons of the experiment.

Table 1. Effect of adding ground treatments on initial, final fruit set and yield.

	Final fruit set %		Yield (kg/tree)	
	2021	2022	2021	2022
Ascorbic acid+ $FeSo_4$	8.83 A	15.95 A	24.60 A	43.97 A
Humic acid + $FeSO_4$	7.43 B	10.60 B	23.60 B	33.66 B
Amino acids + $FeSO_4$	4.46 D	5.93 D	10.80 D	14.36 D
EDDHA	5.51 C	6.43 C	15.33 C	17.06 C
Control	1.85 E	4.64 E	4.580 E	14.36 D
LSD	1.03	0.39	0.45	0.46

The applied treatments gave an increase in the weight, size, length and diameter of the fruit compared to the control, which recorded the lowest for these measurements. Ascorbic acid + ferrous sulfate ($FeSo_4$) gave the best results for these mentioned characteristics, and the humic acid + ferrous sulfate treatment was the next in line (Table 2).

It is clear in this study that the highest yield resulted from treatments with ascorbic acid added to ferrous sulfate. This may be due to lowering the pH in the rhizosphere and increasing the absorption of mineral elements as it increased the iron available to trees (Table 5) and increased the zinc and copper content of the leaves (Table 6), which leads to an increase in yield, size and dimensions of fruits (Brunetto *et al.,* 2015; Bhatla *et al.,* 2018).

The results in Table 3 show the effect of ground treatments on fruit firmness, TSS, acidity, and the ratio of TSS to acidity. Amino acids + $FeSO_4$ treatment was the best treatment

Table 2. Effect of adding ground treatments on weight, size, length and diameter of fruit.

	Fruit weight(g)		Fruit size (cm3)		Fruit length (cm)		Fruit diameter (cm)	
	2021	2022	2021	2022	2021	2022	2021	2022
Ascorbic acid+ $FeSO_4$	164 A	293 A	162 A	291 A	8.30 A	9.63 A	6.40 A	7.87 A
Humic acid + $FeSO_4$	158 B	224 B	155 B	253 B	7.51 B	8.87AB	6.23 B	7.23 B
Amino acids + $FeSO_4$	126 D	167 D	113 D	173 D	7.30 B	7.90 CD	6.07 C	6.60 C
EDDHA	134 C	207 C	146 C	206 C	7.63 B	8.27 BC	6.17 B	6.83 C
Control	104 E	161 E	102 E	160 E	6.62 C	7.40 D	5.90 D	6.17 D
LSD	3.75	4.09	2.18	2.80	0.65	0.80	0.16	0.39

Table 3. Effect of adding ground treatments on firmness, TSS, acidity and TSS/acidity of fruit.

	Firmness (Ib/inch2)		TSS (%)		Acidity (%)		TSS/acidity	
	2021	2022	2021	2022	2021	2022	2021	2022
Ascorbic acid + $FeSO_4$	19.93C	19.83D	15.42B	19 B	0.282C	0.474C	54.68B	40.08B
Humic acid + $FeSO_4$	20.50B	20.73B	15.33B	18.60C	0.286C	0.503B	53.60C	36.98D
Amino acids + $FeSO_4$	22.32A	21.23A	16.00A	19.70A	0.277C	0.461D	57.76A	42.73A
EDDHA	19.37D	20.40C	15.50B	18.73C	0.316B	0.486C	49.05D	38.54C
Control	18.78E	19.80D	15.00C	18.20D	0.371A	0.584A	40.43 E	31.16E
LSD	0.55	0.32	0.23	0.26	0.051	0.016	1.05	1.52

an increasing fruit firmness and TSS, reducing acidity, and increasing the TSS-to-acidity ratio compared to the control, which recorded the lowest values for firmness and TSS, the highest fruit acidity, and the lowest TSS -to-acidity ratio during the two seasons of the study.

In this study, Amino acids + $FeSO_4$ treatment increased fruit firmness may be due that amino acids decreased ethylene influences on fruit cells (Khedr, 2018). Also, higher TSS is due to increasing the leaves' content of potassium, iron and manganese (Table 6) and there by increasing chlorophyll production, leading to enhancing the efficiency of photosynthesis, and increasing protein production from amino acids (Hamouda *et al.*, 2015).

Data in Table 4 showed that; Humic acid + $FeSO_4$ ttreatment gave the longest shoot and shoot thickness compared to the rest of the treatments and control. While Ascorbic acid+ $FeSo_4$ treatment recorded the shortest shoot and control recorded the thinnest branch.

Ascorbic acid+ $FeSo_4$ treatment appeared to be the best in terms of the number of leaves on the branch compared to other treatments and control, which had the lowest number of leaves (Table 4).

Table 4. Effect of adding ground treatments on shoot length diameter and number of leaves

	Shoot length (cm)		Shoot diameter (cm)		Number of leaves	
	2021	2022	2021	2022	2021	2022
Ascorbic acid+ $FeSo_4$	39.25 C	37.38 C	0.86 B	0.83 A	15.08 A	15.33 A
Humic acid + $FeSO_4$	45.50 A	42.63 A	0.91 A	0.84 A	14.88 B	14.25 B
Amino acids + $FeSO_4$	38.13 C	38 C	0.76 D	0.74 B	14.50 C	14 B
EDDHA	39 C	41.38 B	0.81 C	0.81 A	14.67 C	13.42 C
Control	40.67 B	41.42 B	0.64 E	0.72 B	13.17 D	12.92 D
LSD	1.23	1.15	0.04	0.06	0.18	0.45

Data in Table 5 show the effect of application of different organic acids and EDDHA on total and chemically available Fe during the two seasons compared with control. Generally, total and chemically available Fe increased with different treatments compared with control particularly with application of EDDHA. Total Fe concentration increased with application of ascorbic, humic, amino acid, EDDHA reaching 11.2, 12.4, 11.2 and 10.54 %, respectively than that of the control. Where as, the chemically available Fe concentration increased with application of the same treatments were 17.9, 15.9, 9.3 and 14.0%, respectively than that of the control. Data reveal that the application of humic acid increased amount of total Fe in soil whereas, ascorbic acid increased amount of chemically available Fe in soil compared with different treatment. This may be due to humic acids are colloids and behave somewhat like clays. Also, applications of humic acid have been attributed to the improvement of physical, chemical and biological conditions of soil (Yang, *et al.*, 2021; Tiwari, *et al*.,2023). The Application of ascorbic acid may be due to decreases soil pH so chemically available Fe increased in soil (Brunetto *et al.*, 2015; Bhatla *et al.*, 2018).

Table 5. Effect of adding ground treatments on percentage of total iron and available iron in soil samples before and after the experiment.

Treatments	Total Fe (%)		Available Fe (ppm)	
	2/2021	9/2022	2/2021	9/2022
Ascorbic acid + $FeSO_4$	5.46	5.85	5.60	6.31
Humic acid + $FeSO_4$	5.50	5.91	5.65	6.20
Amino acids + $FeSO_4$	5.55	5.85	5.50	5.85
EDDHA	5.51	5.81	5.80	6.10
Control	5.30	5.26	5.35	5.35

Iron concentration and availability at the end of the investigation show that total Fe concentration increased with treatments ascorbic, humic, amino acid, EDDHA reaching 7.14, 7.45, 5.4, and 5.44% respectively than that of the control. wheras, the chemically available Fe concentration increases with application of the same treatments were 12.68, 9.73, 6.36, and 5.45%, respectively, compared to the control.

Table 6. Shows the effect of treatments on the leaves' content of mineral elements.

Treatments	N%		K%		Fe (ppm)	
	2021	2022	2021	2022	2021	2022
Ascorbic acid + $FeSO_4$	2.10B	1.54 C	1.48 C	1.41 B	51.45 D	57.53 C
Humic acid + $FeSO_4$	2.31 A	1.82 A	1.45 C	1.41 B	57.50 C	61.43 B
Amino acids + $FeSO_4$	1.82 D	1.35 D	1.65 A	1.56 A	63.93 A	69.07 A
EDDHA	1.96 C	1.54 C	1.53 B	1.42 B	59.97 B	56.01 D
Control	2.17 B	1.68 B	1.40 D	1.36 C	46.5 E	43.40 E
LSD	0.13	0.11	0.03	0.04	2.45	1.50
Treatments	**Zn (ppm)**		**Mn (ppm)**		**Cu (ppm)**	
	2021	**2022**	**2021**	**2022**	**2021**	**2022**
Ascorbic acid + $FeSO_4$	24.45 A	25.83 A	33.75 C	33.15 C	8.1 A	7.95 A
Humic acid + $FeSO_4$	21.80 E	23.77 D	33.87 C	33.17 C	7.60 B	7.47 C
Amino acids + $FeSO_4$	22.83 D	24.73 B	35.57 A	36.1 A	6.23 D	7.07 D
EDDHA	23.93 B	24.10 C	34.87 B	35 B	6.70 C	7.73 B
Control	23.4 C	23.85 D	27.65 D	32 D	6 E	6.50 E
LSD	0.51	0.24	0.69	1.09	0.21	0.18

Humic acid + $FeSO_4$ treatment gave the highest significant increase in the nitrogen content of leaves compared to the other treatments and the control, while the lowest nitrogen values were for Amino acids + $FeSO_4$ treatment.

Amino acids + $FeSO_4$ treatment gave the highest potassium leaves content compared to the other treatments and the control, which recorded the lowest potassium content during the two seasons (Table 6).

Data in Table 6; show that Amino acids + $FeSO_4$ treatment resulted in significant increases in the Fe and Mn content of the leaves compared to the other treatments and the control, which had the lowest Fe and Mn content in the leaves. Ascorbic acid+ $FeSO_4$ treatment showed significantly better results for the zinc and copper content of the leaves. While, the lowest zinc leaves content were in the trees treated with humic acid + $FeSO_4$. Control had the lowest leaves Cu during the two seasons of the study.

In this study, humic acid + $FeSO_4$ treatment increased the nitrogen content in the leaves, which led to an increase in shoot length and thickness for the same treatment (wang, *et al.*, 2017).

Increasing the potassium, iron and manganese content of leaves by amino acids + FeSO4 treatment may be one of the reasons to explain the increase in TSS and raise the ratio of TSS to acidity (Dar, *et al.*, 2015).

Table 7. Feasibility study for treatment applied on Le-Cont pear in 2021 and 2022 seasons

Treatments	Yield/Fad (Ton)		Cost/Fad (LE)		Total income (LE)		Net profit (LE)	
	2021	2022	2021	2022	2021	2022	2021	2022
Ascorbic acid+ $FeSo_4$	4.16	7.43	2337	2337	41600	89160	39263	86823
Humic acid + $FeSO_4$	3.99	5.69	852	852	39900	68280	39048	67428
Amino acids + $FeSO_4$	1.83	2.43	1485	1485	18300	29160	16815	27675
EDDHA	2.59	2.88	1521	1521	25900	34560	24379	33039
Control	0.77	2.43	0	0	7700	29160	7700	29160

The economic feasibility study (Table 7) showed that Ascorbic acid+ $FeSO_4$ led to the highest productivity per Faddan and the highest net profit per Faddan during the two study seasons. While the control was less productive and had less net profit per Faddan.

The positive effects of these materials + ferrous are due to the increase in iron available in the soil rhizosphere of *Pyrus calleryana* rootstock compared to the control. Iron (Fe) plays a crucial role in photosynthesis producing chlorophyll which involved in the absorption of light needed for plant growth, nitrogen fxation, nitrate synthesis, hormone production, and DNA production, mitochondrial respiration, and, as a cofactor of enzymes and found in high proportions in chloroplasts—up to 80% (Murgia et al., 2022). Also, its composition of many enzymes such as Peroxidase for the formation of lignin and suberine, it plays a fundamental role in the conversion of leaf nitrogen to the protein, it has a major role in the protection of chlorophyll from severe sunlight (Al-Zerfey, 2012).

4. CONCLUSION

The most important results were Ascorbic acid (3.8g/tree) + ferrous (6.2 g/tree) followed by Humic acid (2.7g/tree) + ferrous (7.3g/tree) were added as ground additives under the trees in three doses at the beginning and middle of the growing season and a month before harvest led to highest yield due to an increase in the final set of the trees and an increase in the weight and size of the fruits and the dimensions of the fruits and the highest productivity per Faddan and the highest net profit per Feddan during the two study seasons.

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الملخص العربي

وسائل استخلاب طبيعية بديلة للحديد بالمقارنة مع EDDHA على أشجار الكمثرى الليكونت المطعومة على اصل الكالاريانا

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للتغلب على مشكلة نقص الحديد للاصل الكلاريانا والمتسبب عن .ايادة الجير للذايد انتاج وجود ثمار الكمثرى الليكونت المطعومة عليه تم استخدام بعض المود الطبيعية لخلب الحديد والحديد المخلبى EDDHA.

وهذه المواد هي ١- حامض الاسكوربيك (٣,٨ جم/شجرة) + حديدوز (٦,٢ جم/شجرة) ٢- حمض الهيوميك (٢,٧ جم/شجرة) + حديدوز (٧,٣ جم/شجرة) ٣- أحماض أمينية (٣,٦ جم/شجرة) + حديدية (٦,٤ جم) ٤- 10) EDDHA جم/شجرة) ٥- كنترول, وأضيفت هذه المواد كاضافات أرضية تحت الأشجار على ثلاث جرعات في بداية ومنتصف موسم النمو وقبل شهر من الحصاد.

كانت اهم النتائج: ادت الاضافة الارضية لحامض الاسكوربيك + الحديدوز تليها معاملة حامض الهيوميك + الحديدوز الى زيادة معنوية للعقد النهائى وكمية المحصول للاشجار ووزن وحجم الثمار وابعاد الثمار.

وكانت افضل المعاملات لزيادة الصلابة وتى اس اس وقليل حموضة الثمار نتيجة للمعاملات الارضية بالاحماض الامنية + الحديدوز نتيجة لذيادة محتوى الاوراق من البوتاسيوم.

وظهرت معاملة حامض الهيوميك + الحديدوز زيادة فى معدل النمو الخضرى نتيجة زيادة محتوى الاوراق من النيتروجين.

وترجع التاثيرات الاجابية لهذه المواد + الحديدوز الى زيادة الحديد المتاح لاشجار الكمثرى فى التربة .

الكلمات المفتاحية: الكمثرى، بيرس كاليريانا، حمض الأسكوربيك، الحديدوز، حمض الهيوميك، الأحماض الأمينية، المحصول.