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Manipulation of Irrigation, Emitter Discharges, and Some Anti- Stress Substances in an Attempt to Elevate Le-Conte pear Trees Productivity

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ABSTRACT

This study was carried out during two successive seasons in 2021 and 2022 on 17 year-old "Le-Conte" pear trees grafted on *Pyrus communis* and growing in loamy sandy soil under a drip irrigation system to investigate the effects of irrigation rate treatments (75 and 100% of crop water requirement) as well as different two emitter discharges (4 and 8 L/h) and anti- stress treatments substances (wuaxal amino and free sal) to enhance water use efficiency. Yield (kg/tree), fruit quality (fruit physical and chemical characteristics), and water use efficiency (WUE) were assessed. Results showed that the highest yield values were recorded by applying an irrigation rate of 100% under emitter discharges of 4 L/h with the addition of wuxal or free sal alone. On the other side, increasing the irrigation rate caused an increasing of some fruit characteristics (weight, volume, length, and diameter). The same results were investigated by using emitter discharges of 8 L/h; also, applying wuxal alone was more effective in these characteristics. While both firmness and TSS increased by decreasing the irrigation rate to 75%. The interaction between CWR at 100% + discharges of 8 L/h + wuxal increased fruit weight, volume, length, and diameter. The interaction between CWR at 75% + discharges of 8 with (W+F) or discharges 4L/h with wuxal induced the highest TSS values. While the highest fruit firmness was recorded by the control. Concerning the water use efficiency (WUE), the results indicated that the lower irrigation rate at 75% encouraged the highest WUE values, and the addition of free sal or wuxal alone enhancement WUE values. The interaction between CWR at 75% + discharges of 4 L/h, + wuxal or free sal increased WUF during both seasons.

KEYWORDS: Le-Conte Pear, Irrigation Rate, Emitter Discharges, Wuxal Amino, Free Sal, Fruit Characteristics, Yield

1. INTRODUCTION

One of the most important deciduous fruits cultivated in the world is the pear. The most common pear cultivar in Egypt is called "Le-Conte," which is a cross between) *Pyrus communis* L., and *Pyrus serotina* Rehd (With an average production of 6728 tonnes per feddan, Egypt's farmed land reached 13365 feddans, producing around 79206 tonnes (Ministry of Agricultural and Land Reclamation 2020). Since strong abiotic restrictions like salinity, temperature, and drought are frequently associated with these climate conditions, plant growth, yield amount, and fruit quality are significantly reduced (Ahanger *et al*., 2018; Soliman *et al.,* 2019; Kaya *et al*., 2020; Kononenko *et al*., 2020; Soliman *et al*., 2020a). Under deficit irrigation (DI), the amount of irrigation is less than what is required to achieve maximal evapotranspiration (ET) (English, 1990). However, according to certain research, DI may negatively impact fruit trees' development and yield (Daniells *et al*., 1987). Numerous studies have examined how controlled water deficiencies affect the production, flowering, vegetative growth, and fruit growth of various pear tree varieties in various climates (Caspari *et al.*, 1994; Marsal *et al.,* 2000). Soil salinization is the most detrimental abiotic stressor to crops in terms of plant growth, development, and ultimately agricultural productivity and food security (Sharma *et al*., 2016; Acosta- Motos *et al*., 2020; Soliman *et al*., 2020a). Additionally, the accumulation of ROS, including singlet oxygen, superoxide radicals, and H2O2, is indirectly caused by salinity stress (Ahmad *et al*., 2018b; Mir *et al*., 2018). Under field conditions, the shape of the wetted volume of soil under a drip emitter is, according to Skaggs *et al*., (2010), influenced by soil texture, soil structure, soil hydraulic properties, anisotropy such as horizontal and vertical permeability and impermeable layers. The irrigation system's design parameters, management, rate of application, emitter distance, dripper location, and lateral orientation with respect to the plant row all affect the patterns of soil water content. Free Sal anti-salinity compounds, which consist of 11% calcium and 9% nitrogen. Sholi (2012) showed that in saline soils, the use of high amounts of Ca^{2+} leads to an increase in the plant tolerance to salinity and its yield. Numerous investigations demonstrated that applying calcium reduced the detrimental effects of salt on plants. According to Grattan and Grieve (1994), plants that have higher Ca levels are less susceptible to the harmful effects of sodium chloride. Girija *et al*., (2002) reported that calcium functions as a secondary messenger in the interior environment of cells, influencing the stability and enzyme activity to alleviate the stress. According to the European Union's criteria, Wuxal Amino is eligible for admittance because he practices ecological farming. The effects of Wuxal Amino, a biofertilizer with NPK, 9% organically fixed nitrogen, and many more potent forms of amino acids (proline, alanine, glycine, and threonine) have been the subject of conflicting studies in the past. Additionally, it has a wide range of distinct types of amino acids, which may help woody plants grow vegetatively (Szabó *et al*., 2014).

This study aims to enhance the water use efficiency of "Le- Conte" pear trees under desert soil conditions by using different irrigation rates, emitter discharges and some anti- stress amendments.

2. MATERIALS AND METHODS

The study were conducted on 17 years old Le-Conte pear trees grafted on *Pyrus comunis*, growing in private orchard located at Cairo – Alexandria desert Road (64 Km from Cairo). The trees were planted 5 × 5 m apart and were irrigated using a drip system while following the routinely advised cultural practices.

Irrigation water chemical analysis is presented in Table (1) as well as soil chemical and Mechanical analyses are exhibited in Tables (2, 3) which were determined in the laboratory of Solis, Water and Environment Research Institute.

2.1.The layout of the experiment

48 Le-Conte pear trees, nearly similar in their growth and pathogen-free were carefully selected to build up the Skeleton of such an experiment. Those trees received 16 treatments,

Table 1. Water chemical analysis.

Parameters		Anions		Cations		
EC(ds/m)	3.13	$CO3^{-2}$	-	Ca^{+2}	9.5	
ppm	2003	$HCO3^{-}$	2.00	Mg^{+2}	5.5	Residual sodium carbonates -
PH	7.48	CL	19.5	Na^{+}	15.75	Saturated sodium percentage 5.75
		SO_4^{-2}	9.77	K^{+}	0.52	

Table 2. Soil chemical analysis results for soil paste extract

Anions (mm/L)			Cations (mm/L)					Saturation percent SP	Electrical conductivity EC (ds/m)	Salinity (ppm)	pH 1:2.5
K^{+}	Na^{+}	Mg^{++}	Ca^{++}	$SO_4^{=}$	CL	HCO_3^{-}	$CO_3^{=}$				
0.42	5.75	3.5	4.5	5.17	8.5	0.5	-	28.00	1.42	909	8.33

Table 3. Soil mechanical analysis

Textures	Volumetric distribution of soil granules (%)		
	Clay	Silt	sand
Loamy sand	2.1	46.5	51.5

besides the control. Each treatment was represented by three replicates (trees).

The main structure of that research was depended on the three next investigated factors:

1- Two irrigation rates were used (100 and 75% of crop water requirements).

2- Supertif drippers (4 and 8L/h) were arranged and distributed on two laterals at distances of 50 cm at each side of a tree trunk.

3- Anti–stress amendments (Wuxal amino and Free sal) were used as additional treatments to reduce the harmful effect of water and salt stress as well as enhance water use efficiency. Wuxal was added of the rate of 1L/Fad while Free sal was applied at the rate2.5L/Fad once a month, from April to September each season.

Chemical structure of wuxal amino: Nitrogen (N) 9.1 - phosphor (P) 20% - potassium (K) 10% - Chelating Iron (F) 0.05% - Chelating zinc (Zn) 0.08% - Chelating manganese (Mn) 0.08% - sulphur (S) 2.76% - Boron (B) 0.014% - Amino acid 5.55% - EDITA (Chelating material) 12.0% - PH 5.5.

Chemical structure of free sal: 11% Calcium(Ca) and 9% Nitrogen(N).

Accordingly, the three above mentioned investigated factors were arranged and combined to form the following twelve treatments beside the control.

1. Irrigation rate at 100% + emitter discharges of 4L/h + control(without treatment)
2. Irrigation rate at 100% + emitter discharges of 4L/h + Wuxal alone
3. Irrigation rate at 100% + emitter discharges of 4L/h + Free sal alone
4. Irrigation rate at 100% + emitter discharges of 4L/h + (W +F)
5. Irrigation rate at 100% + emitter discharges of 8L/h + control (without treatment)
6. Irrigation rate at 100% + emitter discharges of 8L/h + Wuxal alone
7. Irrigation rate at 100% + emitter discharges of 8L/h + free sal alone
8. Irrigation rate at 100% + emitter discharges of 8L/h + (W+F)
9. Irrigation rate at 75% + emitter discharges of 4L/h + control (without treatment)
10. Irrigation rate at 75% + emitter discharges of 4L/h + Wuxal alone
11. Irrigation rate at 75% + emitter discharges of 4L/h + free sal alone
12. Irrigation rate at 75% + emitter discharges of 4L/h + (W+F)

13. Irrigation rate at 75% + emitter discharges of 8L/h + control (without treatment)
14. Irrigation rate at 75% + emitter discharges of 8L/h + Wuxal alone
15. Irrigation rate at 75% + emitter discharges of 8L/h + free sal alone
16. Irrigation rate at 75% + emitter discharges of 8L/h + (W+F)

Crop water requirements (CWR) were used to calculate irrigation treatments. The planting region's "TAHRIR" weather data was used to hypothetically compute the amount of water. The amount of water needed was determined using the formula provided by Karmeli and Keller in 1975. Whereas daily irrigation requirements (IR) = (Se.SL.ETo.Kc.Kr/Ea)*(1/1-Lr)

Se. SL = Plant area (Plant distance on lateral x between laterals).
ETo = Daily reference evapotranspiration on mm/day.
Kc = The coefficient factor for pear trees.
Kr = Reduction coefficient Gc/0.85.
Gc = Ground cover (area of tree canopy).
Ea = Efficiency of irrigation system (85%).
Lr = Leaching requirements = Eci/Ecd.
ECi = Electrical conductivity of irrigation water.
ECd = Electrical conductivity of drainage water.

The penman-Monteith method was used to calculate ET crops for pear trees using the CROPWAT model (Smith 1991).

Table 5. The average monthly and total amount of water applied during the year under two water doses (m^3/F/Year).

2020			2021		
Month	**100%CWR(m3)**	**75%CWR(m3)**	**Month**	**100%CWR(m3)**	**75%CWR(m3)**
January	47.7	35.7	**January**	51.2	38.4
February	87.04	65.2	**February**	107.5	80.6
March	161.2	120.9	**March**	173.2	129.9
April	294.9	221.1	**April**	319.4	239.5
May	549.5	412.1	**May**	588.8	441.6
June	667.3	500.4	**June**	725.3	543.9
July	629.7	472.2	**July**	660.4	495.3
August	660.4	495.3	**August**	691.2	518.4
September	465.9	349.4	**September**	501.7	376.2
October	307.2	230.4	**October**	358.4	268.8
November	92.1	69.07	**November**	102.4	76.8
December	64.8	48.6	**December**	68.2	51.1
Total	4027.7	3020.4		4347.7	3260.5

2.2.Assessments

1. Yield

Was calculated either by the average number of fruits /tree or by the average fruit weight (kg) /tree (by multiplying the average fruit weight by the average number of fruits/tree).

2. Fruit characteristics

a. Fruit physical characteristics

Fruit weight (gm) using a digital scale.

Fruit volume (cm^3) using water displaces meter method.

Fruit length and diameter by a vernier caliber.

Fruit shape index (L/D ratio), was measured by dividing the fruit length by its diameter.

Fruit firmness ($Ib/inch^2$) was estimated by using a pressure tester**.**

b. Fruit chemical characteristics

TSS% of fruit pulp Juice was estimated by using a hand refractometer.

Titratable acidity % of fruit pulp juice was determined malic acid according to A.O.A.C (1995).

3. Water use efficiency (WUE):

Was calculated by dividing the yield by the amount of water (m3) that Fadden (4200 m2) consumed, as stated by Ibrahim (2003).

2.3.Statistical analysis:

The experiments involved three factors (A, B and C). The first factor (A) consisted of two levels of irrigation rates (75 and 100%). The second one (B) comprised from two levels of Emitter discharges (4 and 8L/h) and the third factor (C) consists of two anti-stress substances and its combination. Furthermore the irrigation rates, emitter discharges and anti-stress substances were selected up to be the main, sub and sub plots, respectively.

The MSTAT package for analysis of variance (ANOVA) is used to perform computerized statistical analysis on the measured parameter results (Snedecor and Cochran 1980). Additionally, significant differences among means were distinguished according to the an's, multiple test range (Duncan, 1955), whereas capital and small letters were used for differentiating the values of specific and interaction effects of the investigated factors, respectively.

3. RESULTS AND DISCUSSION

3.1. Effect of irrigation rate, emitter discharges and anti-stress treatments on yield (kg)/tree.

Regarding the specific effect of the three investigated factors Table (6) indicate that the trees which were received CWR at 100% produced the a higher significant yield per tree (37.43 and 70.79 kg) in comparison with those trees which received 75% (32.27 and 65.19 kg) during the first and second seasons, respectively. Regarding the specific effect of the two investigated emitter discharges (4 and 8L/h), it was clear that the highest yield recorded by using emitter discharges of 4L/h were (35.21 and 73.25 kg) during the first and second seasons respectively. While the anti-stress treatments, recorded a significant enhancement yield compared with the check treatment, in this respect the highest yield was achieved by wuxal alone treatment (36.89kg) in the first season while free sal alone treatment was the best one (70.03kg) during the second season. Concerning the interaction between irrigation rate, emitter discharges and anti-stress treatments, results in Table (6) illustrated that the highest significant yield per tree was recorded by applying CWR at 100% + emitter discharges of 4L/h with the addition of wuxal alone (48.57kg) in the 1st season or with the addition of free sal alone (86.43 kg) during the second season.

3.2. Effect of irrigation rate, emitter discharges and antistress treatments number of fruit per tree

Regarding the specific effect of the irrigation rate data in Table (6) indicated that applying CWR at 100% has achieved the highest fruits number per tree (206.2 -436.7) comparing to the applying of CWR at 75% (189.1-435.1). As regards the effect of emitter discharge data illustrated that a higher fruit number per tree was induced by emitter discharges of 4L/h (202.3-485.8) during the first and the second season, respectively. The number of fruits produced per tree was not significantly affected by the anti-stress treatments. In this respect, the highest number was recorded by control (209 – 482 fruits/tree) during the first and the second season, respectively. As for the interaction effect, it is clear that the association between CWR at 100% + emitter discharges of 4L/h with the addition of wuxal alone recorded the highest fruits number per tree in the first season (254) while in the second one, the highest fruits number per tree was recorded by the combination of CWR at 75% + emitter discharges of 4L/h + (W+F) treatment (539) respectively.

These results are parallel with Khattab *et al.*, (2011) who found that increasing irrigation levels increased the yield. Furthermore, in "Le Conte" pear trees, Abd El-Messeih and Gendy (2009) found that when the amount of irrigation water applied per tree decreased, the fruit yield per tree also decreased. This was because the soil water potential had decreased and there was an

Table 6. Effect of two irrigation rate, two emitter discharges and some anti-stress treatments on yield (kg/tree) and number of fruits per tree, of Le- Conte pear trees

Parameter		Yield (kg/tree)			Number of fruits per tree		
Emitter discharges (B)	Treatments (C)	Irrigation rate (A) 75 %	Irrigation rate (A) 100 %	Means	Irrigation rate(A) 75 %	Irrigation rate(A) 100 %	Means
				First season; 2020/2021			
4 liter/hours	Control	34.10de	34.10de	Mean (B)**	209bc	209bc	Mean (B)**
	Waxal	29.53h	48.57a	35.21A	170h	254 a	202.3 A
	W + F	31.80fg	34.00de	34.49B	201c	197cd	193 B
	F.S.	32.80ef	36.77c		185ef	194d	
				Mean (C)***			Mean (C)***
8 liter/hours	Control	34.10de	34.10de	34.10C	209bc	209bc	209 A
	Waxal	32.83ef	36.63c	36.89A	187e	183f	198.5 B
	W + F	32.17fg	35.57cd	33.38C	179fg	189de	191.5 C
	F.S.	30.80gh	39.70b	35.02B	173g	215 b	191.7 C
Mean (A)*		32.27B	37.43A		189.1B	206.2 A	
				Second season; 2021/2022			
4 liter/hours	Control	65.13g	65.13g	Mean (B)**	482 d	482 d	Mean (B)**
	Waxal	74.53d	81.47b	73.25A	474de	452 e	485.8 A
	W + F	69.07e	77.17c	62.74B	539 a	494 c	386 B
	F.S.	67.03f	86.43a		436 f	528 b	
				Mean (C)***			Mean (C)***
8 liter/hours	Control	65.13g	65.13g	65.13D	482 d	482 d	482 A
	Waxal	54.37i	65.23g	68.90B	327 k	353j	401.5 C
	W + F	64.10g	61.30h	67.91C	365hi	341jk	434.7 B
	F.S.	62.17h	64.47g	70.03A	376 g	362 h	425.5 C
Mean (A)*		65.19B	70.79A		435.1A	436.7A	

Values followed by the same letters are not significantly different at 5% level.
* refers to specific effect of Irrigation rate respectively.
** refers to specific effect of Emitter discharges respectively.
*** refers to specific effect of Treatments respectively.

imbalance in the overall concentrations of ions because of the ion toxic effect on physiological processes like growth regulation, photosynthesis, respiration, and enzyme activity (Valia and Potiel 1997). On the other hand, this study is in the same line with Osman *et al*., (2012) who stated that a positive relationship was obtained between the percentage of wetted soil area and yield. As the effect of ant stress treatments This study came in line with that reported by Khattab *et al*., (2012), they added a mixture of amino acids to pomegranate trees and found that the higher doses of amino acids enhanced yield weight. Also, these results were in harmony with the finding of Al Khawga (2013) who found that Using Ca at 150ml / palm gave the highest yield in date palm in the two seasons. The increase in the yield may be attributed to the increase of Ca concentration in the soil solution decreasing the osmotic potential of the soil creating severe water stress derailing the uptake processes (Parida and Das, 2005).

3.3. Effect of irrigation rate, emitter discharges and anti-stress treatments on fruit physical characteristics:

3.3.1. Fruit weight (g):

Regarding the specific effect of the irrigation rate, data in Table (7) indicated that applying CWR at 100% has increased fruit weight (181.3 and 164 g). As regards the effect of two emitter discharges (4 and 8L/h), the higher fruit weight (178.9 and 164.8 g) was induced by emitter

Table 7. Effect of two irrigation rate, two emitter discharges and some ant stress treatments on fruit weight (g) and fruit volume(cm^3) of Le- Conte pear trees

Parameter		Fruit weight (g)			Fruit volume (cm3)		
Emitter discharges (B)	Treatments (C)	Irrigation rate(A) 75 %	Irrigation rate(A) 100 %	Means	Irrigation rate (A) 75%	Irrigation rate (A) 100 %	Means
				First season; 2020/2021			
4 liter/hours	Control	162.9i	162.9i	Mean (B)**	156.1h	156.1h	Mean (B)**
	Waxal	173.9g	191.2b	173.5B	177.7d	178.5d	163.3B
	W + F	158.6j	172.0h	178.9A	146.1i	168.4g	174.6A
	F.S.	177.3f	189.0c		156.4h	167.0g	
				Mean (C)***			Mean (C)***
8 liter/hours	Control	162.9i	162.9i	162.9D	156.1h	156.1h	156.1D
	Waxal	175.6g	199.7a	185.1A	168.8g	206.5a	182.9A
	W + F	179.3e	188.4c	174.6C	173.3e	183.9b	167.9C
	F.S.	178.0ef	184.2d	182.1B	171.5f	180.5c	168.8B
Mean (A)*		171.1B	181.3A		163.2B	174.6A	
				Second season; 2021/2022			
4 liter/hours	Control	135.0i	135.0i	Mean (B)**	133.3j	133.3j	Mean (B)**
	Waxal	157.2g	180.1b	151.1B	147.5i	164.2d	146.1B
	W + F	128.0j	156.2g	164.8A	127.7k	153.4gh	156.9A
	F.S.	153.6h	163.5f		151.9h	157.7f	
				Mean (C)***			Mean (C)***
8 liter/hours	Control	135.0i	135.i	135.0D	133.3j	133.3j	133.3D
	Waxal	166.0e	184.6a	172.0A	161.1e	175.9a	162.2A
	W + F	175.3d	179.9b	159.8C	170.0c	172.8b	156.0B
	F.S.	165.2e	177.7c	165.0B	154.0g	154.7g	154.6C
Mean (A)*		151.9B	164.0A		147.3B	155.7A	

Values followed by the same letters are not significantly different at 5% level.
* refers to specific effect of Irrigation rate respectively.
** refers to specific effect of Emitter discharges respectively
*** refers to specific effect of Treatments respectively

discharges of 8L/h during the first and second seasons, respectively. Regarding the specific effect of anti-stress treatments, the results showed that all treatments significantly increased the average fruit weight compared with the control during both seasons. In this respect applying wuxal alone gave the highest fruit weight (185.1 and 172 g) followed by applying free sal alone (182.1 and 165.1g), while the lowest values of such parameter was detected with the control (162.9 and 135.0 g) during the first and second season, respectively. Regarding the interaction between the three investigated factors, data in Table (7) indicate that the highest fruit weight (199.7 and 184.6 g) was recorded by the combination between CWR at 100% + emitter discharge of 8L/h + wuxal alone during the first and second season, respectively.

3.3.2. Fruit volume (cm^3):

With regards the effect of irrigation rate, the results in Table (7) indicated that the higher fruit volume (174 and 155.7 cm^3) was induced by increasing irrigation rate (CWR at 100%) during both seasons.

Regarding the specific effect of emitter discharges (4 and 8L/h), fruit volume (174.6 and 156.9 cm^3) was enhanced by using an emitter discharge of 8L/h during both seasons. Concerning the specific effect of anti-stress treatments, wuxal treatment give the highest fruit volume values (182.9 and 162.2 cm^3) for the first

and the second season respectively. Concerning the interaction between the three studied factors, data presented in Table (7) refer that the combination between CWR at 100% + discharges 8L/h + wuxal alone treatment recorded the highest significant fruit size values (206.5 and 175.9 cm^3), followed by applying CWR at 100% + discharges 8L/h + (W+F) treatment (183.9 and 172.8 cm^3) for the first and second season.

3.3.3. Fruit length (cm):

The specific data concerning effect of irrigation rate, emitter discharges and anti-stress treatments on Le-Conte pear fruit length (cm) during 2021and 2022 seasons are presented in Table(8), applying CWR at 100% improved values of fruit length (7.73 and 6.10 cm) than the lower rate during the first and second seasons, respectively. In regard to the specific effect of emitter discharges, data reveal that an increment value of fruit length was recorded by using emitter discharges of 8L/h only in the first season (7.83cm) but in the second season the significant differences were disappeared. Referring to the specific effect of anti-stress, it was clear that wuxal alone achieved the highest values of fruit length (7.88 and 6.64cm), followed by applying free sal alone (7.83 and 6.07cm). on the other way around, the lowest values were recorded by the control (7.30 and 5.87cm) during the first and second seasons respectively. The interaction between irrigation rate, emitter discharges and ant stress treatments resaved that applying CWR at 100% by emitter discharges of 8L/h with the addition wuxal alone recorded the highest fruit length values (8.30 and 6.30cm) during both seasons.

3.3.4. Fruit width (cm):

Regarding the specific effect of irrigation rate, it was clear from the data presented in Table (8) that applying CWR at 100% maximized fruit width (6.51 and 5.37cm) during both seasons. As regards the effect of emitter discharges (4 and 8 L/h), data obtained that the highest fruit width was recorded by using emitter discharges 8 L/h (6.57 and 5.40 cm) during the first and second seasons, respectively. For the specific effect of anti-stress treatments, there were no significant differences between anti-stress treatments and control in the first season. While during the second season, the highest values of fruit width were recorded by applying wuxal alone. As regards the interaction between the three studied factors the results in Table (8) illustrated that applying CWR at 100% + discharges of 8 L/h + (W+F) recorded the highest fruit width value in the first season (6.90 cm). Meanwhile, in the second season, the highest value was recorded by applying CWR at 100% by emitter discharges of 8 L/h with the addition of wuxal alone.

3.3.5. Fruit shape index (L/W):

Concerning the effect of irrigation rate, data in Table (9) clearly showed that the significant differences were omitted between the two irrigation rates (100 and 75%). With regards the specific effect of emitter discharges there were no significant differences between the two emitter discharges of 4 and 8 L /h on fruit shape index during the first season but in the second season using emitter discharges of 4 L/h was better in this respect. On the other hand, the response of the studied parameter was highly with either wuxal or free sal in the 1st season, while the combination between them reflected more response during the 2nd season. The interaction between CWR at 75% + emitter discharges of 8L/h + free sal was more pronounced during the 1st season, while the combination between CWR at 100% + emitter discharges of 4L/h + free sal was the premier one in that respect during the 2nd season of study.

3.3.6. Fruit firmness (Ib / $inch^2$):

Concerning the specific effect of the two rates irrigation system (75 and 100%) on fruit firmness, it was clear from data presented in Table (9) that irrigation at 100% level reflected fruits with more texture softness as compared with the other level of irrigation (75%) in the first season, while in the second one, both levels of irrigation gave hard fruit texture. Concerning the specific effect of emitter discharge, it was clear that fruit firmness was increased by using emitter discharges of 8 L/h (21.56 and 19,16 Ib / Inch2) in the first and the second seasons, respectively.

Table 8. Effect of two irrigation rate, two emitter discharges and some ant stress treatments on fruit length(cm) and fruit width(cm) of Le-Conte pear trees.

Parameter		Fruit length (cm)			Fruit width (cm)		
Emitter discharges (B)	Treatments (C)	Irrigation rate (A)		Means	Irrigation rate (A)		Means
		75 %	100 %		75 %	100 %	
				First season; 2020/2021			
4 liter/hours	Control	7.30h	7.30h	Mean (B)**	6.40de	6.40de	Mean (B)**
	Waxal	7.63ef	7.83bc	7.45B	6.13f	6.43d	6.28B
	W + F	7.13i	7.50g	7.83A	5.90g	6.27e	6.57A
	F.S.	7.37h	7.53fg		6.33de	6.37de	
				Mean (C)***			Mean (C)***
8 liter/hours	Control	7.30h	7.30h	7.30C	6.40de	6.40de	6.40A
	Waxal	7.77cd	8.30a	7.88A	6.47d	6.70bc	6.43A
	W + F	7.67de	7.90b	7.55B	6.73b	6.90a	6.45A
	F.S.	8.23a	8.20a	7.83A	6.37de	6.60c	6.42A
Mean (A)*		7.55B	7.73A		6.34B	6.51A	
				Second season; 2021/2022			
4 liter/hours	Control	5.87h	5.87h	Mean (B)**	5.20f	5.20f	Mean (B)**
	Waxal	6.43b	6.13d	6.05A	5.57b	5.40d	5.25B
	W + F	5.93gh	5.97fg	6.06A	5.03g	5.20f	5.40A
	F.S.	5.67i	6.53a		5.23ef	5.30e	
				Mean (C)***			Mean (C)***
8 liter/hours	Control	5.87h	5.87h	5.87C	5.20f	5.20f	5.20D
	Waxal	6.10de	6.30c	6.24A	5.20f	5.80a	5.49A
	W + F	6.23c	6.03ef	6.04B	5.53bc	5.47cd	5.28C
	F.S.	5.97fg	6.10de	6.07B	5.30e	5.50bc	5.33B
Mean (A)*		6.01B	6.10A		5.28B	5.37A	

Values followed by the same letters are not significantly different at 5% level.
* refers to specific effect of Irrigation rate respectively.
** refers to specific effect of Emitter discharges respectively.
*** refers to specific effect of Treatments respectively

With regards to the specific effect of anti-stress treatments on fruit firmness, data in Table (9) cleared that all treatments reduced the fruit firmness as compared to the check treatment (control). In such respect control treatment reflected the highest fruit texture firmness (22.57 and 19.80 Lb/Inch^2) in the 1st and the 2nd season, respectively. On other hand, the lowest fruit firmness (18.08 Lb/Inch^2) was recorded by applying (W + F) during the second season only. The interaction between the tested factors indicates that the highest fruit firmness value (22.57 – 19.80 Ib/Inch^2) was detected with control trees in both seasons. Also applying CWR at 75% + emitter of 8 L/h + free sal alone investigated the same results in the second season. On the other hand, irrigation at 100% level with wuxal and 4L/h in the first season (18.83 Inch^2) and irrigation at 75% level combined with free sal and 4L/h (17.4 Inch^2) gave more soft fruit texture respectively.

In general, fruit weight, fruit size, fruit length and fruit diameter significantly increased with increasing applied irrigation water rate of "Le-Conte" pear (Abd El-Messeih and Gendy, 2009). Also, the fruit size of the apricot significantly decreased when the irrigation rate decreased (Eid *et al.,* 2013). In this respect, Küçükyumuk *et al.,* (2013) showed the relationships between plant water consumption and the fruit weight of an apple. It was determined that positive linear relationships between plant

Table 9. Effect of two irrigation rate, two emitter discharges and some ant stress treatments on fruit shape index(cm) and fruit firmness(Ib/inch^2).

Parameter		Fruit shape index(cm)			Fruit firmness (lb/inch2)		
Emitter discharges (B)	Treatments (C)	Irrigation rate (A) 75 %	Irrigation rate (A) 100 %	Means	Irrigation rate (A) 75 %	Irrigation rate (A) 100 %	Means
				First season; 2020/2021			
4 liter/hours	Control	1.141e	1.141e	Mean (B)**	22.57a	22.57a	Mean (B)**
	Waxal	1.245b	1.218bc	1.187A	21.77b	18.83f	21.02B
	W + F	1.209bc	1.197cd	1.193A	21.23c	19.63e	21.56A
	F.S.	1.163de	1.183cd		20.50d	21.03c	
				Mean (C)***			Mean (C)***
8 liter/hours	Control	1.141e	1.141e	1.141B	22.57a	22.57a	22.57A
	Waxal	1.201c	1.239b	1.226A	22.43a	19.90e	20.83C
	W + F	1.139e	1.145e	1.172B	21.27c	21.07c	20.80C
	F.S.	1.293a	1.242b	1.1221A	21.33c	21.37c	21.06B
Mean (A)*		1.191A	1.188A		21.71A	20.87B	
				Second season; 2021/2022			
4 liter/hours	Control	1.128c-e	1.128c-e	Mean (B)**	19.80b	19.80b	Mean (B)**
	Waxal	1.156b-d	1.136c-e	1.52A	18.03f	17.90fg	18.45B
	W + F	1.179b	1.170b-d	1.123B	18.47d	17.67gh	19.16A
	F.S.	1.083f	1.233a		17.40h	18.53cd	
				Mean (C)***			Mean (C)***
8 liter/hours	Control	1.128c-e	1.128c-e	1.128B	19.80b	19.80b	19.80A
	Waxal	1.173bc	1.086c-e	1.138B	18.83c	19.53b	18.58C
	W + F	1.127d-f	1.104ef	1.45A	17.80fg	18.37de	18.08D
	F.S.	1.126d-f	1.109ef	1.138B	21.00a	18.13ef	18.77B
Mean (A)*		1.137A	1.137A		18.89A	18.72A	

Values followed by the same letters are not significantly different at 5% level.
* refers to specific effect of Irrigation rate respectively.
** refers to specific effect of Emitter discharges respectively.
*** refers to specific effect of Treatments respectively.

water consumption and this parameter. The effect of the late deficit on fruit size interacted with the number of fruit per tree with both pear (Naor *et al.*, 2000) and apple (Naor *et al.*, 1997a) as well as with stone fruits (Naor *et al*., 2004). Zaliha and Singh., (2009b) reported that, compared to the applications without any water deficit, fruit diameter decreased in deficit irrigation applications. On the other side, Ilie *et al*., (2017) mentioned that it can be noticed that all fertilization treatments of amino acids enhanced remarkably fruit diameter, and fruit length of apple in both seasons as compared to the control. On the other hand, the concerning data on fruit firmness are the same line with Abd El-Messeih and Gendy., (2009) who indicated that firmness of fruit significantly decreased with increasing applied irrigation water rate to "Le Conte" pear. Whereas fruit firmness may increase due to the reduction of fruit size by water stress (Mpelasoka *et al.*, 2000). Apple fruit firmness was decreased by increasing the amount of water (Küçükyumuk *et al.*, 2013). Similar results were found by Ali., (2006) on peach, Mikhael and Mady., (2007) on the "Anna" apple, and Eid *et al.*, (2013) on apricot. As for the effect of emitter discharges on fruit firmness, this study was in harmony with Ali., (2006) who found that position of 2 emitters/tree (8L/h) installed on two laterals at distances of 50 cm at each side of tree trunk in both seasons gave the highest significant fruit firmness. As anti stress's result Casero *et al*. (2004) found similar

results with Golden Smoothee apples, showing a negative link between bitter pit incidence and this nutrient concentration and a positive correlation between fruit firmness and fruit calcium content. Additionally, Saure (2005) noted that calcium is known to stabilise cell membranes, which may avoid physiological diseases linked to a calcium deficit. This information was provided in relation to fleshed fruit.

3.4. Effect of irrigation rate, emitter discharges and anti-stress treatments on fruit chemical characteristics:

3.4.1. Total soluble solids of fruit pulp juice (TSS%):

Regarding the specific effect of the two irrigation rates on fruit pulp juice (TSS%), data presented in Table (10) cleared that applying CWR at 75% gave higher TSS (%) values (15.60 and 17.31%) than the higher rate in the first and the second seasons, respectively. with regard to the specific effect of emitter discharge, the results indicated that the values of TSS were improved by using emitter discharges of 4 L/h (15.63 and 17.39%) in both seasons, respectively. In the study of the anti-stress effect, the data indicated that all treatments increased fruit TSS (%) as compared to the control, in this respect the highest TSS (%) values were induced by applying (W+F) (15.96 and 17.89%) and free sal alone (16.00 – 17.41%) in the first and the second season, respectively. As for the interaction between irrigation rate, emitter discharges and ant stress treatments, it is clear that the maximum TSS values were detected with applying of CWR at75% + emitter of 4L/h + free sal alone in the first season and application of CWR at 75% + emitter of 8 L/h + (W+F) in the second season. While the lowest TSS (%) values (15.00 – 16.00%) resulted from control trees during the first and second seasons, respectively.

3.4.2. Fruit pulp juice acidity (%):

In relation the specific effect of the two irrigation rates on total acidity (%) data presented in Table(10) refer that there were no significant differences between the two levels of irrigation (75 and 100%) during the first and second seasons. Regarding the specific effect of emitter discharges, it was clear that the two emitter discharges (4 and 8L/h) were significantly equal for average acidity (%) in the two studied seasons. For the specific effect of anti-stress treatments, data indicated that applying free sal alone treatment increased the acidity (2.38 and 1.92%) during the first and the second seasons, respectively. While the lowest fruit acidity was recorded by applying wuxal alone in the first season and control in the second season. with regard to the interaction between the three factors, data refer that the maximum fruit total acidity was detected with the combination applying of Cat 100100% + emitter of 4 L/h + free sal alone (2.53 and 2.27%) in the first and the second seasons, respectively. While the lowest fruit total acidity was recorded by applying CWR at 100% with either emitter discharges of 4L/h in the 1st or 8L/h in 2nd season. + (W+F).

3.4.3. TSS / acid ratio:

Results presented in Table (11) reveal a significant effect on the TSS / acid ratio in response to the two rates of irrigation, the higher TSS / acid ratio was recorded by applying CWR at 75% (6.86 and 9.72%) during the first and the second season, respectively. Regarding the specific effect of two emitter discharges, data refer that using an emitter discharge of 4 L/h recorded the a higher TSS / acidity ratio than 8L/h during the first season, while in the second one, the significant difference between the two emitter discharges (4 and 8 L/h) were omitted.

Concerning the specific effect of anti-stress treatments, it is clear from data in Table (11) that the highest TSS / acidity ratio was induced by applying (W+F) treatment (6.99 and 10.00 %) in the first and second seasons, respectively. Regarding the combination between irrigation rate, emitter discharges and anti-stress treatments, it is evident from the data in Table (11) that the highest TSS / acid ratio was induced by applying CWR at 100% + emitter discharges of 4 L/h + (W+F) treatment (7.90 – 10.33%) in addition, CWR at 75% + emitter discharges of 4 L/h + (W+F) treatment (10.90%) during the second season.

Table 10. Effect of two irrigation rate, two emitter discharges and some ant stress treatments on TSS (%) and Acidity(%) of Le-Conte pear trees

Parameter		TSS (%)			Acidity (%)		
Emitter discharges (B)	Treatments (C)	Irrigation rate (A)		Means	Irrigation rate (A)		Means
		75 %	100 %		75 %	100 %	
First season; 2020/2021							
4 liter/hours	Control	15.00f	15.00f	Mean (B)**	2.30b-d	2.30b-d	Mean (B)**
	Waxal	15.00f	15.33e	15.63A	2.20c-e	2.30b-d	2.25B
	W + F	16.00c	16.33b	15.44B	2.17de	2.07e	2.34A
	F.S.	17.00a	15.33e		2.27b-e	2.53a	
				Mean (C)***			Mean (C)***
8 liter/hours	Control	15.00f	15.00f	15.00C	2.30b-d	2.30b-d	2.30AB
	Waxal	15.30e	15.33e	15.17B	2.10de	2.20c-e	2.20B
	W + F	15.83cd	15.67d	15.96A	2.43ab	2.45ab	2.30AB
	F.S.	16.00c	15.67d	16.00A	2.47ab	2.40a-c	2.38A
Mean (A)*		15.60A	15.46B		2.28A	2.31A	
Second season; 2021/2022							
4 liter/hours	Control	16.00e	16.00e	Mean (B)**	1.60e	1.60e	Mean (B)**
	Waxal	17.83c	17.17d	17.39A	2.00bc	2.13ab	1.85A
	W + F	18.47b	18.37b	16.85B	1.67de	1.83cd	1.76B
	F.S.	16.90d	18.40b		1.70de	2.27a	
				Mean (C)***			Mean (C)***
8 liter/hours	Control	16.00e	16.00e	16.00D	1.60e	1.60e	1.60C
	Waxal	16.87d	16.90d	17.19C	1.77de	1.77de	1.88AB
	W + F	18.73a	16.10e	17.89A	2.17ab	1.60e	1.82B
	F.S.	17.97bc	16.27e	17.41B	1.83cd	1.73de	1.92A
Mean (A)*		17.31A	16.94B		1.79A	1.82A	

Values followed by the same letters are not significantly different at 5% level.
* refers to specific effect of Irrigation rate respectively.
** refers to specific effect of Emitter discharges respectively.
*** refers to specific effect of Treatments respectively.

According to some research, water stress causes an increase in dry matter or the presence of soluble solids (Mpelasoka *et al*., 2000). According to studies conducted by Ali *et al*. (1998) on apples, Hussein (2004) on pears, and Abd El-Samad (2005) on guavas, fruit from trees with low irrigation rates had more soluble solid content than fruit from plants with moderate or excessive irrigation rates. Furthermore, El Morshedy *et al*. (1997) reported that the sugar content and juice TSS% of Le Conte pear tree fruits increased when irrigation water was reduced to 75% of the control. However, AboElmagd *et al*. (2015) discovered that amino acids had a favourable impact on the amount of soluble solids in apple fruit. When compared to flood irrigation, drip irrigation has the potential to greatly raise the pear fruit's treatable acidity (ZHAO *et al2012)*. There were no significant differences between all positions of emitters in these effects on fruit acidity (Ali., 2006). As for the effect of anti-stress treatments on fruit acidity, we can see that this study is in agreement with those of Alina *et al*., (2017) who reported that Apple harvested from all the treated variants with amino acids exhibited decrease in the total treatable acidity compared to control.

3.5. Effect of irrigation rate, emitter discharges and antistress treatments on water efficiency (kg / m^3):

Regarding the specific effect of irrigation rate results in Table (11) clear that the lower irrigation rate at 75% of the actual irrigation requirements was able to achieve an increment in water use efficiency (WUE) values (1.72 and 3.13 kg/m^3) to be higher and better than those which treated with CWR at 100% during the first and second seasons, respectively. As regards the specific effect of emitter discharges (4 and 8L/h), the results illustrated that using emitter discharges of 4L/h improved WUF value only in the second season (3.15 kg/m^3) but in the first season there was no significant difference between discharges of 4 and 8L/h. Concerning the specific effect of anti-stress treatments, applying free sal alone induced the highest WUE values (1.73 and 3.11 kg/m^3) in the 1st and 2nd respectively. Plus the addition wuxal alone (1.72 kg/m^3) in the first seasons. While the lowest WUF values (1.44 – 2.51 kg/m^3) were recorded by control during both seasons. Concerning the combination between irrigation rate, emitter discharges and anti-stress treatments, it is clear from the results in Table (11) that the combination of irrigation rate at 75% + discharges of 4L/h + combined with either (W+F) in the 1st season (1.93kg/ m^3) or with wuxal in the 2nd season (3.83 kg/m^3) were able to encourage the studied parameter to reach to the maximum values. In contrary the lowest WUE values was recorded by the control (1.44 kg/m^3).

These results are in agreement with Glenn., (2000) who stated that Increased risk of losing irrigated land since any material could improve the water use efficiency (WUE) for mature fruit trees and reduce applied water must be used. Also, this study is in agreement with Ali., (2006) who reported that irrigation rates at 75% or 100% CWR had the highest significant WUE in peach trees. Another study on Sweet pepper using the two deficit irrigation treatments showed the highest values of water use efficiency compared with the high irrigation level. Such results are in line with Ismail., (2010) who observed that deficit irrigation tends to increase water use efficiency and decrease the fresh fruit yield of chili pepper. On the other side ZHAO *et al*., (2012) stated that the IWUE of drip irrigation treatments was 190-240% greater than that of flood irrigated treatment.

4. CONCLUSION

It could be concluded from the present investigation that it is possible to increase Le-Conte pear trees productivity and fruits characteristics by using irrigation rate at 100% or 75% as well as emitter discharges of 4L/h and some anti- stress treatments such as wuxal amino as a source of amino acids or free sal as a source of calcium or the combination between both under desert soil conditions.

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Table 11. Effect of two irrigation rate, two emitter discharges and some ant stress treatments on TSS/Acidity ratio (%) and Water use efficiency (kg/m^3).

Parameter		TSS/acid ratio (%)			Water use efficiency (kg/m^3)		
Emitter discharges (B)	Treatments (C)	Irrigation rate (A) 75 %	Irrigation rate (A) 100 %	Means	Irrigation rate (A) 75%	Irrigation rate (A) 100 %	Means
				First season; 2020/2021			
4 liter/hours	Control	6.52e	6.52e	Mean (B)**	1.44g	1.44g	Mean (B)**
	Waxal	6.82d	6.67d	6.96A	1.60d	1.88ab	1.64A
	W + F	7.50b	7.90a	6.61B	1.87ab	1.47f	1.63A
	F.S.	7.38bc	6.39e		1.93a	1.50e	
				Mean (C)***			Mean (C)***
8 liter/hours	Control	6.52e	6.52e	6.52C	1.44g	1.44g	1.44C
	Waxal	7.14cd	6.97d	6.90A	1.84b	1.58d	1.72A
	W + F	6.51e	6.18f	6.99A	1.80bc	1.49e	1.65B
	F.S.	6.49e	6.53e	6.73B	1.85b	1.66c	1.73A
Mean (A)*		6.86A	6.71B		1.72A	1.55B	
				Second season; 2021/2022			
4 liter/hours	Control	9.93bc	9.93bc	Mean (B)**	2.51g	2.51g	Mean (B)**
	Waxal	8.92f	8.05h	9.51A	3.83a	3.14cd	3.15A
	W + F	10.90a	10.33ab	9.63A	3.56ab	2.97d	2.73B
	F.S.	9.94bc	8.16h		3.45b	3.33bc	
				Mean (C)***			Mean (C)***
8 liter/hours	Control	9.93bc	9.93bc	9.93B	2.51g	2.51g	2.51D
	Waxal	9.55e	9.57de	9.02D	2.79e	2.53g	3.07B
	W + F	8.65g	10.06b	10.00A	3.30bc	2.62f	2.97C
	F.S.	9.80cd	9.38e	9.32C	3.19c	2.48h	3.11A
Mean (A)*		9.72A	9.42B		3.13A	2.75B	

Values followed by the same letters are not significantly different at 5% level.
* refers to specific effect of Irrigation rate respectively.
** refers to specific effect of Emitter discharges respectively.
*** refers to specific effect of Treatments respectively.

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الملخص العربى

استخدام معدل الرى وتصريف النقاطات وبعض المواد المضادة للاجهاد فى محاولة لرفع أنتاجية الكمثرى الليكونت

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هذه الدراسة اجريت خلال موسمى ٢٠٢١ و ٢٠٢٢على أشجار كمثرى صنف الليكونت عمرها ١٧عام مطعومة على أصل الكميونس ونامية فى أرض رملية تحت نظام الرى بالتنقيط وذلك لدراسة تاثير كلا من معدلات الرى (١٠٠ و٧٥% من الاحتياجات المائية) و معدل تصريف النقاط (٤ و ٨ لتر فى الساعة) بالاضافة الى تأثير بعض مضادات الاجهاد (الوكسال امينو بمفرده – الفريسال بمفرده – (الوكسال + الفريسال) على المحصول (كجم) وبعض الصفات الثمرية الفيزيائية (الوزن –الحجم – الطول – القطر – الصلابة) والكيميائية (نسبة المواد الصلبة الذائبة – نسبة الحموضة – النسبة بين كلا منهما) وكذلك كفاءة استخدام ماء الرى. أوضحت النتائج ان أعلى كمية محصول تم تسجيلها مع معدل رى ١٠٠% باستخدام نقاطات ذات معدل تصريف ٤ لتر فى الساعة مع اضافة الوكسال بمفرده او الفريسال بمفرده على جانب اخر فان زيادة كمية ماء الرى مع استخدام معدل التصريف الاعلى ٨ لتر فى الساعة واضافة الوكسال بمفرده أدت الى زيادة بعض الصفات الثمرية مثل الوزن والحجم والطول والقطر. بينما كلا من صلابة الثمار والمواد الصلبة الذائبة زادت بانخفاض معدل الرى الى ٧٥% اما بالنسبة للتفاعل بين العوامل الثلاثة فان أعلى قيمة للمواد الصلبة الذائبة تحققت مع معدل رى ٧٥% + معدل تصريف ٨ لتر فى الساعة + اضافة كلا من الوكسال والفريسال معا او استخدام معدل تصريف ٤ لتر فى الساعة مع الوكسال بمفرده بينما أعلى قيمة لصلابة الثمار تم تسجيلها مع الكنترول. اما بالنسبة لكفاءة استخدام ماء الرى فان أعلى قيمة لهذه الصفة تم تسجيلها مع معدل رى ٧٥% مع استخدام نقاطات ذات معدل تصريف ٤ لتر فى الساعة مع الوكسال او الفريسال فى كلا موسمى الدراسة.

الكلمات الافتتاحية: الكمثرى الليكونت – معدل الرى – تصريف النقاط – الوكسال أمينو – الفريسال – المحصول – الصفات الثمرية – كفاءة أستخدام الرى.