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EFFECT OF IRRIGATION RATE AND HUMIC ACID ON "LE-CONTE" PEAR

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ABSTRACT

This study was conducted to evaluate the response of "Le-Conte" pear trees budded on *Pyrus communis* pear rootstock under different irrigation rates and humic acid applications.

Irrigation rate (IR) reduction declined some growth parameters (shoot length, shoot diameter, number of leaves/shoot and leaf area), percentage of burnt spurs (as fire blight symptoms), fruit yield per tree and per feddan, yield income value/tree, fruit weight and size as well as fruit dimensions especially with least IR (14.3 m^3/ tree/ year). On the other hand, IR decrease, markedly increased fruit firmness, fruit juice TSS, TSS/acid ratio and number of fruits in one kg. Also, IR reduction partly increased percentage of fruit set, number of fruits/tree and water use efficiency (WUE). Since, the highest WUE (3.85 kg pear fruits from each m^3 irrigation water) could be obtained from 16.7 m^3/tree/year (2810.6 m^3/feddan/year) irrigation rate.

Humic acid applications (especially 50 ml in 1L of water/tree as soil treatment every other week during the growing season) significantly enhanced the growth parameters, fruit set, fruit characters, yield components, yield income value and water use efficiency while decreased the percentage of burnt spurs, fruit firmness and number of fruits in one kg.

INTRODUCTION

Water is one of the most important components in biological systems, as the biological functions completely depend on water (Salisbury and Ross, 1985). So, plant growth and development retarded when water supply was restricted (Wright and Stark, 1990). However, Storchus and Kosykh (1983) on young peach trees; Semash and Panasenko (1984), Safaa (1994) and Hussein (1998) on "Anna" apple and (2004) on "Le-Conte" pear, used 40, 60, 70 or 80 % field capacity (F.C.) and obtained the best growth parameters and yield components with 80 % F.C.

Moreover, Cathoun (1975) found that, the increase in tension from zero to 0.33 bar released more than 75 % of water in light textured soil but, less than 50 % in heavy ones. Levin *et al*. (1979) pointed out that, drip irrigation enables a restricted volume of wetted soil to be maintained with small fluctuations in water tension and with the deveolpment of a dense root system with minimum loss of water and fertilizers by leaching. However, the use of modern irrigation system is essential for the reduction of irrigation water supply and increasing the demands (Brown, 1999). Therefore, using water soil potential at 100-200 mbar (2173.08 m^3/feddan/year) was recommended as the best level for “Canino” apricot trees irrigation in sandy soil (Kandil and El-Feky, 2006).

Humate salts are complex molecules formed by the breakdown of organic matter. Treating four citrus rootstocks with humates increased root: shoot dry weight ratio without significant effect on root dry weight (Swietlik, 1991). Furthermore, Macan and Petrovic (1995) stated that, humic acid (polymeric polyhydroxy acid) was the most significant component of organic substances in aquatic systems. Also, many reporters revealed that, humic acid has a good influence on plant growth and development (Fernandez *et al*., 1996, Bohme and Lua, 1997; Hartwigsen and Evans 2000, Liu and Cooper, 2002). Likewise, Fathi *et al*. (2002) get the best significant results with regard to yield, fruit quality and growers income of "Desert Red" peach by spraying trees with 5 ppm GA_3 combined with 10 g/5L K-Humate.

Generally, this investigation was carried out to estimate the response of "Le-Conte" pear trees budded on *Pyrus communis* pear rootstock to different irrigation rates. The possibility of using humic acid to reduce irrigation water requirements was also included.

MATERIALS AND METHODS

The present work was preformed at El-Kassassien Res. Sta., Ismalia Governorate, Egypt, during the two seasons 2005-2006 using "Le-Conte" pear trees budded on *Pyrus communis* pear rootstock. The trees were 12-years old, planted 5 × 5 m. apart on sandy soil under drip irrigation system. The common irrigation rate which normaly practice at this Station was 4015.2 m^3/feddan/year (23.9 m^3/tree/year). The tested irrigation rates were:-

1) 4015.2 m^3/feddan/year (23.9 m^3/tree/year) as 100 % of common practice irrigation rate (CPIR).
2) 3613.7 m^3/feddan/year (21.5 m^3/tree/year) as 90 % of (CPIR).
3) 3212.2 m^3/feddan/year (19.1 m^3/tree/year) as 80 % of (CPIR).
4) 2810.6 m^3/feddan/year (16.7 m^3/tree/year) as 70 % of (CPIR).
5) 2409.1 m^3/feddan/year (14.3 m^3/tree/year) as 60 % of (CPIR).

Through the growing season, we enriched the soil with:-

1) 0 ml. in 1L water humic acid/tree.
2) 50 ml. in 1L water humic acid/tree.
3) 75 ml. in 1L water humic acid/tree.

These treatments continued every other week from 15th February till 30th September. The other cultural practices were adopted normally. The following data were recorded:-

A) Growth parameters: shoot length, shoot diameter, number of leaves/shoot and leaf area at Aug. 2005 and 2006.
B) Percentage of fruit set and burnt spurs (as fire blight symptoms).
C) Fruit characters: fruit weight and size, polar and equatorial diameter, fruit firmness, fruit juice TSS and acidity as well as TSS/acid ratio.
D) Yield measurements: number of fruits/tree, fruit yield per tree and per feddan, number of fruits in one kg. and yield value/tree.
E) Water use efficiency = fruit yield (kg.)/feddan ÷ irrigation rate m^3/feddan/year.

The experimental treatments were arranged in a randomized complete block design with three replicates in each and three trees per replicate. The obtained data were subjected to statistical analysis according to Snedecor and Cochran (1990). Averages were compared using LSD test at 5% probability. The regression equations and correlation coefficients between irrigation rate (X) and fruit yield/tree (y) were also calculated.

RESULTS

A. Growth parameters:

Growth parameters included shoot length, shoot diameter, number of leaves/shoot (Table 1) and leaf area (Table 2). The present results showed that, growth parameters gradually decreased with irrigation rate reduction where shoot length decreased from 92.6 to 87.9 to 81.2 to 73.0 to 64.9 cm. and decreased from 95.1 to 92.4 to 85.1 to 78.7 to 69.4 cm. (through 2005 and 2006 seasons) and leaf area declined from 30.0 to 28.9 to 27.0 to 25.7 to 23.8 cm^2 (2005) and decreased from 30.3 to 28.9 to 26.9 to 25.9 to 23.9 cm^2 (2006) as irrigation rate/tree/year, reduced from 23.9 to 21.5 to 19.1 to 16.7 to 14.3 m^3, respectively.

Contrary, data in Tables (1 and 2) clearly showed a gradual increase in shoot length (from 74.6 to 81.6 to 83.5 cm in 2005) (and from 81.3 to 84.6 to 86.5 cm in 2006 season), shoot diameter (from 0.87 to 0.89 to 0.91 cm in 2005), number of leaves/shoot (from 22.0 to 23.7 to 24.0 in 2005) and leaf area (from 26.3 to 27.4 to 27.9 cm^2 in 2006) parallel to increasing humic acid application (from 0 to 50 to 75 cm/tree).

Concerning the interaction effect, (Tables 1 and 2) indicate that, "Le-Conte" pear (irrigated with 23.9 cm^3/tree/year and treated with 50 cm/tree humic acid get the thickest shoots and the most leaves/shoot, while 23.9 m^3/tree/year irrigation water +75 cm. (in the 1st season) and 50 cm. humic acid (in the 2nd season) get the longest shoots and the most expandable leaves.

B. Percentage of fruit set and burnt spurs:

Percentage of fruit set (Table 2) increased in both seasons of study when irrigation rate was decreased from 23.9 to 21.5 m^3/tree/year then decreased with irrigation rate reduction. However, irrigation rate reduction significantly reduced percentage of burnt spurs (with fire blight symptoms). On the other hand, humic acid treatments increased the percentage of fruit set from 11.2 to 11.5 to 11.7 % (in 2005) while decreased the percentage of burnt spurs from 10.0 to 8.7 to 6.9 % (in 2006 season), respectively.

Meanwhile, the highest fruit set percentage (12.1%) was obtained from the interaction (32.9 m^3 irrigation rate + 75 cm humic acid), while the least burnt spurs percentage (4.7%) was get from the combination (14.3 % irrigation rate + 75 cm humic acid). Generally this result confirm that increasing the irrigation rate increase fruit set, while irrigation rate reduction reduced burnt spurs.

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C. Fruit characters:

External and internal fruit characters are presented in Tables (3, 4 and 5). The computed results revealed a gradual decrease in fruit weight (from 193.7 to 190.2 to 173.4 to 149.5 to 119.6 g.), fruit size (from 193.9 to 188.9 to 175.0 to 151.7 to 121.7 cm^3), polar diameter (from 8.4 to 8.3 to 8.1 to 7.6 to 7.1 cm) and equatorial diameter (from 6.9 to 6.6 to 6.3 to 6.1 to 6.0 cm.) parallel to irrigation rate reduction in the same order through 2005 season. On the other hand, fruit firmness, juice TSS and TSS/acid ratio increased (however, the differences sometimes were not significant) with irrigation rate reduction, while juice acidity did not appear any significant trend.

Meanwhile, humic acid treatments successfully enhanced fruit weight (154.1, 170.5 and 171.2 g.), size (155.7, 170.7 and 172.3 cm^3), fruit dimensions (7.6, 8.0 and 8.2 cm & 6.1, 6.4 and 6.6 cm) and juice TSS (13.5, 13.7 and 13.8% through the 1st season as well as the 2nd season took the same trend) while juice acidity and TSS/acid ratio did not show clear trend.

Furthermore, the biggest fruits (197.0 g weight, 198.3 cm^3 size, 9.1 cm polar diameter and 7.3 cm equatorial diameter) can be obtained from the following combination: 23.9 m^3 irrigation rate + 75 cm humic acid.

D. Yield measurements and farm-gate price:

The recorded yield measurements were number of fruits/tree, fruit yield per tree and per feddan (Table 6), number of fruits in one kg. and yield value/tree (Table 7). It is noticeable that, number of fruits/tree increased from 405.3 to 416.0 to 433.7 (through 2006 season) when irrigation rate (IR) decreased from 23.9 to 19.1 to 16.7 m^3/tree, whilst the rates 21.5 and 14.3 m^3/tree reduced number of fruits/tree, respectively. Fruit yield per tree (79.3 , 77.5, 72.3, 64.5 and 46.7 kg) and per feddan (13.3, 13.0, 12.2, 10.8 and 7.8 ton in 2005 season) gradually retarded with restrictive irrigation rate. However, the regression equations ($y = 5.83 + 3.258 \times$ and $y = 16.44 + 2.621 \times$) and correlation coefficients ($r = 0.93$ and $r = 0.95$ in the two studied seasons, respectively) between irrigation rate (x) and fruit yield/tree (y) showed a strong linear relation.

Generally, number of fruits in one kg was reversely related to IR (5.16, 5.27 5.78, 6.71 and 8.46) through 2005 and (5.37, 5.43, 5.95, 6.94 and 8.18) through 2006 seasons. At the harvesting, the farm-gate price was LE 1.5 for fruits weighing 100-<150 g and LE 2.5 for 150-200 g. (yield value/tree). The yield income/tree decreased with IR reduction (LE 198.3, 193.8, 180.7, 141.5 and 70.1 in 2005) but this reduction was more pronounced (LE 70.1 and 75.2) with the least IR (14.3 m^3/tree/year). Nevertheless, the sharp decrease in fruit yield/feddan and fruit weight may explain the pronounced retardation in the yield return/tree.

Furthermore, humic acid application significantly induced a progressive increment of number of fruits/tree (408.6, 414.0 and 418.6), fruit yield per tree (62.5, 70.0 and 71.6 kg) and per feddan (10.5, 11.8 and 12.0 ton in the 1st season) and yield value/tree may be a result of decreasing number of fruits in one kg.

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However, yield return/tree increased sharply (from LE 136.4 to 165.4) when humic acid increased from 0 to 50 cm/tree, whilst the increment was light (from LE 165.4 to 168.9) with humic increase from 50 to 75 cm.

On light of present results, the highest fruit yield/tree (82.6 kg) and/feddan (13.9 ton), the least number of fruits in one kg (5.08) consequently the highest yield value/tree (LE 206.5) in 2005 season, can be obtained by the interaction: 23.9 m^3 IR + 75 humic acid application.

E. Water use efficiency (WUE):

Data in (Table 7) indicate that, water use efficiency was higher in the first season (2005) than in the second one (2006). This result is mainly due to higher yield production in 2005 compared with 2006 season. The decrease in yield production observed in 2006 was much more than the decrease in water consumption. Those two factors are responsible for lower WUE observed in 2006 season.

Regarding the effect of moisture stress on WUE, results pointed out that, WUE gradually and significantly increased (from 3.17 to 3.46 to 3.66 to 3.74 kg/m^3 through 2006 season) with irrigation water decline (from 23.9 to 21.5 to 19.1 to 16.7 m^3, respectively). But WUE sharply decreased (3.49 kg/m^3) with the least irrigation rate (14.3 m^3). So, the highest water use efficiency (3.85 in the 1st season and 3.74 kg fruits/ m^3 in the 2nd one) can be obtained from 16.7 m^3/tree/year. It is also noticeable that, humic acid application, effectively enhanced WUE (from 3.27 to 3.66 to 3.76 kg fruits/ m^3, in 2005 season).

Generally, the interaction of 16.7 m^3 IR + 75 cm humic acid resulted the best water use efficiency (4.06 kg fruits/m^3 irrigation water).

DISCUSSION AND CONCLUSIONS

The present results illustrate that, growth parameters of pears (shoot length, shoot diameter, number of leaves/shoot and leaf area), percentage of burnt spurs, fruit weight and size, fruit dimensions, fruit yield per tree and per feddan and yield value/tree, gradually decreased with irrigation rate reduction. Moreover, the reduction was more significant and sharp with the least irrigation rate IR (14.3 m^3/tree/year). However, these results are in agreement with the conclusion given by Ali *et al*. (1998), Hussein (1998) on apple; Salem *et al*. (1999); Fathi (1999 a & b) on pear trees; Ali (2006) on peach and Kandil and El-Feky (2006) on apricot, who revealed that, vegetative growth and yield were markedly reduced at low irrigation rates.

On the other hand, fruit firmness, juice TSS, TSS/acid ratio and number of fruits in one kg increased with decreasing IR. However, this phenomenon may be as a result of the fact of smaller fruits has higher firmness and more number in one kg. Also, fruits with less juice have higher TSS percentage. Moreover, Chalmers *et al*. (1990), Fathi (1999 a & b) and Hussein (2004) on pear trees disclosed the same trend.

Percentage of fruit set increased when IR decreased from 23.9 to 21.5 m^3/tree/year then descendingly decreased with IR reduction. Also, number of fruits/tree increased when IR declined from 23.9 to 19.1 to 16.7

m^3, whilst decreased with the other rates. Meanwhile, water use efficiency (WUE) significantly increased with IR reduction but sharply decreased with the least IR (14.3 m^3). So, the highest WUE (3.85 kg pear fruits from each m^3 irrigation water) can be obtained from 16.7 m^3/tree/year (70 % from the pear common irrigation rate, 23.9 m^3). Generally, Ali *et al*. (1998) and Salem *et al*. (1999) on apple concluded that for maximizing the values of WUE, IR should be practiced at moderate soil moisture stress, i.e., 40 % depletion in available water. Also, Ritchie (1974); Hussein (2004) and Kandil and El-Feky (2006) pointed out that, some water conservation benefits can be gotten from allowing plants to experience moderate water stress.

Furthermore, humic acid applications effectively enhanced the growth parameters of pear trees (shoot length, shoot diameter, number of leaves/shoot and leaf area), percentage of fruit set, fruit weight and size, fruit dimensions, juice TSS, TSS/acid ratio, yield income value/tree and water use efficiency even under water stress. Conversely, humic acid treatments successfully decreased percentage of burnt spurs, fruit firmness and number of fruits in one kg, while fruit juice acidity did not show any significant trend. However, these beneficial effects were also reported by many other investigators as Bohme and Lua (1997); Jianguo *et al*. (1998); Liu and Cooper (2002); Fathi *et al*. (2002); Eissa *et al*. (2003) and Shaddad *et al*. (2005). Likewise, Ghabbour and Davies (1998) explained that humic acid slowly release micronutrient to plants, has high water-holding, stimulates plant growth, increases the availability of phosphate by breaking the bond between P and Fe or Ca as well as help mineralization and immobilization of N in soil. Besides, being a source of nutrients for plants, humic acid also affect the physico-chemical properties of soil, which are important in controlling the uptake of nutrients, their retention and counteracting soil acidity (Hartwigsen and Evans, 2000).

So, we can recommend pear growers to: 1) irrigate pear trees (on sandy soils) with 16.7 m^3/tree/year (2810.6 m^3/feddan/year) to get the highest water use efficiency (3.85 kg pear fruits from each m^3 irrigation water and saved 30 % of irrigation water and 2) use humic acid as soil application at the rate of 50 ml in 1L of water every other week during the growing season/tree.

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تأثير معدلات الرى و حامض الهيوميك على صنف الكمثرى ليكونت

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تم تنفيذ هذه التجربة فى محطة بحوث البساتين بالقصاصين – الإسماعيلية لتقييم استجابة صنف الكمثرى ليكونت المطعوم على أصل الكمثرى بيرس كميونس لمختلف معدلات الرى وتأثير حامض الهيوميك.

نقص معدل الرى قلل بعض مظاهر النمو (طول الفرع – قطر الفرع – عدد الأوراق على الفرع ومساحة الورقة) والنسبة المئوية للدوابر المحترقة ومحصول الشجرة والفدان والعائد النقدى للمحصول، وأيضاً وزن وحجم الثمرة وأبعاد الثمرة خاصة مع أقل معدل رى (١٤,٣ م٣/شجرة/سنة). ومن جانب أخر فإن نقص معدل الرى ساعد ونشط صلابة الثمار ونسبة المواد الصلبة الكلية الذائبة، ونسبة المواد الصلبة : الحموضة وعدد الثمار فى الكيلو جرام. كذلك يمكن ملاحظة أن تقليل معدل الرى سبب زيادة النسبة المئوية لعقد الثمار وعدد الثمار على الشجرة وكفاءة استخدام الماء. لذلك فإن أعلى كفاءة لاستخدام ماء الرى (٣,٨٥ كيلو جرام ثمار كمثرى/م٣ ماء رى) يمكن الحصول عليها من معدل الرى ١٦,٧ م٣/شجرة/سنة وهو ما يعادل ٢٨١٠,٦ م٣/فدان/سنة.

أظهرت التجربة أن المعاملة بحامض الهيوميك (٥٠ سم/لتر ماء توضع حول جذع الشجرة مرة كل أسبوعين من ١٥ فبراير وحتى ٣٠ سبتمبر) نشطت مواصفات النمو وعقد الثمار ومواصفات الجودة ومحصول الثمار والعائد النقدى للمحصول كما زادت كفاءة استخدام ماء الرى كما قللت النسبة المئوية للدوابر المحترقة وصلابة الثمار وعدد الثمار فى الكيلو جرام (عن طريق زيادة حجم الثمار).