Effect of foliar application of micronutrients on "Le-Conte" pear trees under calcareous soil conditions

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Abstract: The present study was conducted during 2011 and 2012 seasons on "Le-Conte" pear trees. The trees were 7 years old, budded on Pyrus communis rootstock and grown on calcareous soil and under flood irrigation system in a private orchard located at Borg El-Arab region, Alexandria Governorate. Thirty trees as uniform a possible were selected for this study. The trees were at 5 x 5 m. apart. The experiment involved the following ten treatments: Control, 0.50 g Micronutrients + 0.3 ml P/L at full bloom, 0.75 g Micronutrients + 0.3 ml P/L at full bloom, 1.00 g Micronutrients + 0.3 ml P/L at full bloom, 0.50 g Micronutrients + 0.3 ml P/L at fruit set, 0.75 g Micronutrients + 0.3 ml P/L at fruit set, 1.00 g Micronutrients + 0.3 ml P/L at fruit set, 0.50 g Micronutrients + 0.3 ml P/L at full bloom + fruit set, 0.75 g Micronutrients + 0.3 ml P/L at full bloom + fruit set and 1.00g Micronutrients + 0.3 ml P/L at full bloom + fruit set. The results revealed that spray with 1.00g Micronutrients + 0.3 ml P/L at full bloom + fruit set gave the best results in comparison with control. This treatment gave the highest values of leaf and fruit mineral content, improved all vegetative growth parameters and chlorophyll content of leaves, in addition to ensured the best yield, improved the physical and chemical characteristics of fruits.
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1-INTRODUCTION

Essential elements either as macro or micro-nutrients play a good role in growth and productivity of fruit crops. Several investigators have demonstrated the role of potassium and boron in growth (Semenovich and Salmina, (1979); Delcheva and Makariev, (1982), yield (Mantinger, 1983) and fruit quality (Ljones, (1974); Yogaratnam and Johnson, (1982). The foliar application of micronutrients has become in wide use to correct the problem of micronutrients deficiency in many fruit crops. Although micronutrients are needed in relatively very small quantities for adequate plant growth and production, their deficiencies, cause a great disturbance in the physiological and metabolic processes involved in the plant as a result from effect of foliar application of chelated iron, zinc and manganese on Thompson Seedless grapes (El-Gazzar *et al*., 1979).

Some work has been carried out in Egypt concerning the effect of microelements spray on deciduous fruits (Awad and Atawia, 1995; Kabeel et al., 1998; Gobara (1998) on pear; El-Shazly 1999; El-Shobaky *et al*., 2001and Naiema 2006). Also, El-Seginy *et al*. (2003) reported that, foliar application of Anna apple trees with GA_3 and/or a mixture of chelated (Fe, Zn, and Mn) is recommended to increase fruit set, yield quantity and fruit quality of trees grown on calcareous soil.

"Le-conte" is the main pear cultivar, widely grown in Egypt grafted on the main rootstock, *P. communis* that shows high susceptibility to pear blights (Reimer, 1950).

The target of this study was achieving the possibility of improving of growth, yield and fruit quality through foliar application of micronutrients at different stages of "Le-Conte" pear trees.

2-MATERIALS AND METHODS:

2.1.Materials:

2.1.1.Samples:

The present study was conducted during 2011 and 2012 seasons on "Le-Conte" pear trees *(Pyrus communis X Pyrus pyrifolia).* The trees were 7 years old, budded on Pyrus communis rootstock and grown on calcareous soil and under flood irrigation system in a private orchard located at Borg El-Arab region, Alexandria Governorate. Some physical and chemical analysis of this experimental soil were conducted at Saba Basha, Alexandria University is illustrated in Table (1).

Thirty trees as uniform a possible were selected for this study. The trees were at 5 x 5 m. apart. The trees received the cultural practices that are recommended by Agriculture Ministry. Complete randomized block design was applied.

2.1.2.Treatments:

The experiment involved the following ten treatments:

1-Control.

2-050g Micronutrients + 0.3 ml P/L at full bloom
3-0.75g Micronutrients + 0.3 ml P/L at full bloom
4-1.00g Micronutrients + 0.3 ml P/L at full bloom
5-0.50g Micronutrients + 0.3 ml P/L at fruit set
6-0.75g Micronutrients + 0.3 ml P/L at fruit set
7-1.00g Micronutrients + 0.3 ml P/L at fruit set
8-0.50 g Micronutrients + 0.3 ml P/L at full bloom + fruit set
9-0.75 g Micronutrients + 0.3 ml P/L at full bloom + fruit set
10-1.00 g Micronutrients + 0.3 ml P/L at full bloom + fruit set

Table (1): Physical and chemical characters of experimental orchard soil.

Clay (%)	17.5	$CaCO_3$	20.26
Silt (%)	12.5	Ca^{++} (meq/L)	6.35
Sand (%)	70	Mg^{++}	3.81
Texture	Sandy loam	Na^{+}	6.087
EC (Ds/m)	0.761	K^{+}	0.513
Organic matter %	3.76	Cl^{-}	5.5
Co3- and HCO_3-(meq/L)	17.27	So_4^{-}	4.1
Available P (meq/L)	37.76	Total N^{+} (ppm)	7.1
pH	7.6	B (ppm)	1.539

2.2. Methods:

2.2.1.Applying treatments as following:

Each treatment was replicated three times, one tree per each. Untreated trees (control treatment) were sprayed with water containing 0.1% Triton B.

Micronutrients (Al-Ahram Company) for minimizing introduced the high quality Egyptian product that approved its high efficacy for ten years in different kinds of soils.

Each treatment was added 0.3 ml phosphoric acid per litre (P/L).

Samples of twenty leaves from the middle part of the shoots (*according to Chuntanaperb and Cummings, 1981*) were selected at random from each replicate (Last week of August) to determine their of Fe, Zn, Mn, Cu, and B *(according to Wilde et al. 1985*). Leaf and fruit samples were washed with tap water rinsed twice in distilled water, oven dried at 70 C to constant weight and then ground. The ground samples were digested with sulphoric acid and hydrogen peroxide *(according to Evenhuis and DeWaard (1980).*

2.2.2.Measurements:

a-Vegetative growth measurements:

Shoot length, diameter and leaf area were determined. Four main branches as similar as possible were chosen at the four cardinal points of each treated tree, tagged and the average of the current shoot per selected branch was counted, their length and diameter were measured with (cm) on mid October, in both seasons. Leaf area was determined using leaf area meter (Model CI-203, CID, Inc., U.S.A.).

Leaf total chlorophyll content was determined by MINOLTA CHLOROPHYLL METER SPAD-502 (Minolta camera.Co, LtD Japan). Ten readings were taken on ten leaves (the fourth leaf of the new shoot) of each experimental tree on mid-June. The readings were taken at the middle of leaf blade *(Westwood, 1988).*

b-Percentage of fruit set and fruit drop:

The total number of flowers on each tagged limb was counted at full bloom. The number of set fruit was counted on the same limbs after one month from full bloom. Fruit set percentage was calculated as follows:

Fruit set% = Number of developing fruitlets X 100
Total number of flowers *(According to Westwood, 1988*).

Furthermore, number of dropped fruits were recorded till harvest time, then estimated as percentage on the basis of initial number of fruitlets according to this equation:

Number of dropped fruits X 100Number of set fruitlets

c-Yield and percentage of yield increment than control;

The average of tree in Kg for each treatment was determined at harvest time (at maturity stage). Furthermore the yield increment percentage for each treatment as compared to the control was estimated according to the following equation:

% Yield incr. = Yield/treatment – Yield/ control X 100Yield/ control

d-Fruit quality:

At harvest time (at maturity stage), ten fruits from each replicate were randomly sampled and following characteristics were determined including average fruit weight (gm), fruit dimensions (cm) and fruit firmness ($lb/inch^2$) using a Magness and Tylor (1925). Furthermore, fruit chemical properties were also determined including the average TSS percentage using hand refracto-meter, fruit juice acidity (%) percentage as malic acid *(%)(according to A.O.A.C. (1992);Vogel (1968),* TSS/ acid ratio was calculated. Total sugar (%) contents were determined (*according to Malik and Singth, 1980).*

The obtained data throughout the investigated seasons were statistically analyzed (*according to Snedecor and Cochran, 1990)* and L.S.D. test at 0.05 levels was used for comparison between treatments.

3-RESULTS AND DISCUSSION

3.1.Leaf mineral content

As shown in (Table, 2), it is apparent that all mineral content of leaves i.e. Fe, Zn, Mn, Cu and B were significantly affected by fertilizer treatments

in the both seasons. It was found that application of 1.00 g Micronutrients + 0.3 ml P/L at full bloom + fruit set recorded the highest values of these parameters followed in a descending order by 0.75 g Micronutrients + 0.3 ml P/L at full bloom + fruit set, whereas, the lowest values were obtained from control in the both seasons.

The results are agree with those obtained with Mohamed and Ahmed (1991) who reported that supplying trees of "Anna" apple with three micronutrients (zinc, iron and copper) together by spraying has raised their concentrations resulted in a considerable increase in leaf content of Zn, Fe and Cu. However, the same results were pointed out by Amer et al., (2010) studied the effect of different levels of soil and foliar application of micronutrients fertilizer on "Toffahy and Balahy" Indian per trees in sandy soil. They found that soil applied micronutrients (Cu, Zn, Mn and Fe) increased their concentration in leaves more than foliar application except Cu.

Table (2): Effect of foliar application on leaf mineral content of "Le-Conte" pear trees during 2011 and 2012 seasons.

Treatments	Fe (ppm)		Zn (ppm)		Mn (ppm)		Cu (ppm)		B (ppm)	
Season	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
Control	104.3	106.3	19.3	20.7	45.0	46.0	9.3	10.3	90.7	91.7
(0.50 g) FB	106.7	110.0	21.7	23.0	46.7	48.7	10.3	11.7	92.0	94.0
(0.75 g) FB	113.3	114.3	25.0	27.0	50.3	53.0	13.3	14.0	94.3	96.0
(1.00 g) FB	118.3	119.0	28.7	31.0	54.7	57.7	15.7	17.0	97.0	99.0
(0.50 g) FS	109.3	110.3	22.0	23.0	47.3	49.0	12.3	11.0	92.7	94.7
(0.75 g) FS	114.7	115.7	25.0	27.3	51.3	53.0	14.3	15.3	94.0	96.3
(1.00 g) FS	120.3	122.0	29.7	32.3	55.3	57.3	16.0	17.3	97.7	100.3
(0.50 g) FB + FS	124.3	128.0	28.3	32.0	52.7	53.3	15.7	17.7	96.3	100.3
(0.75 g) FB + FS	129.7	131.7	35.3	37.3	60.0	62.3	20.0	22.7	99.7	103.7
(1.00 g) FB + FS	144.7	147.3	39.0	43.3	63.3	67.0	26.0	28.3	107.0	109.0
L.S.D. at 0.05	3.5	2.6	2.1	2.2	1.7	1.6	1.8	1.5	2.1	1.6

3.2.Fruit mineral content

The results presented in (Table, 3) revealed that all mineral content of fruits such as Fe, Zn, Mn, Cu and B were significantly affected by fertilizer treatments in the both seasons. It was noticed that application of 1.00 g Micronutrients + 0.3 ml P/L at full bloom + fruit set recorded the highest values of these parameters followed in a descending order by 0.75 g Micronutrients + 0.3 ml P/L at full bloom + fruit set. On the other hand, control recorded the lowest values of these parameters in the both seasons.

These results agreed with EL-Sisy (2011) who reported that there were a significant increase in fruit Fe, Mn and Zn comparing with control in both seasons of study. On the other hand, EL-Gazzar *et al*., (1979) who reported that fruits of grapes were not significantly affected by either soil or foliar application of $FeSO_4$ and $ZnSO_4$.

3.3.Vegetative growth measurements and leaf total chlorophyll content

As shown in (Table, 4), it is apparent that all vegetative growth parameters i.e. shoot length, shoot diameter and leaf area and chlorophyll content of leaves were significantly affected by fertilizer treatments in the both seasons. It was found that application of 1.00 g Micronutrients + 0.3 ml P/L at full bloom + fruit set recorded the highest values of these parameters followed in a descending order by 0.75 g Micronutrients + 0.3 ml P/L at full bloom + fruit set, whereas, the lowest values were obtained from control in the both seasons.

These resulted were in line with many investigators who reported that, vegetative growth are increased due to using micronutrients, Mohamed and Ahmed, (1991) on "Anna" apple, Naiema (2006) on pear. Also, El-Khawaga (2007) on olive, Amer *et al*. (2010) on "Toffahy and Balahy" Indian ber trees and EL-Sisy (2011) on guava trees found that spraying nutrients was effective in stimulating leaf area.

3.4.Percentage of fruit set, fruit drop and yield

The results presented in (Table, 5) revealed that percentage of fruit set, fruit drop and yield were significantly affected by fertilizer treatments in the both seasons. It was noticed that application of 1.00 g Micronutrients + 0.3 ml P/L at full bloom + fruit set recorded the highest percentage of fruit set and yield with the lowest percentage of fruit drop. On the other hand, control recorded the lowest percentage of fruit set and yield with the highest percentage of fruit drop in the both seasons.

Table (3): Effect of foliar application on fruit mineral content of "Le-Conte" pear trees during 2011 and 2012 seasons.

Treatments	Fe (ppm)		Zn (ppm)		Mn (ppm)		Cu (ppm)		B (ppm)	
Season	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Control	85.0	86.3	11.7	13.0	40.0	41.0	8.3	9.7	51.7	52.7
(0.50 g) FB	88.3	91.0	13.0	14.3	42.0	43.7	9.0	11.0	53.7	55.0
(0.75 g) FB	93.3	96.0	16.3	18.0	45.3	47.0	11.3	13.0	56.7	59.0
(1.00 g) FB	98.0	99.0	21.0	23.0	49.7	52.3	14.3	16.0	60.0	62.3
(0.50 g) FS	89.3	91.3	13.0	13.7	41.3	43.0	9.0	11.3	53.3	56.0
(0.75 g) FS	96.3	97.7	15.7	17.3	45.3	46.7	11.3	13.3	57.0	59.0
(1.00 g) FS	99.0	102.0	20.3	22.0	50.3	52.0	14.3	15.7	59.7	61.7
(0.50 g) FB + FS	103.7	105.7	18.7	21.3	48.3	51.0	13.0	15.0	61.0	64.0
(0.75 g) FB + FS	108.7	111.7	23.7	26.7	56.0	57.0	18.7	22.0	68.7	70.0
(1.00 g) FB + FS	114.0	119.0	32.0	35.3	59.7	62.0	23.3	26.3	71.0	73.7
L.S.D. at 0.05	2.0	1.8	2.2	1.8	2.3	1.6	2.1	1.6	1.8	1.5

Table (4): Effect of foliar application on vegetative growth measurements and leaf total chlorophyll content of "Le-Conte" pear trees during 2011 and 2012 seasons.

Treatments	Shoot length (cm)		Shoot diameter (cm)		Leaf area (cm2)		Total chlorophyll	
Season	2011	2012	2011	2012	2011	2012	2011	2012
Control	42.84	43.93	0.87	0.89	23.58	23.98	33.10	33.41
(0.50 g) FB	45.00	44.60	0.92	0.93	24.96	25.35	35.12	35.69
(0.75 g) FB	47.34	47.54	0.97	0.98	26.69	26.88	37.26	37.59
(1.00 g) FB	49.76	50.13	0.99	1.01	29.16	29.73	39.64	40.51
(0.50 g) FS	44.86	44.75	0.91	0.93	24.97	25.43	35.32	36.03
(0.75 g) FS	47.46	48.09	0.95	0.95	27.13	27.06	37.35	37.78
(1.00 g) FS	49.50	50.18	0.99	1.02	29.03	29.67	39.55	40.15
(0.50 g) FB + FS	49.20	51.34	0.96	0.99	27.86	28.62	39.70	40.58
(0.75 g) FB + FS	52.31	53.85	1.04	1.09	29.63	30.90	43.40	43.84
(1.00 g) FB + FS	58.18	59.37	1.19	1.21	32.39	33.30	46.84	47.03
L.S.D. at 0.05	0.86	1.03	0.02	0.02	0.91	0.91	0.90	1.18

These results were in line with those obtained by El-Seginy *et al*., (2003) reported that the chelated Fe, Zn and Mn at all rates increased total yield as compared with control of Anna apple trees. Also, EL-Sisy, (2011) noticed that foliar or soil application of guava trees with mixture of chelated or sulphate (Fe + Zn + Mn) in high rate (3000 ppm) added twice annually was the best treatment for enhancing yield. Also, Datir et al., (2012) who found that the application of amino acid-micronutrients chelate like (Zn, Fe, Cu and Mn) at the concentration of 1.5% and 2.0% resulted in more fruits per plant and more total yield per plant of "Chilli" (Capsicum annum L.) trees.

Table (5): Effect of foliar application on percentage of fruit set, fruit drop and yield of "Le-Conte" pear trees during 2011 and 2012 seasons.

Treatments	Fruit set (%)		Fruit drop (%)		Yield (Kg/tree)		Yield (Ton/Feddan)		Yield increment than control (%)	
Season	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Control	13.78	14.54	37.67	37.96	41.19	43.89	6.92	7.37	0.00	0.00
(0.50 g) FB	17.95	18.82	36.17	36.64	43.39	45.58	7.29	7.66	5.36	3.86
(0.75 g) FB	21.48	22.49	32.09	34.30	45.45	47.80	7.63	8.03	10.36	8.93
(1.00 g) FB	28.44	28.98	29.17	30.83	46.96	49.15	7.89	8.26	14.06	11.99
(0.50 g) FS	13.59	14.57	34.94	36.39	45.00	48.35	7.56	8.12	9.25	10.19
(0.75 g) FS	14.03	14.67	31.25	33.92	47.07	49.81	7.91	8.37	14.27	13.49
(1.00 g) FS	13.97	14.67	27.47	30.32	47.64	50.96	8.00	8.56	15.65	16.10
(0.50 g) FB + FS	18.32	18.86	32.28	31.95	49.38	52.76	8.29	8.90	19.89	20.69
(0.75 g) FB + FS	22.32	22.71	22.28	21.27	52.38	55.49	8.69	9.32	27.21	26.45
(1.00 g) FB + FS	29.31	29.11	16.53	16.39	53.15	57.89	8.99	9.72	29.07	31.92
L.S.D. at 0.05	0.69	0.49	1.37	1.09	1.62	0.80	0.26	0.14	4.00	1.87

3.5.Physical characteristics of fruits

As shown in (Table, 6), it is apparent that all physical characteristics of fruits i.e. fruit weight, fruit length, fruit diameter and fruit firmness were significantly affected by fertilizer treatments in the both seasons. It was found that application of 1.00 g Micronutrients + 0.3 ml P/L at full bloom + fruit set recorded the highest values of these parameters followed in a descending order by 0.75 g Micronutrients + 0.3 ml P/L at full bloom + fruit set, whereas, the lowest values were obtained from control in the both seasons.

The results of this study are in harmony with those reported by El-Seginy and Khalil (2000) on pear, Abd-Ella and Waffaa (2006) on fig trees, Amer et al., (2010) on "Toffahy and Balahy" Indian ber trees and El-Sisy (2011) on guava trees.

3.6.Chemical characteristics of fruits

The results presented in (Table, 7) revealed that all chemical characteristics of fruits such as total soluble solids, titratable acidity, TSS/acid ratio and total sugars were significantly affected by fertilizer treatments in the both seasons. It was noticed that application of 1.00 g Micronutrients + 0.3 ml P/L at full bloom + fruit set recorded the highest values of total soluble solids, titratable acidity and TSS/acid ratio with the lowest values of percentage of total sugars.

On the other hand, control recorded the lowest values of total soluble solids, titratable acidity and TSS/acid ratio with the highest values of percentage of total sugars in the both seasons.

The results of this study are in harmony with those reported by Mohamed and Ahmed (1991) found that applying the three elements together (Cu + Zn + Fe) at the higher rate was also accompanied with an improve in total soluble solids in apple trees.

Table (6): Effect of foliar application on physical characteristics of fruits of "Le-Conte" pear trees during 2011 and 2012 seasons.

Treatments	Fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)		Fruit firmness (Ib/inch2)	
Season	2011	2012	2011	2012	2011	2012	2011	2012
Control	161.78	163.66	8.02	8.05	6.76	6.79	11.98	11.67
(0.50 g) FB	168.77	170.08	8.17	8.19	6.88	7.92	12.91	11.98
(0.75 g) FB	175.43	176.69	8.31	8.32	6.96	6.98	14.11	12.65
(1.00 g) FB	187.74	189.80	8.53	8.56	7.17	7.18	15.09	13.14
(0.50 g) FS	175.29	176.69	8.27	8.20	6.97	6.97	12.77	12.36
(0.75 g) FS	182.44	184.55	8.39	8.40	7.02	7.03	14.38	13.17
(1.00 g) FS	190.64	192.39	8.61	8.62	7.23	7.31	15.17	13.88
(0.50 g) FB + FS	194.95	198.17	8.82	8.84	7.44	7.47	15.96	14.75
(0.75 g) FB + FS	215.21	214.85	8.98	9.03	7.76	7.76	16.68	15.20
(1.00 g) FB + FS	242.50	245.11	9.24	9.27	8.08	8.11	17.76	17.18
L.S.D. at 0.05	4.26	3.91	0.07	0.09	0.10	0.94	0.68	0.51

Table (7): Effect of foliar application on chemical characteristics of fruits of "Le-Conte" pear trees during 2011 and 2012 seasons.

Treatments	TSS (%)		Acidity (%)		TSS/acid ratio		Total sugar (%)	
Season	2011	2012	2011	2012	2011	2012	2011	2012
Control	11.53	11.67	0.56	0.54	20.79	21.60	7.90	8.11
(0.50 g) FB	11.60	11.77	0.57	0.55	20.25	21.40	7.84	7.98
(0.75 g) FB	11.93	12.00	0.59	0.57	20.24	20.93	7.69	7.84
(1.00 g) FB	12.30	12.37	0.62	0.61	19.74	20.28	7.73	7.79
(0.50 g) FS	11.57	11.80	0.58	0.56	20.06	21.20	7.75	7.82
(0.75 g) FS	11.87	12.07	0.60	0.58	19.67	20.69	7.65	7.82
(1.00 g) FS	12.40	12.47	0.64	0.63	19.49	19.79	7.57	7.66
(0.50 g) FB + FS	13.27	12.77	0.60	0.61	21.99	21.04	7.36	7.54
(0.75 g)FB + FS	13.80	13.20	0.65	0.64	21.24	20.63	7.42	7.38
(1.00 g)FB + FS	14.93	13.67	0.68	0.67	21.85	20.30	7.32	7.28
L.S.D.at 0.05	0.35	0.25	0.03	0.01	1.26	0.50	0.24	0.14

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