Effect of Shoot Bending, Shoot Girdling and GA_3 Application Treatments on Growth, Fruit Set %, Yield and Fruit Quality of "Le Conte" Pear

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ABSTRACT

The present investigation was carried out in private orchard at south El-Tahreer region, EL Behera governorate, on 5-years-old "Le Conte" pear trees *(Pyrus communis* L.× *Pyrus pyrifolia* N.*)* budded on *(Pyrus betulaefolia)* rootstock, during two growing seasons (2009 and 2010). The aim of this research was to study the effect of shoot bending, shoot girdling and GA_3 application on the vegetative growth, yield and fruit quality.

The results indicated that gibberellic acid (GA_3) application and shoot bending three years old treatments induced significant increment in leaf area, spurs number, fruit set %, number of fruits per tree, total yield (ton / fed.), fruit weight, fruit size, fruit length, fruit diameter, fruit firmness, total soluble solids (TSS %) and total sugars compared with that of the control in both seasons of study. Shoot girdling (3y.) significantly gave the highest increase of spurs number, number of fruits per tree, fruit weight, fruit size, fruit firmness, total soluble solids (TSS %) and the reducing sugars, while, it gave significant decrease in fruit acidity % in both seasons of study.

INTRODUCTION

"Le Conte" pear trees (*Pyrus communis* L.) is one of the most important deciduous fruit crops grown in Egypt. The tree needs essential elements, growth regulator and water in order to complete its life cycle with high production of good quality. The necessity to regulate excessive vegetative (branch) growth and to increase flowering and fruiting becomes even more significant for economic reasons, i.e. cost reduction, since the ratio between production costs and market prices for fruit has increased in recent years. Among traditional methods of orchard management and cultural practices applied in an orchard to control growth and fruiting, branch bending has proved the most successful. Branch bending is a long established and widely used as a-cultural practice in high-density orchards, and its concept has nowadays been integrated into the Solaxe training system (Costes *et al.*, 2006). "Le Conte" pear is considered a popular fruit in the temperate regions and in addition, it represents an important share of the cultivars grown in Egypt. Sansavini, 2002 indicated that pear is a low fertile, medium yielding cultivar that crops 40–50% on spurs from branches of 2-and 3-year of age as well as on older ones (Sansavini, 2002). Also, Lauri and Lespinasse (2001) have shown that the tree's reaction to bending also varies with the genotype and the time of bending, as well as with the angle of bending, the duration of bending time, etc. trunk or scaffold branches to promote larger fruit size and earlier maturity.

As a wounding process, girdling is not without risks. For optimum results with the least detrimental effect, girdling must be done correctly. Girdling has been practiced on fruit trees for centuries to increase fruit size. In an optimal circumstance, girdling can: (1) increase fruit size (sometimes yield); (2) promote earliness of harvest (usually advancing harvest by three to five days); (3) result in fewer pickings (from four to three, or three to two); 4) increase the percentage crop harvested during the first picking; and (5) increase red skin color in some cultivars (enhanced marketability). Arboricultural practices such as artificial bending or fruit thinning are crucial interventions in orchard management and are used for controlling tree size, penetration of light into the canopy and the equilibrium between vegetative and reproductive growth (Fumey *et al*. 2011 and Lauri *et al*. 2011).

Gibberellins usually produced mainly in very young leaves, young embryos, young fruits and in roots. They function in cell elongation, aid in breaking rest of seeds and dormant buds, prevent flower initiation, and seem to work with auxin to prevent abscission of young fruits. According to Burström and Svensson (1972), GA has hardly any effect on the growth of roots or root segments. They do mention that excised root segments, which may have been deprived of their source of GA, show some response to the addition of exogenous GA. Tanimoto (2005) also states that, compared to auxin, GA functions in roots are less remarkable over a wide range of concentrations, but that it does still play an indispensable role in the normal development of roots. Wareing and Phillips (1981) stated that application of GA to intact plants generally has little effect on root elongation, but excised roots growing in aseptic culture sometimes grow more in length when supplied with GA. The importance of GA in root growth has also been demonstrated by Rademacher (2000) by using inhibitors of GA biosynthesis to decrease the endogenous GA in roots. From the above it seems that, although, not as concentration-dependent as auxin, GA is also important for root growth to take place. It is therefore possible that

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root growth can be inhibited by removal of the above ground sources of GA, such as would be the case when girdling a tree. Hawerroth *et al*. (2011) reported that, the low fruit set of 'Shinseiki' pear trees in the Southern Brazil conditions is one of the limiting factors to pear production in the country. However, the use of plant growth regulators may minimize this problem. They added that the application of growth regulators was performed when the pears have reached the full bloom stage. When sprayed on full bloom stage, thidiazuron and gibberellic acid, and combinations of these substances, both at a concentration of 20 mg/L, increased significantly the fruit set and the fruit production of 'Shinseiki' pears.

Thus, the present work was imposed to study the effect of trunk girdling, branch bending and GA_3 application on vegetative growth, yield and fruit quality of "Le Conte" pear trees.

MATERIALS AND METHODS

The present investigation was conducted during two growing seasons 2009 and 2010, on 5-years-old "Le Conte" pear trees *(Pyrus communis* L.× *Pyrus pyrifolia* N.*)* budded on *(Pyrus betulaefolia)* rootstock, to study the influence of shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments on the vegetative growth, fruit set percentage, yield and fruit quality.

The studied 60 pear trees spaced at 5×5 meters apart, trees were grown in sand soil at El-Kefah village, south El-Tahreer city, EL Behera governorate. The trees were selected to be healthy and similar in their vigor, as possible, and treated with normal agricultural practices.

The ten treatments were as follows:

1- Untreated trees (control).

2- Shoot bending of one year old (four branches) at mid November (SB.1Y).

3- Shoot bending of two years old (four branches) at mid November (SB.2Y).

4- Shoot bending of three years old (four branches) at mid November (SB.3Y).

5- Shoot girdling on one year old (5 mm in width) at mid April (SG.1Y).

6- Shoot girdling on two years old (5 mm in width) at mid April (SG.2Y).

7- Shoot girdling on three years old (5 mm in width) at mid April (SG.3Y).

8- Foliar application of (10 ppm GA_3) to trees at full bloom.

9- Foliar application of (15 ppm GA_3) to trees at full bloom.

10- Foliar application of (20 ppm GA_3) to trees at full bloom.

The experimental treatments were arranged in a complete randomized block design and the treatments were replicated 6 times in each replicate, i-e. 10 treatments × 3 replicates × 2 experimental unit = 60 trees.

The trees were subjected to several measurements and determinations as follows:

1. Vegetative growth measurements:

Four main treated branches as uniform as possible of each studied tree were chosen at the four cardinal points of each tree (east, west, north & south) and tagged. The number of current shoots on each treated branch was counted, on October, 21 of each experimental year and the length of 15 new shoots on each chosen branch was recorded. The number of spurs / one meter of investigated branches was counted. To determine the leaf area, samples of 10 mature leaves were collected at random from each studied tree on August, 22, washed with tap water and dried with a piece of cotton tissue. The determination of leaf area was carried out using leaf area meter (Model CI-203, CID, Inc, U.S.A.).

2. Fruit set percentage (%) and yield:

The total number of flowers on each tagged branch was counted at full bloom. The number of set fruits was counted on the same branch one month later. Fruit set percentage was calculated as follows:

Fruit set percentage (%)= (No. of developing fruitlels / Total numbers of flowers) × 100.

At harvest, the total number of fruits per tree was counted and the average fruit number was determined, then the total yield (ton / fed.) was calculated.

3. Fruit quality:

A sample of ten fruits was harvested on 1st August from each experimental tree to determine the different parameters of fruit quality. Fruit weight, length, diameter and size were determined in each sample in both seasons of study. In addition, four fruits of each experimental tree were used to determine the fruit firmness Magness & Taylor (1982) using pressure tester a 5/16 plunger. Two readings were taken at two different positions on the fruit flesh after peeling. The percentage of total soluble solids in the juice of each fruit sample was determined by a hand refractometer according to Chen and Mellenthin (1981). Two readings were taken from the juice of each fruit. Fruit juice acidity was determined according to the A.O.A.C. (1980), by titration with 0.1 N sodium hydroxide. Acidity was expressed as percent of malic acid in fruit juice. To determine the total sugars in the fruit plulp tissues, four fruits from each replicate were washed separately with distilled water, cut into small pieces by a clean knife, mixed well and then dried at 70°C in an air drying oven. 0.5 gm of ground dried material was used to extract the reducing and total soluble sugars of each replicate by distilled water. The reducing sugars were determined by Nelson-arsenate molybdate colorimetric method (Malik & Singh, 1980) before and after hydrolysis with concentrated HCL, while total sugars were determined by phenol sulfuric method according to Dubois et al. (1956).

4. Statistical analysis:

The obtained data of both seasons were statistically analyzed according to Snedecor & Cochran (1980). And L.S.D. test at o.o5 level was used for comparison between treatments.

RESULTS AND DISCUSSION

1. Vegetative growth characters:

A. Shoot length:

The effect of shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments on the shoot length are shown in Table (1). The data of both experimental seasons, indicated that shoot bending and shoot girdling reduced shoot length as compared with control or gibberellic acid (GA_3) application. Generally, gibberellic acid (GA_3) application at (20 ppm) gave the highest values of shoot length, while shoot girdling of one year treatment gave the lowest values in both seasons. Shoot girdling reduced shoot length by 58.17, 51.61 and 48.42 % in the first season and by 53.59, 39.04 and 47.96 % in the second season for shoot of one year, two years and three years as compared with control, respectively. These data are supported with those obtained by Ingels (2002) on pear trees who found that, all girdling methods reduced pruning weights by 30 to 40% compared to non-girdled trees. In addition Arakawa *et al*. (1998) on apples showed that, all girdling methods reduced shoot length. Moreover, Sousa *et al*. (2005) revealed that, girdling only reduced shoot growth in "Forelle" apple trees. Finally, Girish Sharma and Ananda (2004) on apples and Ouma (2008) on pears found that applications of GA_3 resulted in significantly high increase in vegetative growth over the control.

B. Leaf area:

The data representing the effect of the above mentioned treatments on leaf area are shown in Table (1). In general, the obtained results indicated that, in both seasons of study, the highest leaf area was obtained from trees treated with (GA_3 20 ppm), (GA_3 15 ppm) and [(GA_3 10 ppm)& shoot bending (3y.) in the first season only], followed by control treatments. The lowest results were obtained from trees under shoot bending (1y.) treatment while, the other treatments were in between. The differences between treatments in general were statistically significant. The data are in line with those obtained by Park JeongGwan *et al*. (2004) who reported that, 90 degrees of bending of 4-year-old apple trees produced wider leaves. On the other hand Girish Sharma and Ananda (2004) on apples found that, applications of GA_3 at 10-40 ppm and GA_3 at 10 ppm + BA at 5 ppm resulted in significantly high increase in vegetative growth over the control.

C. The number of spurs / one meter:

Data concerning the effect of the used treatments on the number of spurs / one meter of "Le Conte" pear trees in both seasons are presented in Table (1). The data clearly indicated that, all treatments, except shoot bending (1y.) and shoot girdling (1y.) treatments, increased the number of spurs / one meter over the control. Generally, (GA_3) application at (20 ppm), shoot bending (3y.) and shoot girdling (2y.) treatment, gave the highest number of spurs / one meter. These data are in harmony with those obtained by Rufato *et al.* (2004) who noticed that, girdling were efficient in stimulating the vegetative growth of lateral branches of Riograndense peach tree. In addition, Arakawa *et al*. (1998) showed that, girdling increased spur shoot ratio of apples. Moreover, Khattab *et al.* (2003) reported that winter shoot bending increased lateral growth, spur number and flowering spurs of "Le Conte" pear trees. On the other hand, Sharma and Kaur (2006) found that, bending of branches in pear enhanced spur formation and precocity. Finally, Chen Chung *et al*. (1997) indicated that, shoot bending in summer of "Hosui" pears was effective in promoting lateral bud formation at the end of the year.

2. Fruit set and yield:

A. Fruit set percent:

The data concerning the effect of shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments on the percentage of fruit set are presented in Table (1). The results indicated that, in both seasons of study, the greatest increase of fruit set percent was obtained from trees treated with (GA_3 20 ppm), in addition all treatments, except shoot bending (1y.) and shoot girdling (1y.) treatments in the second season, significantly increased the percentage of fruit set over the control. Fruit set was increased by 54.41, 71.16 and 132.55 % in the first season and by 55.09, 78.70 and 158.79 % in the second season for shoot girdling (3y.), shoot bending (3y.) and (GA_3 20 ppm) respectively as compared with the control. These results are in harmony with those found by Khattab *et al.* (2003) who indicated second to the fourth year from planting, the trees yielded more fruits than those regulated by pruning only. In addition, Raffo *et al*. (2011) on pear trees, Poniedzialek *et al*. (2001) on apple trees and Baljit Kumar and Harminder Singh (2008) on peach trees proved that all the used girdling treatments significantly increased fruit number, fruit weight and fruit yield. Moreover, Girish Sharma and Ananda (2004) and Moneruzzaman *et al.* (2011) on apple trees observed that, the application of GA_3 at 50 mg/L increased fruit number, weight and yield, however, spraying with 20 mg/L GA_3 increased the number of buds and fruit setting and reduced bud dropping before anthesis.

3. Fruit physical properties:

A. Average fruit weight:

Data concerning the effect of shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments on fruit weight of "Le Conte" pear trees are shown in Table (2). Its clear that all treatments except shoot girdling (1y.) and shoot bending (1y.) in 1st season significantly increased fruit weight as compared with control. Moreover, a gradual increase in fruit weight was observed with trees treated with (GA_3 20 ppm), followed by GA_3 15 ppm, shoot girdling (3y.) and shoot bending (3y.) in both season of study. While, shoot girdling(1y.), shoot bending (1y.) and control treatments gave the lowest values in both seasons. Fruit weight increased by 71.67, 37.50 and 37.40 % in the first season and by 75.21, 51.85 and 54.31 % in the second season for (20 ppm GA_3), shoot girdling (3y.) and shoot bending (3y.) respectively, as compared with control. These results are in line with the findings of Gao MeiXiou (1997), Chanana and Gill (2006), Baljit Kumar and Harminder Singh (2008) on peach trees, Sousa *et al*. (2005) on pear trees and Meintjes *et al.* (2005) on apples, who found that girdling increased mean fruit weight. In addition, Moneruzzaman *et al.* (2011) on apples observed that the application of GA_3 increased fruit weight. On the other hand, Li YongWu *et al*. (2006) on apples indicated that, fruit weight reached the highest when the bending branch angle was 110 degrees.

B. Fruit size:

The data representing the effect of shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments on fruit size are shown in Table (2). The results indicated that, all used treatments, except shoot girdling (1y.) in 1st season significantly increased fruit size as compared with control. In addition, a gradual increase fruit size was observed with trees treated with (GA_3 20 ppm), followed by GA_3 15 ppm, shoot girdling (3y.) and shoot bending (3y.) in both seasons of study. While, shoot girdling (1y.), shoot bending (2y.) and control treatments gave the lowest values in both years. On the other hand, no significant differences were found between shoot girdling (1y.) and control treatments in the first season. Fruit size increased by 69.63, 37.73 and 38.39 % in the first season and by 73.11, 51.26 and 50.18 % in the second season for (20 ppm GA_3), shoot girdling (3y.) and shoot bending (3y.) respectively, as compared with control. These results are in harmony with those obtained by Chanana and Shefali Beri (2004), Taylor (2004), Wang XueJiang and Han Wei (2007) and Allan *et al.* (1995) on peach trees who indicated that, girdling improved fruit size. In addition, Mebelo Mataa *et al*. (1998) on Citrus observed that, July and September girdling improved fruit size. Moreover, Smit *et al*. (2005) on pear trees observed that, girdling tended to increase final fruit size.

C. Fruit firmness:

The results given in Table (2) represented the effect of shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments on fruit firmness during the both seasons. The results indicated that, in the first season, a gradual increase in fruit firmness was observed with trees treated with (GA_3), followed by shoot bending (3y.). All treatments, except shoot bending (2y.) and shoot girdling (1y.), (2y.) significantly increased fruit firmness as compared with control. In the second season, a gradual increase in fruit firmness was observed with trees treated with (GA_3 20 ppm), followed by (GA_3 15 ppm), (GA_3 10 ppm), and shoot bending (3y.). Fruit firmness was increased by 15.55, 6.12 and 17.65 % in the first season and by 17.97, 6.9 and 10.97 % in the second season for (20 ppm GA_3), shoot girdling (3y.) and shoot bending (3y.) respectively, as compared with control. These findings agreed with those previously reported by Teng YuanWen *et al*. (1998) on pear trees, who found that girdling increased flesh firmness. In addition, Girish Sharma and Ananda (2004) on apple trees, found that applications of GA_3 gave the best quality fruits (fruit firmness). Moreover, Baljit Kumar and Harminder Singh (2008) on peach trees reported that, all the tested girdling treatments significantly increased fruit quality. Finally, Li YongWu *et al*. (2006) on apple trees indicated that, fruit hardness reached the highest when the bending branch angle was 110 degrees.

D. Fruit length:

Data concerning fruit length in response to shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments are presented in Table (2). The obtained data cleared that in both seasons (GA_3) application treatments increased fruit length as compared with other treatments. Shoot bending and shoot girdling treatments didn't affect fruit length. These findings disagreed with those previously reported by

Table 1. Effect of shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments on some vegetative growth parameters and yield components of "Le-Conte" pear trees during 2009 and 2010 growing seasons

Treatments	Vegetative growth parameters						Yield components					
	Shoot length (cm)		Leaf area (cm^2)		No spurs / meter		Fruit set percentage %		No. of fruits / tree		Yield (ton / fed.)	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Shoot bending (1y.)	49.30	54.32	32.22	32.39	9.66	12.53	2.43	2.78	99.70	105.24	2.275	2.342
Shoot bending (2y.)	57.70	62.19	33.78	32.72	24.81	30.05	3.52	3.42	132.23	135.99	2.732	3.173
Shoot bending (3y.)	58.49	74.97	36.64	33.20	28.53	29.37	3.68	3.86	143.04	146.69	3.571	3.864
Shoot girdling (1y.)	36.81	37.15	31.47	30.17	10.00	15.30	2.64	2.74	115.76	119.99	2.186	2.550
Shoot girdling (2y.)	42.58	48.80	33.10	32.02	30.95	31.23	3.31	3.36	133.60	134.74	2.914	3.619
Shoot girdling (3y.)	45.39	41.66	32.78	33.22	23.33	25.97	3.32	3.35	143.03	146.63	3.572	3.802
GA_3 Application (10 ppm)	85.83	85.82	37.39	35.90	22.06	23.06	3.83	3.88	130.23	133.69	3.469	3.558
GA_3 Application (15 ppm)	92.50	96.94	36.79	36.77	20.47	20.63	4.58	4.63	151.22	155.34	4.040	4.534
GA_3 Application (20 ppm)	94.08	96.81	37.01	38.21	28.37	29.19	5.06	5.59	184.49	186.76	5.658	5.681
Control	88.01	80.06	34.42	34.58	15.19	15.79	2.15	2.16	99.72	100.38	1.746	1.778
L.S.D. *at 0.05 level*	7.40	7.19	1.90	1.71	11.08	8.13	0.33	0.75	30.57	31.92	1.042	1.071

Table 2. Effect of shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments on fruit length, fruit diameter, L / D ratio, fruit weight, fruit size, and fruit firmness of "Le-Conte" pear trees during 2009 and 2010 growing seasons

Treatments	Fruit length (cm)		Fruit diameter (cm)		L /D ratio		Fruit weight (gm)		Fruit size (cm^3)		Fruit firmness (pound/inch^2)	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Shoot bending (1y.)	6.9	7.26	6.15	6.13	1.13	1.14	128.67	139.80	113.50	124.50	12.23	10.00
Shoot bending (2y.)	5.97	6.5	5.1	5.7	1.17	1.12	119.60	142.87	106.30	120.00	11.53	11.43
Shoot bending (3y.)	7.03	7.1	6.03	6.23	1.17	1.14	144.93	160.80	129.33	139.00	12.86	11.73
Shoot girdling (1y.)	6.67	6.5	5.66	5.36	1.17	1.21	112.43	126.50	100.83	112.10	11.50	11.07
Shoot girdling (2y.)	6.36	6.4	5.56	5.16	1.14	1.23	128.77	161.27	114.35	138.00	10.80	10.43
Shoot girdling (3y.)	6.8	6.1	5.07	5.5	1.12	1.35	145.03	158.23	128.71	140.00	11.60	11.30
GA_3 Application (10 ppm)	7.5	7.7	6.43	6.83	1.17	1.13	154.03	156.63	139.03	139.40	12.47	12.27
GA_3 Application (15 ppm)	7.57	7.5	6.63	6.46	1.14	1.16	158.83	178.50	136.80	158.86	12.47	12.27
GA_3 Application (20 ppm)	7.8	8.17	6.66	6.57	1.17	1.24	181.07	182.57	158.52	160.22	12.63	12.47
Control	6.8	6.77	5.86	5.8	1.16	1.17	105.47	104.2	93.45	92.55	10.93	10.57
L.S.D. *at 0.05 level*	0.58	1.01	0.74	0.84	N.S	N.S	14.43	16.73	10.53	6.62	0.67	0.99

Sousa *et al*. (2005) on pear trees who found that, girdling increased fruit length.

E. Fruit diameter:

The results given in Table (2) represented the effect of shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments on fruit diameter during the both seasons. The data indicated that, in the first season a gradual increase in fruit diameter was observed on trees treated with (GA_3 20 ppm), followed by GA_3 15 ppm, while shoot girdling (3y.) treatment gave the lowest values compared with the control. In the second season, except (GA_3 15 ppm) the differences between treatments were not big enough to be significant. These findings agreed with those obtained by Sousa *et al*. (2008) on pear trees who proved that girdling resulted in less fruit of smaller diameter compared with the control.

F. Fruit shape (L /D ratio):

The results given in Table (2) represented the effect of used treatments on fruit shape during the both studied seasons. The data indicated that, the differences between treatments were not big enough to be significant in both seasons. These findings agreed with those obtained by Han MingYu *et al.* (2008) on apple trees who showed that, there were no significant differences in fruit shape index between the different investigated treatments of branch bending angle.

4. Fruit chemical properties:

A. Total soluble solids:

The data representing the effect of shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments on total soluble solids (TSS %) of "Le Conte" pear fruits in both seasons as shown in Table (3). The obtained results revealed that, all treatments significantly increased (TSS %) as compared with the control in both seasons of study. Gibberellic acid treatments at 10 or 15 and 20 ppm markedly increased TSS % as compared with the control in both seasons. However, there were no significant differences in (TSS %) between shoot bending and shoot girdling treatments. (TSS %) was increased by 26.61, 25.64 and 22.44 % in the first season and by 32.60, 23.77 and 16.52 % in the second season for (20 ppm GA_3), shoot girdling (3y.) and shoot bending (3y.) respectively, as compared with the control. These findings agreed with those obtained by Baljit Kumar and Harminder Singh (2008), Taylor (2004), Onguso *et al.* (2004), Chanana and Shefali Beri (2004) and Gao MeiXiou (1997) on peach trees who found that fruit total soluble solids in all used girdled treatments were higher than on the non-girdled treatments. In addition, Arakawa *et al*. (1998) on apple trees they found that, ringing increased fruit soluble solids content. Moreover, Sousa *et al*. (2008) and Teng YuanWen *et al*. (1998) on pear trees reported that, girdling treatments increased (TSS %). Finally, Li YongWu *et al*. (2006) on apple trees indicated that, shoot bending increased (TSS %).

B. Acidity %:

Data illustrated in Table (3) showed the acidity % in fruits of "Le Conte" pear trees as influenced by shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments in both seasons of study. The present results showed that all treatments significantly decreased acidity % as compared with the control. There were no significant differences in acidity % between shoot bending, shoot girdling or gibberellic acid (GA_3) application treatments. Similar results were previously registered by El-Sabagh and Ahmed (2004) on apple trees, they found that gibberellic acid application treatments decreased fruit acidity percentage compared to the control. Moreover, Han MingYu *et al.* (2008) and Li YongWu *et al*. (2006) on apple trees, found that shoot bending treatments decreased fruit acidity percentage compared to the control.

C. TSS / acid ratio:

The data concerning the effect of shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments on the maturity index TSS : acid ratio of "Le Conte" pear trees in both seasons of study are shown in Table (3). The data revealed that, all treatments significantly increased TSS : acid ratio as compared with control in both seasons of study. There were no significant differences in TSS : acid ratio between shoot bending, shoot girdling or gibberellic acid (GA_3) application treatments. These findings are supported with those obtained by El-Sabagh and Ahmed (2004) on apple trees, who revealed that TSS/acid ratio increased significantly as a result of (GA_3) application treatments.

D. Reducing sugars:

Results in Table (3) introduced the effect of shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments on reducing sugars content of "Le Conte" pear fruits in two seasons of study. The data indicated that, all studied treatments significantly increased reducing sugars content as compared with the control in both seasons of study. In addition, in the first season a gradual increase in the reducing sugars content was observed on trees treated with (GA_3 20 ppm) and shoot girdling (3y.), followed by (GA_3 15 ppm) and shoot bending (3y.), while, in the second season a gradual increase in the reducing sugars content was observed with trees treated with (GA_3 20 ppm) followed by shoot girdling (3y.), GA_3 10 ppm, GA_3 15 ppm and shoot girdling (1y.) treatments.

Table 3. Effect of shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments on TSS, acidity, TSS: acid ratio, reducing sugars, non-reducing sugars and total sugars of "Le-Conte" pear trees during 2009 and 2010 growing seasons

Treatments	TSS (%)		Acidity (%)		TSS : Acid ratio		Reducing sugars %		Non-reducing sugars %		Total sugars %	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Shoot bending (1y.)	14.43	13.27	0.27	0.31	53.44	42.80	6.44	5.75	2.26	3.01	8.70	8.76
Shoot bending (2y.)	13.23	13.56	0.28	0.31	47.25	43.74	6.41	6.30	2.30	2.45	8.71	8.75
Shoot bending (3y.)	13.8	13.33	0.24	0.27	57.50	49.37	6.49	6.43	2.34	2.42	8.83	8.85
Shoot girdling (1y.)	13.6	13.83	0.28	0.30	48.57	46.10	6.62	6.53	1.90	1.97	8.52	8.50
Shoot girdling (2y.)	12.67	13.00	0.24	0.27	52.79	48.14	6.64	6.59	1.88	1.94	8.52	8.53
Shoot girdling (3y.)	14.16	14.16	0.23	0.25	61.56	56.64	6.79	6.78	1.74	1.81	8.53	8.59
GA_3 Application (10 ppm)	14.76	14.53	0.23	0.33	64.17	44.03	6.25	6.61	2.22	2.22	8.81	8.83
GA_3 Application (15 ppm)	14.63	14.73	0.24	0.29	60.95	50.79	6.57	6.56	2.35	2.47	8.92	9.04
GA_3 Application (20 ppm)	14.27	15.17	0.27	0.26	52.85	58.34	6.80	6.82	2.25	2.25	9.05	9.07
Control	11.27	11.44	0.49	0.53	23.00	21.58	5.60	5.56	1.80	1.76	7.40	7.32
L.S.D. *at 0.05 level*	1.36	1.51	0.07	0.12	15.33	13.27	0.34	0.04	0.12	0.10	0.10	0.10

E. Non–reducing sugars:

Results in Table (3) illustrated the effect of shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments on the non–reducing sugars content of "Le Conte" pear fruits in the two seasons of study. The data indicated that, in the first season (GA_3) application and shoot bending treatments significantly increased the non–reducing sugars content as compared with the control or shoot girdling treatments. In addition, (GA_3) application at (15 ppm) and shoot bending (3y.) treatments gave the highest values of the non–reducing sugars content as compared with the control. Moreover, no significant differences were found between the control or shoot girdling treatments. While, in the second season, shoot bending (1y.) treatments gave the highest value of the non–reducing sugars content as compared with the control, followed by shoot bending (2y.), (1y.) and GA_3 (15 ppm) treatments. On the other hand, there were significant differences in the non–reducing sugars content between the control and shoot girdling treatments except (3y.).

E. Total sugars:

Results in Table (3) introduced the effect of shoot bending, shoot girdling and gibberellic acid (GA_3) application treatments on the total sugars content of "Le Conte" pear fruits in the two seasons of study. The data indicated that, all studied treatments significantly increased the total sugars content as compared with the control in both seasons of study. In addition, in the first season a gradual increase in the total sugars content was observed on trees treated with GA_3 (20 ppm) and GA_3 (15 ppm) treatments, followed by shoot bending (3y.) and GA_3 (10 ppm). In the second season a gradual increase in the total sugars content was observed on trees treated with GA_3 (20 ppm) and GA_3 (15 ppm), followed by shoot bending (3y.), GA_3 (10 ppm), and shoot bending (1y.). These findings agreed with those previously reported by Li YongWu *et al*. (2006) on apple trees who indicated that, total sugars reached the highest values when the bending branch angle was 110 degrees. In addition, Moneruzzaman *et al.* (2011) on apple trees observed that, the application of GA_3 increased the total sugars content in the fruits by 97% compared with the control treatment. Moreover, Girish Sharma and Ananda (2004) on apple trees found that, applications of GA_3 at 10 ppm + NAA at 5 ppm gave the best quality fruits (total sugars).

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الملخص العر

تأث معاملات الث والتحليق و ض ا يليك على النمو ا ضري ونسبة عقد الثمار وا صول وصفات جودة الثمار الكمثرى صنف " ليكونت"

مود أ د على، ثناء مصطفى عز، وصفى ماهر عبد ا سيح، دي السيد الدمرداش

أجرى هذا البحث خلال مـو ي(٢٠٠٩ و ٢٠١٠) علـى أشجار الكمثرى صنف" ليكونت"مطعمة على أصل البتيوليفوليـا عمرها س سنوات زرعة خاصة منطقـة جنـوب التحريـر حافظة البحـ ة بدف دراسة تأث معاملات الث و التحليق و ض ا يليك على النمو ا ضري و ا صول وجودة الثمار

وقد أظهرت النتائج أن معاملات ض ا يليك ومعـاملات ث الأفرع عمر ثلاث سنوات أعطت زيادة معنويـة مـساحة الورقة وعدد الدوابر الثمرية ا تر الطو ونسبة العقـد وعـدد الثمار لكل شجرة وا صول الكلى للفدان بالطن ووزن الثمرة وحجـم الثمرة وطول الثمرة وعرض الثمرة وصلابة الثمار ونـسبة ا ـواد الصلبة الذائبة والسكريات الكلية كما أدت إ خفض نسبة وضة الثمار مقارنة بالكنترول كلا ا و .

وأوضحت النتائج أيضا أن ليق الأفرع عمر ثلاث سـنوات أعطت زيادة معنوية عدد الدوابر الثمرية ا تر الطو وعـدد الثمار لكل شجرة ووزن الثمرة وحجم الثمـرة وصـلابة الثمـار ونسبة ا واد الصلبة الذائبة والسكريات ا ختزلـة بينمـا أدت إ ا فاض نسبة وضة الثمار مقارنة بالكنترول كلا ا و .