Journal of Plant Production

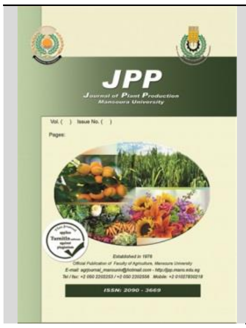
Journal homepage: www.jpp.mans.edu.eg
Available online at: www. jpp.journals.ekb.eg

Benefit Optimization of Molybdenum and Iron Roles in Raising Productivity Efficiency and Fruit Attributes of Le-Conte Pear Trees

Cross Mark

Abd-El-Latif, F. M.[1]; Kh. A. Bakry[1]; S. F. El-Gioushy[1]; A.M. Hussein[2] and M. S. Mohamed[2*]

[1] Horticulture Department, Faculty of Agriculture (Moshtohor), Benha University, Egypt
[2] Horticulture Research Institute, Agricultural Research Center, Egypt



ABSTRACT

This study was carried out during 2018 and 2019 seasons on 12- year- old Le Conte pear trees (*Pyrus communis L.X Pyrus pyrifolia N.*) budded on *Pyrus betulaefolia* rootstock, planted at 5 × 5 meters apart (168 trees / feddan) in sandy soil under drip irrigation system and grown at El-Kassasien Horticultural Research Station, Ismailia Governorate. This done aimed to benefit from Mo and Fe roles in improving le-conte pear trees productivity and fruit quality. The results indicate that the combinations between the two investigated elements reflected apposstive effect on yield and fruit quality than spraying with each component individually. The best result was achived with Mo at 0.5 cm/L combined with Fe at 3g/L as such treatment improved all studied parameters. The un sprayed trees were the inferior one in this respect.

Keywords: Molybdenum- Iron- Fruit Attributes - Pear Trees

INTRODUCTION

Le-Conte pear trees is one of the important deciduous fruits trees in Egypt. It can be grown in a wide range of climatic conditions as it can tolerate as low as -26°C temperature when dormant and as high as 45°C during growing period. A large number of pear cultivars require about 1200 hours below 7°C during winter to meet their chilling requirements to flower and fruit satisfactorily.

Molybdenum is a trace element essential for plant growth. However, apart from its function in nitrate reductase, there is little known about the function of molybdenum in higher plants (Agarwala *et al.* 1979).

The transition element molybdenum (Mo) is a very rare but essential micronutrient for all organisms (Fortescue, 1992), and understanding of its role and function in plants is progressing rapidly. Its importance for plants has been known for a long time (Coughlan, 1980), even though Mo itself seems to be catalytically inactive in biological systems until it is complexed by a special cofactor, the pterin (Mendel and Hänsch, 2002) which binds to diverse apoproteins. This latter compound is a unique pterin named molybdopterin or metal-containing pterin. In this form, it occurs in more than 40 enzymes catalysing many redox reactions, four of which have been found in plants (Hille, 1996; Kappl *et al*., 2002). One of these is nitrate reductase (NR) that catalyses the first step in nitrate assimilation, a pathway of key importance for plant nutrition. Nitrate reductase is the key-enzyme for nitrate assimilation while nitrogenase is found in nitrogen- fixing bacteria inside nodules of symbiotically growing species. The last step of abscisic acid biosynthesis is catalyzed by the molybdenum-enzyme aldehyde oxidase, and sulfite oxidase protects the plant against toxic levels of sulfite (Hänsch and Mendel, 2009) The mobility of iron in the plant is very low; it is present in two oxidation forms, Fe+3 (ferric) and Fe+2 (ferrous). In the presence of O2 Fe+2 is rapidly oxidized to Fe+3, which is poorly soluble in water and becomes unavailable to plants. When a plant grows in calcareous (high concentration of calcium carbonates) or alkaline soils (pH "7 to 9"), it develops symptoms of iron chlorosis that result because Fe isn't found in an available form. New growth that emerges will be chlorotic (Tagliavini *et al*., 2000). So, rapid response is required to correct a chlorotic condition by foliar spray with iron sulfate solution (Salazar-García, 1999, El-Jendoubi *et al*., 2014 and Hamouda *et al*., 2015).

Foliar application of iron sources (Fe-EDTA, Fe-EDDHA and Fe-Mineral "FeSO4.7H2O") led to significantly increases of leaves and fruits nutrient, chlorophyll contents and active iron in the leaves, as well as there is a strong significant relationship between fruit nutrient contents, yield and pear fruit quality (Hamouda *et al*., 2015). In this respect, several literatures on pear were published (Álvarez-Fernández *et al*., 2004; Álvarez-Fernández *et al*., 2006; Álvarez-Fernández *et al*., 2011; Mansour *et al*., 2008; Dar *et al.*, 2012; Asaad *et al*., 2013).

Balancing of micronutrients is important for plant system, depending on its life cycle, environment and its genotypic characteristics to realize its maximum genetic potential. Synergism and antagonism between two mineral nutrients become even more important when the contents of both elements are near deficiency range (Malvi, 2011).

The aim of this study is to examine the effect of foliar spraying with molobidenum and iron on yield and fruit quality attributes of le-conte pear trees.

MATERIALS AND METHODS

This investigation was carried out during 2018 and 2019 growing seasons on 12- year- old Le-Conte pear trees (*Pyrus communis L.X Pyrus pyrifolia N.)* budded on *Pyrus betulaefolia* rootstock, planted at 5 × 5 meters apart (168 trees / feddan) in sandy soil under drip irrigation system and grown at El-Kassasien Horticultural Research Station, Ismailia

*** Corresponding author.**
E-mail address: Mohamed.sami661@yahoo.com
DOI: 10.21608/jpp.2020.110569

Governorate. Twenty seven fruitful "Le-Conte" pear trees were carefully selected for this work.

Those trees were similar in growth vigor, size, shape ,diseases free and they received the same Horticulture managements adopted in such Station, included the organic fertilization with compost at the rate of 25kg/tree on December and NPK mineral fertilizers which were added at the recommended rate by the Ministry of Agriculture (450, 100 and 500 g N, P and K per tree/ year, respectively) in the two seasons of study through drip irrigation system. The chemical fertilizers doses were added as soil applications into three equal doses at first week of March, second week of May and first week of July. ammonium nitrate (NH_4NO_3, 33.5 % N) was used as a source of nitrogen at1321g, mono Calcium phosphate (15.5 % PO_5) at 645 g and potassium sulphate (high dissolve, 50% K_2O) was used as a source of potassium at1000g of both seasons.

Mechanical and chemical analysis of orchard soil have been carried out prior to the first season according to Piper (1947) and Jackson (1967) as shown in Table (1).

Table 1. Physical and chemical analysis of orchard soil.

Physical characteristics %		Chemical characteristics	
Field capacity	11.77	$CaCO_3$ %	12.25
Available water	7.54	Organic matter %	0.08
Wilting point	4.23	pH	7.5
Coarse sand	67.01	EC (ds/m)	2.14
Fine sand	9.5	Ca(mg/100g)	0.14
Silt	0.7	Na (mg/100g)	0.34
Clay	5.2	K (mg/100g)	0.16
Texture class	Sandy	Cl (mg/100g)	0.30

Rate and method of the investigated materials application will be summarized briefly as follows:

Molybdenum Foliar Spray

Agro leen (Commeriac name) was used as source of Mo which contains (3 %Mo and 1 % Br). Mo was used in two doses 0.5 and 1.5 cm/L, each dose was sprayed in early flowering, after fruit set and one month after fruit harvesting.

Iron as Foliar Spray

Ferrous sulphate ($FeSO4.7H_2O$) was used as source of iron in two concencentrations 1 and 3 g/L, each one was sprayed three different times, early flowering, after fruit set and one month after fruit harvesting.

The two investigated materials including:

Molybdenum and Iron were arranged and designed in different combinations in order to build up the skeleton of the following eight investigated treatments beside the control.

T1. Water spray (untreated control)
T2. Mo 0.5 cm / L / tree / dose
T3. Mo 1.5 cm / L / tree / dose
T4. Fe 1g / L / tree / dose
T5. Fe 3g / L / tree / dose
T6. Mo 0.5 cm / L / dose + Fe 1g / L / tree / dose
T7. Mo 0.5 cm / L / dose + Fe 3g / L / tree / dose
T8. Mo 1.5 cm / L / dose + Fe 1g / L / tree / dose
T9. Mo 1.5 cm / L / dose + Fe 3g / L / tree / dose

The extent to which trees responded to the treatments was examined by stadying the following factors:

Fruiting aspects: Initial fruit set percentage:

Four branches with the same age (more than two years) were selected on each tree (replicate). The total number of flowers on each limb was counted at full bloom and the number of set fruits was counted on the same limbs. Fruit set % was calculated as follows:

Initial Fruit set percentage = (number of developing fruitlets / total number of flowers) X100

Yield per tree: Fruits were harvested at maturity stage (the last week of August) from each tree of various replicates and yield was recorded either as number of fruits/tree or as Kg/tree.

Fruit characteristics: Fruit samples were taken from the tested trees at a rate of 15 fruits per tree (15 fruits / replicate) for the following determinations:

Fruit Physical properties: Average fruit weight (g): Average fruit size (volume) (cm3): Average fruit length (L) and diameter (D) in (cm):

Fruit shape index (L/D): Fruit firmness (L/inch2): was determined by using penetrometer (pressure tester) (advance force gorge RH 13 UK). Fruit Chemical properties:

Fruit pulp juice total soluble solids (T.S.S): were measured by using a carl zeiss hand refractometer.

Fruit flesh total acidity (%): determined as malic acid (g/ 100g flesh weight) according to Association of Official Agricultural Chemists (1995).

TSS/acid ratio:

TSS/acid ratio was estimated by dividing the TSS % on total acidity %.

Fruit flesh total sugars content: Total sugars of the fruit pulp were determined coloremetrically according to (Dubais *et al*., 1956). Vitamin C: fruit vitamin C was estimated as (mg/ 100 g) fresh pulp according to Association of Official Agricultural Chemists (1995).

Statistical Analysis:

The Complete randomized blocks design was used for arranging the above mentioned nine treatments, whereas each treatment was replicated three times and each replicate was represented by an individual fruitful pear tree. All data in the both seasons of study were statistically analyzed using the analysis of variance method according to Snedecor and Cochran (1980). However, means were distinguished by the Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISSECTION

Some fruit aspects:

Initial fruit set percentage (%):

The data in Table (2) cleard that all the treatments improved the studied parameter. Furthermore, combination between Mo and Fe. while the application of element alone reflected less response. The high dose of Fe (3g/L) assouated with Mo without regard to its concentration (T8 and T9) were the superior two treatments in this respect.

Number of fruits / tree:

With respect to the response of number of fruits/tree of Le-Conte pear trees as impacted by Mo and Fe, data presented in Table (2) clear that there were significant differences between the investigated treatments in relation to number of fruits /tree. Furthermore, the trees which were with Mo + Fe at 1.5cm/L/tree, 1g/L/tree, respectively (T8) gave the highest sprayed number of fruits /tree as compared with the other investigate treatments. Meanwhile, sprayed trees with Mo at 0.5 cm/L with Fe either at 1 or 3 g/L (T6and T7) reflected an acceptable increment in number of fruits /tree and in turn both treatments ranked the second in this respect. In addition, sprayed trees with either element (Mo or Fe) alone

(T3, T4 and T5) came after the abovementioned two treatments (T6 and T7) and ansubsequently occupied the third rank in this respect. Such trend was true during both seasons of study. On the other way around, the reverse was true with untreated trees (control-T1) which exhibited the lowest number of fruits/tree as it was the inferior one in this respect followed in ascending order by those sprayed with Mo at 0.5 cm /L (T2).

Yield (kg/tree):

Regarding the impact of the different investigated treatments on yield (kg/tree) of Le-Conte pear trees, data in Table (2), indicate that the investigated parameter (yield) was highly significant affected by the different tested treatments. Herein, sprayed pear trees with Mo at 1.5 cm /L and Fe at 1g/L (T8) proved to be the superior one in this respect as it maximized the investigated parameter (yield /tree) comparing to the other investigated treatments. Such trend was true during two seasons of study. Meanwhile, spraying with Mo combined with Fe (T6 , T7 and T9) was better than spraying with either Fe at 3g/L alone (T5) or Mo at 0.5 cm /L alone (T2). On the other hand, the worsen yield value was obtained when the trees were not received any of the investigated treatments (untreated trees-controlT1). These results coincided with those found by Hafez *et al.*, (2018) and El-Dahshouri *et al.*, (2017) on Le Conte pear trees. They found that foliar spraying by five mineral iron concentrations (0.0, 250, 500, 1000 and 2000 ppm) as ferrous sulphate (FeSO4.7H2O) form at two times (Mid May and June) led to highest increment of yield/ tree compared with the untreated trees.

Table 2. Initial fruit set percentage (%), Number of fruits /tree and Yield (kg/tree) of "Le-Conte" pear trees as impacted by foliar spray with molybdenum and iron during 2018 and 2019 seasons.

Evaluated parameters	fruit set (%)		Number of fruits /tree		Yield (kg/tree)	
Seasons treatments	2018	2019	2018	2019	2018	2019
T1- Water spray (untreated control)	6.59 e	6.59 e	165 e	168 e	26.25 d	27.28 d
T2- Mo 0.5 cm / L / tree / dose	7.69 d	7.70 d	177.33 d	181.33d	30.31 c	31.72 c
T3- Mo 1.5 cm / L / tree / dose	8.00 d	8.03cd	185.33 c	191.33 c	35.22b	36.65 b
T4- Fe 1gm / L / tree / dose	8.08 d	8.11 cd	186 c	190.33 c	34.08b	35.22 d
T5- Fe 3gm / L / tree / dose	7.98 d	8.02 cd	182.67 c	187 c	32.50c	33.53c
T6- Mo 0.5 cm/L + Fe 1g/L	9.62 b	9.64 b	189.67 b	195.33b	34.72b	36.22 b
T7- Mo 0.5 cm/L + Fe 3g/L	8.76 c	8.77 c	189 b	194.33bc	35.95b	37.39 b
T8- Mo 1.5 cm/L + Fe 1g/L	11.86 a	11.93a	212 a	226 a	45.18 a	51.04 a
T9- Mo 1.5 cm/L + Fe 3g/L	11.39 a	11.42 a	195 b	199.67b	38.73 b	40.05 b
LSD	0.561	0.587	8.194	7.923	3.235	1.57

Fruit characteristics:

Fruit physical properties:

Fruit weight (g)

Concerning fruit weight of Le-Conte pear trees as affected by the different studied treatments, data presented in Table (3) reveal that there was a variable response to the different investigated treatments. The highly positive response of fruit weight was detected with those trees which were sprayed with Mo at 1.5 cm/L +Fe at 1g/L-T8, as such treatment was in the top of the treatments evaluation. Such treatment produced the heaviest fruit weight comparing with the other investigated treatments during 2018 and 2019 seasons of study, followed by spraying with Mo + Fe (Mo at 1.5 cm/L and Fe at 3g/L (T9 and T7) which ranked respectiely second in the frame of treatments evaluation, meanwhile spraying with either Fe alone (Fe 1g/L T4) or combined with Mo at 0.5 cm/L (T6) came third. On the other hand, the least fruit weight was gotten with untreated trees (T1). These results are in harmony with those reported by Hafez *et al.*, (2018) and Hamouda *et al.*, (2015) they studied the effect of foliar application with different iron sources (Fe-EDTA, Fe-EDDHA and Fe-mineral as form ferric sulphate "FeSO4.7H2O" on fruit pear quality. They found that Fe was effective in stimulating fruit weight fruit diminsions.

Fruit volume (cm3):

Data dealing with fruit size (volume) of Le-Conte pear trees as impacted by the different investigated treatments, are presented in Table (3). It was quite clear that there were remarkable significant variations among the investigated treatments, when fruit size parameter was concerned. Furthermore, foliar spray with Mo + Fe (Mo 1.5 cm/L + Fe at 1g/L T8) was the best one in this respect, as it maximized the investigated parameter, as compared with the other investigated treatments. Meanwhile, foliar spray with Mo + Fe (Mo 1.5 cm/L + Fe at 3g/L T9) came after (T8) and in turn standed the second rank in this respect. On the other hand, the untreated trees with any of the investigated treatments (control-T1) was the inferior one in this respect as it recorded the least value of fruit size, followed in ascending order by spraying with Mo at 0.5 cm/L (T2) during both seasons of study.

Fruit firmness L/inch2:

Referring to the relation between fruit firmness of le-conte pear trees and the different investigated treatments, data in Table (3) indicated that fruit flesh firmness of le-conte pear fruits was significantly responded to the different studied treatments. Herein, the addition of the Mo as foliar spray alone (Mo at 0.5cm/L T2, Mo 1.5cm/L T3) and foliar spray with Fe or Mo alone led to produce fruit with highly firmness flesh texture comparing with the other treatments in this study, while all the combinations besides the control treatment. as such treatment resulted in producing more flesh softened fruits during both seasons of study. It was noticed that there was a positive relationship between fruit size and its firmness, the larger the fruit, the more texture. Is likely to be these results are in accordance with those found by Abd-Elmegeed *et al.*, (2013) on "Le-Conte" pear trees (Pyrus communis x Pyrus pyrifolia)who studied the application of Potassium sulphate at 0.1%, Copper sulphate at 0.02%, Sequestrated zinc at 0.04%, Sequestrated iron at 0.06% and Mixed nutrients applied three times during both seasons increased fruit weight, fruit volume, fruit dimensions (length &diameter), fruit shape index.

Table 3. Fruit weight (g), Fruit volume (cm3) and Fruit firmness L/inch2of "Le-Conte" pear trees as impacted by Mo and Fe during 2018 and 2019 seasons.

Evaluated parameters	Fruit weight (g)		Fruit size (cm^3)		Fruit firmness L/$inch^2$	
Seasons Treatments	2018	2019	2018	2019	2018	2019
T1- Water spray (untreated control)	159.07 e	162.42e	156.10 f	158.53f	19.54a	19.56ab
T2- Mo 0.5 cm / L	170.9 d	174.94d	162.10 e	164.57e	19.84a	19.89 a
T3- Mo 1.5 cm / L	190.03 b	191.56b	172.57 d	175.27d	19.84a	19.89 a
T4- Fe 1gm / L	183.27c	185.03c	172.63 d	174.87d	18.96b	18.97bc
T5- Fe 3gm / L	177.9 cd	179.33d	174.9 d	174.67d	18.84b	18.87bc
T6- Mo 0.5 cm/L + Fe 1g/L	183.03c	185.41c	172.5 d	183.1c	19.90a	19.98a
T7- Mo 0.5 cm/L + Fe 3g/L	190.23 b	192.44c	181.03 c	183.1c	18.22b	18.27 c
T8- Mo 1.5 cm/L + Fe 1g/L	213.1 a	225.82a	197.33 a	201.8 a	18.18b	18.21 c
T9- Mo 1.5 cm/L + Fe 3g/L	198.63 b	200.59b	186.0 b	188.4 b	18.54b	18.24 c
LSD	11.74	6.81	4.298	6.165	0.549	0.59

Fruit length (cm):

Regarding fruit length of Le-Conte pear fruit as affected by the different studied treatments, data presented in Table (4) showed that such parameter was significantly responded to the different investigated treatments. Herein, the trees which were foliar spray Mo + Fe (Mo 1.5cm/L + Fe at 1g/L T8) was the best one as it maximized le-Conte pear fruit length. But the other treatments came in the second rank in this field. Where, the least significant of fruit length recorded with untreated trees (T1) and in turn it was the inferior in this respect.

Fruit diameter (cm):

Data concerning fruit diameter of Le-Conte pear trees are tabulated in Table (4).Those data refer that the behavior of such parameter was nearly closed to fruit length behavior which has been discussed earlier. Hence, T8 enhanced fruit diameter as those treatments achieved the highest fruit diameter as compared with the other treatments. These obtained results are in accordance with those found by Dimri and Lokesh Bora (2016) ,Abd-Elmegeed *et al.,* (2013) on "Le-Conte" pear trees and Asaad (2014) on "Anna" apple . They reported that trees applied with amixture of Zn,Mn and Fe reflected an increment in fruit weight, fruit volume, fruit dimensions (length &diameter), fruit shape index.

Fruit shape index:

Data dealing with fruit shape index are presented in Table (4). Such data reflected that all the investigated treatments were not able to change fruit shap because fruit length and diameter response was parlled.

Table 4. Fruit length (cm), fruit diameter (cm) and Fruit shape index of "Le-Conte" pear trees as impacted Mo and Fe during 2018 and 2019 seasons.

Evaluated parameters	Fruit length (cm)		Fruit diameter (cm)		Fruit shape index	
Seasons Treatments	2018	2019	2018	2019	2018	2019
T1- Water spray (untreated control)	6.60 c	6.61 c	5.51 c	5.52 c	1.19 a	1.19 a
T2- Mo 0.5 cm / L	6.83 bc	6.86 b	5.69 bc	5.72 bc	1.19 a	1.19 a
T3- Mo 1.5 cm / L	6.96 b	6.98 b	5.83 b	5.87 b	1.19 a	1.18 a
T4- Fe 1gm / L	6.88 bc	6.93 b	5.80 bc	5.81 b	1.18 a	1.19 a
T5- Fe 3gm / L	6.88 bc	6.93 b	5.80 bc	5.81 b	1.16 a	1.19 a
T6- Mo 0.5 cm/L + Fe 1g/L	6.81 bc	6.86 b	5.71 bc	5.72 bc	1.13 a	1.19 a
T7- Mo 0.5 cm/L + Fe 3g/L	6.90 bc	6.92b	5.80 bc	5.82 b	1.18 a	1.18 a
T8- Mo 1.5 cm/L + Fe 1g/L	7.80 a	7.89 a	6.49 a	6.52 a	1.20 a	1.20 a
T9- Mo 1.5 cm/L + Fe 3g/L	7.13 b	7.15 b	5.99 b	6.01 b	1.19 a	1.18 a
LSD	0.145	0.193	0.201	0.189	0.072	0.039

Fruit chemical properties:

Fruit flesh total soluble solids (TSS %):

Regarding total soluble solids (TSS) of Le-Conte pear fruits as impacted by the different studied treatments, data in Table (5) refer that the investigated parameter was significantly responded to the treatments in this field. Herein, the trees which were foliar sprayed with Mo + Fe (Mo 1.5cm/L + Fe at 1g/L T8) was the superior one, as it recorded the highest significant value of TSS, followed by spraying with Mo at 0.5cm/L individual Mo and Fe combined with Fe at 1 or 3g/L T7 and T9) . Such trend was true during both seasons of study. The other treatments including the control were less effective. These results are in accordance with those found by Hafez *et al.,* (2018). on Le Conte pear trees and Hamouda *et al* (2016) . on pomegranate (Manfalouty cv.), they reported that foliar sprays of iron, manganese and zinc sulphates500, 1000 mg L-1 for Fe, 800, 1600 mgL-1for Mn and 1000, 2000 mg L-1 for Zn increased fruit TSS content.

Fruit flesh total titratable acidity percentage:

Regarding the relationship between the investigated treatments and total acidity percentage, data in Table (5) display that the studied parameter was significantly responded to the treatments in this field. Meanwhile, the least value of fruit total acidity % was associated with those sprayed trees with the Mo + Fe (T8), such treatment minimized the investigated parameter as compared to the other investigated treatments during both seasons of study. On the other hand, the highest value of fruit acidity % was connected with untreated trees with any of the investigated treatments (control-T1), during the 1st and 2nd seasons of study. In this concern, our results are confirmed by Abd-Elmegeed *et al.,* (2013) on "Le-Conte" pear trees and Asaad (2014) on Anna apple trees found that used amixture of Fe,Zn and Mn decreased fruit acidity .

TSS/acid ratio:

Data of TSS/acid ratio parameter of Le-Conte pear fruits as influenced by the differential investigated treatments are presented in Table (5) gave significant differences among the investigated treatments in relation to the studied parameter. Hence, the trees which were foliar spray Mo +Fe (Mo 1.5cm/L + Fe at 1g/L T8) proved to be the most effective one in this respect, as it reflected the highest significant value of TSS/ acid ratio comparing to the other investigated treatments during two seasons of study. In addition, spraying Mo and Fe (Mo 1.5cm/L + Fe at 3g/L T9) associated with Mo and Fe (Mo 0.5cm/L + Fe at 3g/L T7) improved TSS/acid ratio as compared with the other studied treatments. On the other hand, the untreated trees (control. T1) produced fruits having the least value of TSS/acid ratio during two seasons of study. These results are in agreement with those stated by Hafez *et al*., (2018). on Le Conte pear trees and Hamouda *et al*., (2016). on pomegranate (Manfalouty cv.) trees.

Table 5. (TSS) %, total acidity % and TSS/acid ratio of "Le-Conte" pear trees as impacted by Mo and Fe during 2018 and 2019 seasons.

Evaluated parameters	TSS (%)		Fruit acidity %		TSS/acid ratio	
Seasons Treatments	2018	2019	2018	2019	2018	2019
T1- Water spray (untreated control)	12.68 c	12.69c	0.273 a	0.274 a	46.43d	46.36 d
T2- Mo 0.5 cm / L	12.90 c	12.91c	0.256 b	0.256 b	50.33c	50.51 c
T3- Mo 1.5 cm / L	12.95 c	12.96c	0.253 b	0.252 b	51.20c	51.36 c
T4- Fe 1gm / L	12.87 c	12.88c	0.253 b	0.253 b	50.78c	50.97 c
T5- Fe 3gm / L	12.87 c	12.87c	0.252 b	0.251 b	51.07c	51.22 c
T6- Mo 0.5 cm/L + Fe 1g/L	13.04 c	13.06c	0.250 b	0.250 bc	52.10c	52.23 c
T7- Mo 0.5 cm/L + Fe 3g/L	13.80 b	13.81b	0.249 b	0.249 bc	55.26b	55.46 b
T8- Mo 1.5 cm/L + Fe 1g/L	14.98 a	14.99a	0.239 d	0.238 d	62.67a	63.02 a
T9- Mo 1.5 cm/L + Fe 3g/L	13.87 b	13.88b	0.246 c	0.245 c	56.37b	56.67 b
LSD	0.478	0.481	0.005	0.005	2.021	2.052

Fruit pulp sugar content:

Concerning the impact of different investigated treatments on le-conte pear fruit sugar content, data presented in Table (6) indicates that fruit total sugars content was significantly responded to the studied treatments. Furthermore, the trees which were sprayed with the combination between both elements without regard to the concentration produced fruits having the highest sugar content as compared with the other investigated treatments while spraying each individual element alone came later in such respect. On the other way around, the reverse was true with those untreated trees with any of the investigated treatments (control. T1) which gave the lowest sweetened fruits. These results are in harmony with those reported by El-Dahshouri. *et al.*, (2017). Found that foliar spraying by five mineral iron concentrations (0.0, 250, 500, 1000 and 2000 ppm) as ferrous sulphate (FeSO4.7H2O) in different combinations enhanced fruit sugar content of Le Conte pear trees.

Reducing and non reducing sugars:

Concerning the impact of different investigated treatments on le-conte pear fruit sugar content, data in Table (6) indicates that fruit reducing sugars and non reducing sugar content was significantly responded to the studied treatments. Furthermore, the trees which were sprayed all combination between Mo and Fe produced fruits having the highest reducing and non reducing sugars content comparing to the other studied treatments while the individual elements and the control were less effective. These results are in harmony with those reported by El-Dahshouri *et al.,* (2017). Reported that foliar spraying by five mineral iron concentrations (0.0, 250, 500, 1000 and 2000 ppm) as ferrous sulphate (FeSO4.7H2O) in different combinations enhanced fruit sugar content of Le Conte pear trees. Asimilar trend was earlier confirmed by, Hudina (2004) on pear trees and Balesini *et al.*, (2013) on apple trees.

Vitamin C content (V.C.):

Data concerning the relationship between fruit ascorbic acid content of Le-Conte pear fruit and the different investigated treatments are presented in Table (6) indicates that fruit Vitamin C content was significantly responded to the studied treatments. Furthermore, the trees which were sprayed with the Mo + Fe (Mo 1.5 cm/L + Fe at 1g/L T8) produced fruits having the highest Vitamin C content comparing to the other studied treatments followed by (T9) which came in the second rank. Such trend was true during both seasons of study. On the other way around, the reverse was true with those untreated trees with any of the investigated treatments (control. T1) as it reflected the least value of fruit ascorbic acid content. These results are in harmony with those reported by Amjad *et al*.,(2014)who found that foliar sprayed peach trees with micronutrients increased fruit ascorbic acid.

Williams *et al*., (2004) reported that standard rate of sodium molybdate (300 g/ha) was applied to vines twice in spring. When applied to molybdenum deficient vines, Mo-treatment improved yield. The improvement in yield was attributed to both heavier bunches and more bunches per vine. The increase in bunch weight was reported to be a function of a higher proportion of larger berries Also, Longbottom *et al*., (2010) indicated that Mo- treatment increased vine Mo status, however, yield increased on Mo-deficient vines. The increase in yield was a function of improved fruit set.

The transition element Mo is a very rare but essential micronutrient for all organisms (Fortescue 1992). Mo seems to be catalytically inactive in biological systems until it is complexed by a special cofactor, the pterin (Mendal and Hansch 2002)) which binds to diverse apoprotein.

The later compound is named molybdopterin or a metal- containing petrin. In this form, it occurs in more than 40 enzymes catalysing many redox reactions, four of them have been found in plant (Kapple *et al.*, 2002). One of these is nitrate reductase (NR), Mo has an importand role in benefing N and subsequently N soil supply will decrase and in the same time, fruit set, yield and fruit quality will increase.

Table 6. vitamin C, total fruit flesh sugar and Reducing and non reducing sugars contents of "Le-Conte" pear trees as impacted by Mo and Fe during 2018 and 2019 seasons.

Evaluated parameters	Total fruit flesh sugar %		Reducing sugar		Non Reducing sugar		Vitamin (c) mg/100ml juice	
Seasons treatments	2018	2019	2018	2019	2018	2019	2018	2019
T1- Water spray (untreated control)	10.69 c	11.03 e	8.23 b	8.31 b	2.46 c	2.72 d	2.32 f	2.33 e
T2- Mo 0.5 cm / L	11.44 b	11.44 d	8.40 b	8.41 b	3.03 b	3.04 cd	2.53 e	2.53 d
T3- Mo 1.5 cm / L	11.42 b	11.43 d	8.38 b	8.39 b	3.04 b	3.04 cd	2.59 de	2.59 d
T4- 1gm / L	11.52 b	11.53 d	8.54 b	8.55 b	2.98 b	2.98 c	2.62 d	7.63 d
T5- 3gm / L	11.51 b	11.52 d	8.50 b	8.51 b	3.01 b	3.01 cd	2.62 d	2.63 d
T6- Mo 0.5 cm/L + Fe 1g/L	12.73 a	12.74 c	9.33 a	9.34 a	3.39 ab	3.40 bc	2.82 c	2.83 c
T7- Mo 0.5 cm/L + Fe 3g/L	12.71 a	12.72 c	9.10 a	9.11 a	3.61 a	3.62 ab	2.79 c	2.79 c
T8- Mo 1.5 cm/L + Fe 1g/L	12.99 a	13.04 a	9.19 a	9.23 a	3.80 a	3.81 a	3.03 a	3.08 a
T9- Mo 1.5 cm/L + Fe 3g/L	12.85 a	12.86 b	9.17 a	9.18 a	3.68 a	3.68 ab	2.91 b	2.92 b
LSD	0.351	0.088	0.309	0.297	0.364	0.292	0.071	0.079

REFERENCES

Abd-Elmegeed, N. A., Nabeel, W. A. and Nasr, M. M. (2013). Effect of foliar application of some nutrients on "Le-Conte" pear trees grown under calcareous soil conditions. Egyptian Journal of Horticulture, 40(2):277-293.

Agarwala, S.C., Chaterjee, C., Sharma, P.N., Sharma, C.P. and Nautiyal, N. (1979) Pollen development in maize plants subjected to molybdenum deficiency. Canadian Journal of Botany 57,1946–1950.

Àlvarez-Fernàndez, A., Abadía, J. and Abadía, A. (2006) Iron deficiency, fruit yield and fruit quality. In Iron Nutrition in Plants and Rhizospheric Microorganisms, 85–101.

Álvarez-Fernández, A., Abadía, J. J. and Abadía, A. (2011) Effects of moderate and severe iron deficiency chlorosis on fruit yield, appearance and composition in pear (Pyrus communis L.) and peach (Prunus persica (L.) Batsch). Environmental and Experimental Botany, 71(2): 280–286.

Álvarez-Fernández, A., García-Laviña, P., Fidalgo, C., Abadía, J. and Abadía, A. (2004). Foliar fertilization to control iron chlorosis in pear (Pyrus communis L.) trees. Plant Soil, 263(1): 5–15.

Amjad, A., Sajida, P., Syed, N.M. S., Zengqiang, Z., Fazli, W., Mohib, S., Shahida, B. and Abdul Majid (2014) . Effect of Foliar Application of Micronutrients on Fruit Quality of Peach. American Journal of Plant Sciences, 5, 1258-1264.

Asaad- Samia, A. (2014). The influence of spraying sitofex, iron, manganese and zinc on "Anna" apple trees planted on new reclaimed calcareous land. Life Science Journal, 11(1s): 1-8.

Asaad, S. A., N. A. A. El-Megeed, and E. S. Atalla. (2013) . Effect of foliar application of micronutrients on "Le-Conte" pear trees under calcareous soil conditions. *American Journal of Science*, 9(7s): 123–128.

Association of Official Analytical Chemists (A.O.A.C). (1995). "Official methods of analysis, the A.O.A.C 14th Ed., Benjamin Franklin Station, Washington, D.C.U.A. pp490-510.

Balesini, Y. M., Imani ,A. and Piri, S. (2013) . Effects of some of nutritional materials on fruit set and its characteristics in apple. J. Basic Appl. Sci. Res., 3(1): 281- 285.

Coughlan, M.P., (1980) . Aldehyde oxidase, xanthine oxidase and xanthinedehydrogenase: hydroxyl lases contain in gmolybdenum, iron-sulfur and flavin, 119-185. - In: Coughan M.P.(ed.) Molybdenum and Molybdenum-containing Enzymes. Pergamon Press, Oxford, UK.

Dar, M. A., J. A. Wani, S. K. Raina, M. Y. Bhat. (2012). Effect of available nutrients on yield and quality of pear fruit Bartlett in Kashmir valley India. *Journal of Environmental biology*, 33: 1011–1014.

Dimri, B. P. and Lokesh Bora, D. C. (2016) . Effect of pre-harvest spray of calcium and potassium on fruit physical attributes and yield of pear cv. Pathernakh. Environment and Ecology; 34(3):997-1000.

Dubais, M.; Gilles, K. A.; Hamilton, J. K.; Rebres, P. A. and Smith, F. (1956). Colorimetric methods for determination of sugars on related to substances. Analytical Chemistry, 28: (3) 350-356.

Duncan, D. B. (1955). Multiple ranges and multiple F. test. Biometrics, 11: 1-42.

El-Dahshouri, M. F., H. A. Hamouda, O. M. Hafez, S. A. Khafagy. (2017). Enhancing le-conte pear trees performance by foliar spray with different Iron concentrations. Agricultural Engineering International: CIGR Journal, Special issue: 201–210.

El-Jendoubi, H., S. Vázquez, A. Calatayud, P. Vavpetič, K. Vogel-Mikuš, P. Pelicon, J. Abadía, A. Abadía, and F. Morales. (2014). The effects of foliar fertilization with iron sulfate in chlorotic leaves are limited to the treated area. A study with peach trees (*Prunus persica*L. Batsch) grown in the field and sugar beet (*Beta vulgaris*L.) grown in hydroponics. Frontiers in Plant Science, 5(2): 2.

Fortescue, J.A.C. (1992) Landscape geochemistry: retrospect and prospect 1990.-Appl. Geochem., 7: 1-53.

Hafez,O.M., Hamouda H. A., El-Dahshouri M. F., and EL-Saady A.M.(2018). Response of Le Conte Pear Trees to Some Nutrients, Salicylic Acid and Yeast Foliar Application under Newly Reclaimed Soil. Middle East Journal of Applied Sciences. Pages: 251-258.

Hamouda, H. A., Khalifa1, R.Kh. M., El-Dahshouri1, M.F. and Nagwa G. Zahran (2016) . Yield, fruit quality and nutrients content of pomegranate leaves and fruit as influenced by iron, manganese and zinc foliar spray. International Journal of PharmTech Research. pp46-57.

Hamouda, H. A., M. F. El-Dahshouri, O. M. Hafez, and N. G. Zahran. (2015). Response of Le Conte pear performance, chlorophyll content and active iron to foliar application of different iron sources under the newly reclaimed soil conditions. International Journal of Chemistry Technolgy Research, 8(4): 1446–1453.

Hansch, R. and Mendel, R.R., (2009). Physiological functions of mineral micronutrients (Cu, Zn, Mn, Fe, Ni, Mo, B., Cl). - Curr. Opin. Plant Biol., 12(3): 259-266.

Hille, R., (1996) . The mononuclear molybdenum enzymes. - Chem. Rev., 96: 2757-2816.

Hudina, M. (2004). How to increase the pear fruit quality? Zbornik referatov 1. Slovenskega sadjarskega kongresa z mednarodno udelezbo, Krsko, Slovenia, 24-26 marec. Del 1; 2004. 163-168.

Jackson, M. L. (1967). Soil chemical analysis. Prentice – Hall. Inc. Englewood Clif., N, I. Library Congress, U. S. A.

Kappl, R., Huttermann, J., Fetzner, S. (2002) The molybdenum- containing hydroxylases of quinoline, isoquinoline, and quinaldine,481-538.- In: SIGELA., and H. SIGEL(eds.) Molybdenum and Tungsten. Their roles in biological processes.Marcel Dekker, New York, USA.

Longbottom, M.L., Dry, P.R. and Sedgley, M. (2010) Effects of sodium molybdate foliar sprays on molybdenum concentration in the vegetative and reproductive structures and on yield components of Vitis vinifera cv. Merlot. Australian Journal of Grape andWine Research 16,477–490.

Malvi, U. R. (2011). Interaction of micronutrients with major nutrients with special reference to potassium. Karnataka Journal of Agricultural Sciences, 24(1): 106–109.

Mansour, A. E. M., F. F. Ahmed, E. A. Shaaban, A. A Fouad. (2008). The beneficial of using citric acid withsome nutrients for improving productivity of Le- Conte pear tree. Journal Research Journal of Agriculture and Biological Sciences, 4(3): 245–250.

Mendel, R.R. and Hansch, R. (2002) . Molybdoenzymes and molybdenum cofactor in plants. - J. Exp. Bot., 53(375): 1689- 1698.

Piper, C. S. (1947). Soil and plant Analysis. Inter. Sci. Publishers. New York, 213-217.

Salazar-García, S. (1999). Iron nutrition and deficiency: A review with emphasis in avocado (Persea 209 mericana Mill). Revista Chapingo Serie Horticultura, 5(2): 67–76.

Snedecor, G. W. and Cochran, W. G. (1980). Statistical Methods. Oxford and J.B.H. publishing com. 7th edition, 593 p.

Tagliavinia, M., J. Abadíab, A. D. Rombolàa, A. Abadíab, C. Tsipouridisc, and B. Marangonia. (2000). Agronomic means for the control of iron deficiency chlorosis in deciduous fruit trees. Journal of Plant Nutrition, 23: 2007–2022.

Williams, C.M.J., Maier, N.A. and Bartlett, L. (2004). Effect of molybdenum foliar sprays on yield, berry size, seed formation and petiolar nutrient composition of ‘Merlot’ grapevines. Journal of Plant Nutrition 27, 1891–1916.

الاستفادة المثلى من أدوار الموليبدينوم والحديد في رفع كفاءة الإنتاجية وصفات الثمار لأشجار الكمثرى الليكونت

فؤاد محمد عبد اللطيف[1]، خالد على بكرى[1]، شريف فتحى الجيوشى[1]، عاطف معتمد حسين[2] و محمد سامى محمد[2]*

[1] قسم البساتين بكلية الزراعة (مشتهر) جامعة بنها مصر

[2] معهد بحوث البساتين ، مركز البحوث الزراعية ، مصر

تم إجراء هذا البحث خلال موسمي 2018 و 2019 على أشجار الكمثرى الليكونت عمرها 12 عامًا مطعومة على أصل البتشليفوليا ، المزروعة على مسافة 5 × 5 أمتار (168 شجرة / فدان) في تربة رملية تحت نظام الري بالتنقيط بمحطة بحوث القصاصين بمحافظة الإسماعيلية. تهدف هذه الدراسة إلى الاستفادة من دور الموالبدينم و الحديد في تحسين إنتاجية أشجار الكمثرى وجودة الثمار. وتشير النتائج إلى أن التوليفات بين العنصرين المدروسين تعكس تأثيرًا إيجابيًا على المحصول وجودة الثمار مقارنة بالرش بكل عنصر على حدة. تم الحصول على أفضل نتيجة باستخدام الموالبدينم بتركيز 1.5 سم / لتر مع الحديد بمعدل 3 جم / لتر حيث أدت هذه المعاملة إلى تحسين جميع الصفات المدروسة. وأعطت الأشجار التي لم يتم رشها أقل القيم في هذا الصدد.