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Response of Le Conte Pear Trees to Some Nutrients, Salicylic Acid and Yeast Foliar Application under Newly Reclaimed Soil

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ABSTRACT

The present investigation was carried out during 2015 and 2016 seasons on Le Conte pear trees, in order to evaluation the foliar spraying of potassium sulphate (0.1 %), zinc sulphate (1600 ppm), salicylic acid (SA) (20 ppm) and dry yeast (0.5 %) on trees nutritional status, yield and fruit quality. All different treatments sprayed two times in each season (Mid of May and June), while the control trees were sprayed with water. Results showed that K_2SO_4 treatment cause progress in fruit weight, firmness, TSS %, maturity index (MI), yield/tree (Kg) and yield/fed (ton). In addition, it showed superiority in leaf K, Ca and Fe content. While, ($ZnSO_4.7H_2O$) treatment gave pronounced values for fruit length, shape, TSS % and MI as well as superiority in leaf N, P, Ca, Fe and Zn contents. Moreover, yeast treatment recorded dominated values of fruit shape, TSS % and total sugars as well as leaf P, K, Zn, Mn and Cu contents. Also, SA treatment was surpassed in fruit diameter, firmness and number. Besides, its superiority in leaf contents of N, P, Ca, Mn and Cu. Contrary, the untreated trees gave the lowest significant values of TSS % and total sugars. It is worth mentioning, the SA treatment recorded the highest significant increase of TA% and the lowest statistical decrease of MI in both seasons. Accordingly, the conclusion is foliar application with different treatments two times of Le Conte pear trees were favorable in improving performance, yield quantity and quality under newly reclaimed soil conditions.

Key words: Le Conte pear, potassium and zinc sulphate, salicylic acid, yeast, nutritional status, yield and fruit quality

Introduction

Le Conte pear is one of the most important commercial crops grown in Egypt. The newly reclaimed soil is mostly a combination of environmental stress conditions including low water, saline soil, nutrients reduction, temperature fluctuations and high irradiances. Applying the optimum cultural practices with different nutrients that play an important role in helping plants to overcome partially the unfavorable conditions and avoid their negative effects on yield quantity and quality (Dawood *et al*., 2013).

Fertilization is considered an important practice during the growing season to obtain an economic yield and to improve the fruit quality characters. Also, they are known by their enhancement action for all growth aspects and plant production, due to the activation of enzymes responsible for the formation of Adenosine Triphosphate (ATP) and regulation of photosynthesis rate. One of the direct benefits is the increase of protein, which enhances the meristematic tissues and leading to better effect on both cell division and elongation (Hafez-Omaima & El- Metwally, 2007 and Hafez-Omaima *et al*., 2012). Spraying potassium has a positive effect on fruit setting, retention, yield and fruit quality because it plays an important regulatory role in many physiological and biochemical processes of plant (Ashraf *et al*., 2013). Also the important useful effect of zinc is a micro element which acts as a component of almost 60 enzymes, has a role in producing the growth hormone IAA, nitrogen metabolism and protein content (Mengel, 2002) and (Esam *et al*., 2016).

Salicylic acid (SA) is classified as a phenolic compound, a group of substances that can regulate plant growth (Amanullah *et al*., 2010). SA application influences a wide variety of plant processes,

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including stomata closure (Ananieva *et al*., 2002), plant growth and yield (Khodary, 2004) and induction of antioxidant synthesis (Yordanova and Popova, 2007). The known effects of SA on stomata function, chlorophyll content, transpiration rate and respiratory pathways indicate that SA and related phenolic compounds may be involved in regulation of some photosynthetic reactions (Ghasemzadeh and Jaafar, 2012).

The possibility of using yeast as natural biofertilizer and safety which is rich sources of phytohormones especially cytokinins, sugar, vitamins, enzymes and amino acids in order to improve the growth and productivity (Fathy and Farid, 1996). It has stimulating effects on cell division, cell elongation, synthesis of protein and nucleic acid as well as chlorophyll formation (Abou El-Yazied and Mady, 2012).

Hence, the target of this study was achieving the potential to enhancing of the nutritional status, yield and fruit quality through foliar application of different nutrients like potassium sulphate, zinc sulphate, salicylic acid and yeast on Le-Conte pear trees under reclaimed soil condition.

Materials and Methods

Pear Orchard

The present study was conducted during 2015 and 2016 seasons on uniform in vigor fifteen year's old Le Conte pear trees (*Pyrus communis*, L.) budded on Pyrus communis rootstock grown in sandy soil in a private orchard located at El-Tall El-Kepeer, Ismailia Governorate, Egypt, spaced 4x4 m, under drip irrigation system. The trees received the same horticultural practices that are recommended by The Egyptian Ministry of Agriculture. Complete randomized block design was adopted.

The soil analysis of the experimental site was used with physical properties i.e. pH 8.48, E.C 0.17 dSm^{-1}, $CaCO_3$ 1.33% and organic matter 0.38%, macronutrients mg/100g as (P 0.26, K 19.0, Ca 325, Mg 12.1 and Na 15.2) and micronutrients ppm as (Fe 3.2 , Mn 4.2, Zn 1.16 and Cu 0.12).

Foliar Spray Application

Different foliar treatments like 0.1 % potassium sulphate (K_2SO_4), 1600 ppm Zinc sulphate ($ZnSO_4.7H_2O$), 20 ppm salicylic acid (SA) and 0.5 % yeast. Addition to, control trees were sprayed with water. All foliar sprayed two times in each season (Mid of May and June). All spray solutions contained 0.1% triton B as a wetting agent and sprayed till run off.

Measurements and Determinations

Leaf Nutrient Contents

Samples of thirty leaves from the middle part of non fruited shoots were selected at random from each replicate. The leaves were washed, dried at 70ºC till constant weight, grind and digested to determine the macro-nutrients (N, P, K and Ca %) and micro-nutrient (Fe, Zn, Mn and Cu ppm) contents (Rebbeca, 2004).

Yield

In August of each year (2015 and 2016) at harvesting time, the fruit yield of Le Conte pear was estimated on basis of number and weight of fruits (Kg)/ tree. Also yield (ton)/ fed were calculated.

Fruit Quality Assessment

Samples of 15 fruits from each tree were randomly taken for determining the physical and chemical characteristics.

Physical Characters

Fruit weight (g), fruit length (L) (cm), fruit diameter (D) (cm) and shape L/D ratio were calculated. Also, fruit firmness was determined as Lb/inch^2 by using fruit pressure tester model FT 327 (3-27Lbs).

Chemical Characters

Total Soluble Solids percentage (TSS %) by using hand refractometer, Total Acidity (TA %) was estimated as percentage of Malic acid in fruit juice (AOAC, 2000). Maturity Index (MI) was calculated as a ratio of Total Soluble Solids/ Total Acidity. Total Sugars (TS) (g/ 100g FW) was determined using the phenol and sulphoric acid (Smith *et al*., 1956).

Statistical Analysis

The results were submitted to analysis of variance (Snedecor and Cochran, 1967). Differences among treatment means were determined as using the LSD test at a significance level of 0.05 (Waller and Duncan, 1969).

Results and Discussion

Nutritional Status

Leaf Macronutrients Content

Data recorded in Table (1) showed that leaves N, P, K and Ca content were significantly increased as a result of foliar application by different treatments when compared to untreated trees in both studied seasons. The highest significant of N % in leaves were obtained by SA (2.54 & 2.74 %), followed by zinc sulphate (2.51 & 2.71%). While, the highest value of P leaves content were revealed from yeast treatment (0.19 & 0.21%) and $ZnSO_4$ treatment (0.19 & 0.20 %) with no significant differ between them in both seasons.

Table 1: Effect of potassium sulphate, zinc sulphate, salicylic acid and yeast on nutritional status of Le Conte pear trees during 2015 and 2016 seasons

Treatments	**Leaf macronutrients content (%)**							
	N		P		K		Ca	
	1st	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**
K_2SO_4 (0.1%)	2.46	2.66	0.16	0.17	2.56	2.72	1.82	1.93
$ZnSO_4.7H_2O$ (1600ppm)	2.51	2.71	0.19	0.20	1.99	2.12	1.72	1.82
SA (20 ppm)	2.54	2.74	0.15	0.16	2.02	2.14	1.24	1.31
Yeast (0.5 %)	2.45	2.65	0.19	0.21	2.08	2.14	1.20	1.27
Control (water)	2.25	2.45	0.12	0.13	1.86	1.97	1.45	1.54
LSD $_{0.05}$	**0.01**	**0.01**	**0.01**	**0.01**	**0.03**	**0.11**	**0.02**	**0.01**
Treatments	**Leaf micronutrients content (ppm)**							
	Fe		Zn		Mn		Cu	
	1st	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**
K_2SO_4 (0.1%)	146.7	155.7	98.3	110.4	131.7	145.8	7.52	7.98
$ZnSO_4.7H_2O$ (1600ppm)	161.4	171.3	247.1	268.3	161.5	177.5	10.59	11.24
SA (20 ppm)	101.6	107.8	83.0	94.1	166.3	182.6	6.83	7.25
Yeast (0.5 %)	135.1	143.4	103.8	116.2	198.4	116.6	18.45	19.58
Control (water)	107.0	106.0	86.0	88.0	122.0	128.0	4.86	5.77
LSD $_{0.05}$	**2.2**	**1.1**	**6.4**	**3.13**	**4.1**	**2.08**	**0.47**	**0.26**

Meanwhile, the foliar spray of potassium sulphate recorded the highest statistical K leaves content (2.56 & 2.72 %), respectively in the two seasons. The yeast treatment (2.08 & 2.14 %) came next in both seasons in this regard, but the other treatments not appear statistical differences among them in the second season. In case of leaves Ca content, foliar application by K_2SO_4 and $ZnSO_4$ gave the highest significant increment in this respect, which recorded (1.82 & 1.93 %) and (1.72 & 1.82 %) consecutively in both seasons .The lowest values of all the aforementioned characters was obtained when Le Conte pear orchards were untreated.

Leaf Micronutrients Content

Results in Table (1) revealed that all foliar treatments significant increased Le Conte pear leaves of micro mineral content (Fe, Mn, Zn and Cu ppm), in the two seasons, except SA in respect of Fe in both seasons and Zn in 1st season. The highest significant values of Fe content were recorded with zinc sulphate (161.4 & 171.3 ppm), followed by potassium sulphate (146.7 & 155.7 ppm). Regarding Zn leaves content, trees treated by $ZnSO_4$ gave the highest statistical values of leaves Zn content which recorded (247.1 & 268.3 ppm). Followed by, the yeast treatment (103.8 & 116.2 ppm). As for Mn leaves content, the yeast treatment recorded the highest significant increment in this respect (198.4 & 116.6 ppm), followed by SA treatment (166.3 & 182.6 ppm). Concerning leaves Cu content, yeast treatment clearly evident the highest significant increase of leaves Cu content (18.45 & 19.58 ppm), followed by $ZnSO_4$ treatment (10.59 & 11.24 ppm), respectively in the two seasons. On the other vise, the untreated trees recorded the lowest significant values leaves content of Fe (107.0 & 106.0 ppm), Zn (86.0 & 88.0 ppm), Mn (122.0 & 128.0 ppm) and Cu (4.86 & 5.77 ppm), respectively in both seasons.

The increase of pear nutrient status resulted from spraying different nutrient solutions may be attributed to quick absorption via leaves and the limited loss of the nutrients when they were sprayed (Marschner, 1995). These results may be due to role of K and Zn in plant such as photosynthesis reactions, nucleic acids metabolism, protein and carbohydrate biosynthesis which due to increase of leaf mineral content (Hafez-Omaima & El-Metwally, 2007). On the other side, the lowest values of leaf N, P, K and Zn content were recorded when Le Conte pear trees were not foliar spraying with zinc or potassium. The same results were reported by (El-Shazly, 1999 and El-Seginy *et al*., 2003) on apple, (El-Seginy & Khalil, 2000 and Sayed *et al*., 2013) on pear. Meanwhile, other results also indicated that there was no significant effect of zinc or potassium on leaf Mn content of pear (Abd-Elmegeed-Nagwa *et al*., 2013).

Also, application of active dry yeast was very effective in releasing CO_2 which reflected on improving net photosynthesis (Fayed, 2010), besides its effectiveness in enhancing growth and nutritional status of trees was mentioned by (Barkat & Sayed, 2012, Hafez-Omaima *et al*., 2013 and Thanaa *et al*., 2015).

These results are in line with the findings (Khan *et al*., 2003 and Gunes *et al*., 2007) they found that salicylic acid is an endogenous growth regulator of phenolic nature and acts as potential non-enzymatic antioxidant which participates in the regulation of many physiological processes in plants, such as stomatal closure, photosynthesis, ion uptake. In addition, (Vazirimehr & Rigi, 2014) explaining that the promotive effect of salicylic acid could be attributed to its bio regulator effects on physiological and biochemical processes in plants such as ion uptake.

Yield and Its Components

Yield Components

Results in Table (2) indicated that fruit weight (g) and number of fruits/tree were significantly increased by using the different treatments especially in the 2nd season. This was true in both seasons. Potassium sulphate treatment recorded the highest values of fruit weight (175.2 & 200.9 g) and number of fruits/ tree (314.3 & 326) in the two seasons, respectively as compared with other treatments. On the contrary, the lowest values of fruit weight (154.8 & 179.3 g) and fruit number/tree (237.3 & 244.5) were recorded with the control treatment in the two seasons respectively.

Table 2: Effect of potassium sulphate, zinc sulphate, salicylic acid and yeast on yield and its components of Le Conte pear trees during 2015 and 2016 seasons

Treatments	Yield components				Yield			
	Fruit weight (g)		Fruit number		(Kg) / tree		(ton) /fed.	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
K_2SO_4 (0.1%)	175.2	200.9	314.3	326.0	55.07	65.49	13.77	16.37
$ZnSO_4.7H_2O$ (1600 ppm)	167.4	196.9	271.3	310.3	45.42	52.72	11.36	13.18
SA (20 ppm)	159.6	192.8	312.0	313.0	49.80	60.35	12.45	15.09
Yeast (0.5 %)	165.4	190.9	275.7	290.0	45.60	55.36	11.40	13.84
Control (water)	154.8	179.3	237.3	244.5	36.73	43.84	9.18	10.96
LSD 0.05	**12.8**	**11.44**	**37.0**	**33.20**	**8.19**	**11.85**	**1.48**	**2.13**

Yield

In both seasons, all foliar application of different nutrients developed significant effects on yield (kg)/tree and yield (ton)/fed except yeast in the 2nd season as showed in Table (2). K_2SO_4 treatment recorded the greatest yield per tree and fed. as compared with the other treatments including control. SA, yeast and $ZnSO_4$ treatments markedly produced higher yield (kg)/tree than untreated trees. These superior treatments increased the average of yield (kg)/tree than the control treatment by about 49.9, 35.6, 24.2 and 23.7 % in the first season and 49.4, 37.7, 26.3 and 20.3 % in the second season, respectively. In contrast, the lowest value of yield/tree was recorded with the control (36.73 & 43.84 kg/tree) and (9.18 & 10.96 ton/ fed), consecutively in the two seasons.

The previous mentioned enhancement on nutritional status of pear trees due to treatments surely reflected on improving trees productivity. The results obtained here indicated that foliar application of different treatments like K_2SO_4, SA, yeast and $ZnSO_4$ produced a promising effect on nutritional status of Le Conte pear trees, main characteristics of yield components (fruits weight and number) and yield (kg)/ tree as well as yield (ton)/ feddan in comparison with the untreated trees. The superiority in tree productivity may be due to accumulative effect of macro and micronutrient that resulted in better effect (El-Seginy *et al*., 2003 and Esam *et al*., 2016).

Salicylic acid, a naturally occurring plant hormone acting as an important signaling molecule adds to tolerance against a biotic stresses. It plays a vital role in plant growth, ion uptake and transport. Also, it is involved in endogenous signaling to trigger plant defense against pathogens (Khan *et al*., 2003 and (Vazirimehr & Rigi, 2014). Moreover, by boosting photosynthetic rate in response to enhanced antioxidant enzyme activities, it therefore appears that SA can generally be used as a growth regulator to enhance plant growth, nutritional status and yield (Ghasemzadeh & Jaafar, 2013).

The potential using yeast as biofertilizer to it role in available of minerals and increases levels of extracts N, P, K, Fe, Zn and Mn. Also, may be capable of producing growth regulator like auxins, cytokinins, gibberellins or vitamin B which can be transferred to the plant (Mohamed and Hafez, 2004). Our results are also in harmony with those reported by (Fayed, 2010; Abou El-Yazied & Mady, 2012; and Hafez-Omaima *et al*., 2013).

Fruit Quality Assessment

Physical Characteristics

Data in Table (3) evident that fruit length (cm), fruit diameter (cm), fruit shape and fruit firmness (Lb/ $inch^2$) were significantly increased by foliar application of different treatments in both experimental seasons. $ZnSO_4$ treatment recorded the highest significant values of fruit length (9.27 & 9.91 cm), followed by SA treatment (9.02 & 9.76 cm) consecutively in the 1st and the 2nd seasons. SA and/or $ZnSO_4$ treatments obtained the highest values of fruit diameter (6.81 & 7.36 cm) and (6.81 & 7.29 cm), respectively in both seasons with not significant differ between them. The $ZnSO_4$ and yeast treatments gave the largest significant shape (1.36 & 1.36) and (1.34 & 1.34), successively in the two seasons. While, K_2SO_4 and SA treatments recorded the hardness fruits with high significant differences between them in both seasons, when compared with the other treatments including

control. On the contrast, the lowest values of all the previous characters were recorded with the control treatment.

Table 3: Effect of potassium sulphate, zinc sulphate, salicylic acid and yeast on fruit quality assessment of Le - Conte pear trees during 2015 and 2016 seasons

Treatments	Physical characteristics							
	Fruit length (L) (cm)		Fruit diameter (D) (cm)		Fruit shape (L/D)		Fruit firmness ($Lb/inch^2$)	
	1st	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**
K_2SO_4 (0.1%)	8.40	9.01	6.53	7.01	1.29	1.29	29.33	36.57
$ZnSO_4.7H_2O$ (1600 ppm)	9.27	9.91	6.81	7.29	1.36	1.36	26.81	34.80
SA (20 ppm)	9.02	9.76	6.81	7.36	1.33	1.33	28.10	35.44
Yeast (0.5 %)	8.42	9.03	6.29	6.74	1.34	1.34	25.44	31.88
Control (water)	8.78	9.18	6.60	6.91	1.33	1.33	23.88	30.50
LSD 0.05	**0.37**	**0.52**	**0.29**	**0.40**	**0.01**	**0.01**	**1.41**	**2.47**
Treatments	**Chemical characteristics**							
	Total soluble solids (%)		Total acidity (%)		Maturity index		Total sugars (g/100g *FW)	
	1st	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**
K_2SO_4 (0.1%)	13.63	14.30	1.50	1.63	9.09	8.77	10.50	11.01
$ZnSO_4.7H_2O$ (1600 ppm)	13.37	14.07	1.43	1.57	9.35	8.99	10.29	10.83
SA (20 ppm)	13.27	13.87	1.90	2.20	7.02	6.32	10.22	10.68
Yeast (0.5 %)	13.93	14.73	1.70	1.87	8.20	7.90	10.73	11.34
Control (water)	13.20	13.67	1.50	1.80	8.89	7.62	10.16	10.52
LSD 0.05	**0.34**	**0.29**	**0.19**	**0.14**	**1.23**	**0.57**	**0.33**	**0.23**

**FW: fresh weight*

Chemical Characteristics

Data also, in Table (3) revealed that Le Conte pear trees sprayed with yeast treatment recorded superior increase TSS (13.93 & 14.73 %) and total sugars (10.73 & 11.34 g/ 100g FW), respectively in the two seasons when compared with all treatments including control. Followed by K_2SO_4 treatment this recorded (13.63 & 14.30 %) of TSS and (10.50 & 11.01 g/ 100g FW) in total sugars, consecutively in both seasons. Other vise, trees application with $ZnSO_4$ treatment followed descending by K_2SO_4 treatment showed highest values of maturity index (9.35 & 8.995 %) and (9.09 & 8.77 %), respectively in the 1st and the 2nd seasons. While, trees foliar with $ZnSO_4$ treatment followed ascending by K_2SO_4 treatment showed lowest values of TA (1.43 & 1.57 %) and (1.50 & 1.63 %), consecutively in both seasons. Contrally, the untreated trees gave the lowest significant values of TSS (13.20 &13 67 %) and TS (10.16 & 10.52 g/100g FW), respectively in the two seasons. It is worth mentioning, the SA treatment obtained the highest significant increase of TA (1.90 & 2.20 %) as well as the lowest statistical decrease of MI (7.02 & 6.32), consecutively in both seasons.

Many investigations studied the effect of macro and micronutrients foliar application on deciduous fruits recommended to increase fruit set, yield quantity and fruit quality of trees grown on calcareous soil (El-Seginy & Khalil, 2000; El-Seginy *et al*., 2003; Abd-Elmegeed-Nagwa *et al*., 2013 and Ashraf *et al*., 2013).

Also, application of active dry yeast was very effective in releasing CO_2 which reflected on improving net photosynthesis (Hafez-Omaima *et al*., 2013), besides its effectiveness in improving growth, nutritional status, productivity and fruit quality (Thanaa *et al*., 2015).

The promotive effect of salicylic acid could be attributed to its bio regulator effects on physiological and biochemical processes in plants such as ion uptake, cell elongation, cell division, cell differentiation, sink/source regulation, enzymatic activities, protein synthesis and photosynthetic activity as well as increase the antioxidant capacity of plants (Elwan and El-Hamahmy, 2009; Fayed, 2010 and Tahira *et al*., 2013). It may be decreasing MI by SA due to it increase the acidity.

Conclusion

Accordingly, the conclusion is foliar application of (K_2SO_4 (0.1%), $ZnSO_4.7H_2O$ (1600 ppm), SA (20 ppm) and yeast (0.5 %) two times (Mid of May and June) were favorable in improving performance, yield and fruit quality of Le-Conte pear trees under the newly reclaimed soil conditions**.**

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