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Effect of Some Horticultural Practices on Fruit Set, Yield and Quality of "Le-Conte" Pear Trees

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ABSTRACT

The present investigation was carried out for two successive seasons (2013/2014 and 2014/2015) on "Le-Conte" pear trees grown at Horticultural Research Institute Research Orchard (HRI) in Giza Twelve- years- old trees budded on *Pyrus communis* rootstock were used in this investigation. The aim of this research was to study the effect of bending shoot alone, or combined with remove one third shoot length or girdling, on spur %, shoots and dormant buds number %, shoot length and diameter, flower date, fruit set % , yield kg./ tree, fruit quality, leaf area, chlorophyll and dry matter %. In addition to total carbohydrates %, nitrogen %, C/N ratio and the endogenous hormones ABA, GA3, IAA.

The results indicated that, all horticultural treatments hastened full blooming date 9-16 days and 3-11 days in both seasons, increased spurs, shoot number % and diameter, dry matter, fruit set % , fruit yield and improved fruit quality also chlorophyll, leaf area, IAA and GA_3. While, decreased shoots length, dormant buds %, fruit firmness and ABA level. Furthermore, treatment of (bending combined with girdling and remove one third shoot length) were the most positive effective treatment followed by (bending combined with girdling) and (bending combined with remove one third shoot length). Thus, treatment of (bending on the first of October combined with girdling on the first of January and remove one third shoot length on the first of October) could be recommended as regard to the above mentioned results.

Key word: Horticultural treatments, bending shoot, girdling, fruit set, yield, pear trees

Introduction

Le-Conte pear is a hybrid between (*Pyrus Communis* and *P. Serotina*) and considered the main pear cultivar grown in Egypt, but its characterized by a distinct period of rest (endodormancy) which expends from late fall till early spring. Regrowth and flowering in the new season needs overcoming such dormancy (Westwood, 1978). However, management practices are important for lowering the chilling requirements of buds. These include controlling tree vigour, training, fertilization, defoliation and delaying winter pruning (Lang *et al*., 1987).

Flower buds of pear are formed on terminal of shoots and short spurs of 2-years-old and older. Flower bud development can be altered by many factors and practices. Shoot bending may enhance flowering of young trees, encourage the development of flower buds and increase yield in apple trees (Isac, 1986; Wei, 1987 and Edwards and Notodimedjo, 1987) and in pears (Lin, *et al*., 1990 and Chen Chung *et al*., 1997). Shoot bending treatments also caused a rapid increase in the number of nodes in the auxiliary buds in Japanese pear (Pyrus Serotina Rehd) and the final percentage of flower bud formation in the control only reached 15.2 % compared with approximately 60 % for the treated shoots (Banno *et al*., 1985). Also (Abd EL-Rahman, 2002) noticed that, winter bending (1 and 5 Novembers in both seasons) with two angle 45º for three year-old shoots while 90º angle for one and two year-old shoots enhancing vegetative growth, quality and fruits quantity of “Le Conte” pear trees. Moreover, bending significantly increased C/N ratio of spur wood on 2 and 3-year old shoots but significantly decreased this ratio on one year old shoots, bending increased IAA, GA3 and decreased ABA level, furthermore (Jana, 2015) noticed that, growth retardant chemicals like SADH and shoot bending increase ethylene synthesis in damaged cells which influence early flower bud formation in pear plant also (Zhang, *et al*. 2015) observed that ABA and ZR concentration in shoot terminals increased but IAA and GA3 concentration decreased as the bending angle increased from 70 to 110 degrees of apple trees.

Heading back increased average fruit weight and reduced fruit number and yield per tree comparing with control (Naiema *et al*., 2006). Moreover
(Sharma, 2014) found that, fruit weight, diameter and total soluble solids (TSS) also increased with the increase in pruning intensities (1/4 or 1/2 heading back and thinning out) however, non significant difference was observed on firmness and acidity of Starking delicious apple.

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Girdling apple limbs or trees inhibited vegetative growth (Greene and Lord 1983) promoted the formation of flower buds, thereby increasing bloom density, fruit set, fruit size and yield (Wei, 1993 and Li- Tain *et al*., 1996).

On orange (Monselise *et al*., 1972) reported that girdling increased endogenous gibberellins' contents and their activity. They may act in a double way, causing both abortion of late flowers which are in the first stages of differentiation and increasing setting of ovaries of earlier flower. There is another effect of girdling on fruit characters. It stimulated spurs formation at basal part of shoot in Le-Conte cv., also increase ABA, IAA, total carbohydrates % and C/N ratio in buds of all tested cultivars. From another way, girdling decrease in total nitrogen and this may be caused a chemical state that enhanced formation of flowering spurs (Fayek *et al*., 2004). On the other hand, the amount of diffusible indolle-3-acetic acid (IAA) in shoots of Japanese pear was decreased when the vertical shoots were bent at an angle of 45º which inhibited IAA transportation. It caused increasing of flower bud formation in Kosui cv. (Ito *et al*., 2001). On the other side, (Kondratenko *et al*., 1998) found that girdling leads to deposition of excess assimilates in the form of starch, initiation of photosynthesis, premature aging of leaves and stimulates the initiation of generative organs. Also (Damandeep *et al*., 2014) reported that sub-limb girdling performed on 15 days after flower initiation (DFI) was the best in enhancing fruit yield (162.0 kg/tree) compared to control (135.3 kg/tree) and physico-chemical composition of "Patharnakh" pear under sub-tropic of north India

Shoot bending and girdling caused an increase in spur percentage, fruit set and yield of Le –Cont pear. Moreover, girdling treatment gave the best fruit weight, volume, height and diameter (Bahlool *et al*., 2000).

Bending and girdling techniques reduce shoot growth and increase spurs, fruit set, and improve fruit quality of different deciduous fruits (Ahmed, *et al*., 2002 on apple; Said, *et al*., 2003 on apricot and Fayek, *et al*., 2004 on pear). While it gave significant decrease in fruit firmness, acidity, leaf N content in the 1st and 2nd seasons of Anna apple trees, (Kandil *et al*., 2006).

Choi Seakwon and Kim KyuRqe (2000) revealed that, girdling and girdling + pinching treatments on Sekaiichi apples markedly reduced June drop and accelerated fruit growth in early stages of fruit development. Girdling + pinching and pinching only reduced bourse shoot growth compared with non treated controls. There were no significant differences in flower bud formation in the following year among treatments-it was assumed that the optimum period for girdling is the 5 days leading up to full bloom. (Ito, 2001) studied the role of plant hormones in the flower bud formation of Japanese pear

Some pear growers were used trunk girdling at, or shortly after full bloom in order to reduce vegetative growth of trees that are particularly vigorous. Reducing vigor allows more sun to reach lower fruiting wood, making it more productive. It may reduce fire blight damage, particularly shoot blight. The results of girdling have not always produced a noticeable effect, and practice can be risk if done incorrectly (Glenn and Campostrini, 2011). Moreover, (Mohamed, 2012) reported that, shoot bending of two and three years old shoot at mid November or shoot girdling on three years old (5mm in width) at mid April increased number of spurs, fruit set percent, total number of fruits per tree, total yield (ton / fed) and improved fruit quality of 5-years-old "Le Conte" pear trees. Furthermore, (Rufato *et al*., 2015) reported that, the use of trunk cutting and girdling in adult orchards decreased the vegetative growth of "Packham 's Triumph" pear trees.

Thus, the present work was implemented to study the effect of bending, girdling and remove one third length of shoot on vegetative growth, fruit set, yield, fruit quality dry matter, mineral content, carbohydrates and hormones of "LE Conte" pear tree, the other target is to produce a suitable fruit yield of good quality with reducing the coast without harming the environment or human's health.

Materials and Methods

This study was carried out during two successive seasons 2013-2014 and 2014-2015 on "Le-Cone" pear trees grown at Horticulture Research Institute Orchard (HRI) in Giza, Egypt. Twelve years old trees budded on *Pyrus Communis* rootstock were used in this investigation. .Trees spacing was 3.5 m. between rows and 4 m. between trees within the row. Orchard soil is loamy clay, fertile and of good drainage, all trees supported to the received the recommended orchard management.

This research was conducted to assess the effect of some horticultural tratments on phonological and physiological traits of shoots as follow:

1 - Control.
2 - Bending.
3 - Bending + Remove one third length of shoot.
4 - Bending + Girdling.
5 - Bending + Remove one third length of shoot + Girdling.

Bended shoots were made by an angle of 45 rom vertical and tied down with strings to the trellis at height of 90 cm. whereas control shoots were left vertical. Bending was done twice on November 1 and 5 in the first and the second seasons respectively. Remove the third length of all one year old shoots on the tree for all

seasons on November 15. Girdling treatment was made on January 8 in both seasons removing about 5 cm. wide-ring (complete ring) at 10 cm. above the base of branches of old shoots (branches bearing). Control trees did not receive any treatment. Treatments were randomized on the selected trees in random complete blocks design with single tree plot replicated 3 times for each treatment. The study tested fifteen trees; the same trees were used in the two seasons of study.

1–Phonological characteristics:-

Percentage of (spurs, shoots and dormant buds) %:-

Number of (spurs, shoots and dormant buds were counted in both seasons on one-year-old shoots and the percentage of each type was calculated in relation to the total number of buds on shoots.

Shoots (length and diameter).

Counting was done before bending (in 25 October 2013 and October 1st 2014) and (October 1st 2015) at the end of the two growing seasons respectively recounted again.

The dates of beginning flowering, full bloom and start of fruit set:-

Flower beginning, full bloom and start fruit set were detected in the following spring of 2014 and 2015 seasons. Dates of beginning flowering, full bloom and start fruit set were recorded when approximately 5%, 70% and 90% of the buds reached the aforementioned stages respectively (Julian day, the system of numbering naming and ordering days introduced by Julius Caesar , 1-365 day or 366).

Fruit set percentage %:-

In 30th March of 2014 and 2015 seasons, twenty of well distributed spurs of shoots were selected around each tree and their flowers at full bloom were counted during March, 29th 2014 and March, 30th 2015. Fruit number was recorded (after fruit drop) for fruit retention determination.

Fruit set % was calculated on the basis of initial number of flower as follows:-

$$\text{Fruit set \%} = \frac{\text{Total No. of fruits}}{\text{Total No. of flowers}} \text{ X100}$$

1-5- Yield kg. /tree: -

Tree yield was calculated as follows:-

$$\text{Yield (kg /tree)} = \frac{\text{No. of mature fruit/tree}}{1000} \text{ X average weight of fruit gm.}$$

Fruit characteristics:-

Mature fruit were picked from the experimented trees. Samples were collected for maturity determination then picked as reached the physical and chemical indices mentioned previously by (Kilany, 1982), harvesting was carried out 130 – 135 day from petal fall.

Physical fruit characteristics:-

Fruit weight, fruit size, length, diameter and firmness average were determined at harvest.

Chemical fruit characteristics:-

Total soluble solids of juice (TSS) were measured by using ATAGO (ATC - No.1) refractometer (Mika, *et al*., 1982). Juice acidity was determined as malice acid according to (A.O.A.C., 1990). TSS / acid were also calculated.

Leaf measurements and contents:-

- *Leaf area (cm^2),* was measured by Bleasdale, (1978).

- *Chlorophyll content***,** SPAD by chlorophyll meter (Minolta Corporation, Ramsey NJ, USA).

- *Dry weight,* Leaf samples which collected oven dried at 50 $\overset{o}{C}$ (A.O.A.C. 1990) till constant weight in grams dry mater was determined as follow :-

$$\text{Dry mater \%} = \frac{\text{Wet weight – dry weight}}{\text{Wet weight}} \text{ X 100}$$

-*Total carbohydrates %,* were determined colorimetrically according to Dubios *et al*., (1956) as gm/100 gm weigh and were measured by using spectrophotometer at 490nm.

- *Total nitrogen,* was determined according to (A.O.A.C. 1990).
- *Carbohydrates / nitrogen ratio,* was calculated by dividing the total carbohydrates by total nitrogen.

The above measurements were determined after two weeks from collecting the yield (in august of both seasons 2014 – 2015) as follow: - leaf area was studied on samples taken from the current shoots (unbarring shoots) as well as spur leaves collected from the different ages of the bearing shoots in august. Each sample was represented by ten leaves per replicate for all treatments.

Hormonal constituents of spur:-

After month of bending (December) up to March the following year (before bud burst) spurs samples (5 gm) after removing the terminal buds from the former were taken monthly for determined hormonal constituents i.e. IAA, ABA and GA3 for hormonal determination, fresh samples were frozen in cold 80% aqueous methanol, volume was adjusted to 20 ml for each gram fresh weight and stored for 48 hours at 2 ^{o}C. GA3, IAA and ABA were extracted, fractionated and determination by using (HPLC) according to the method described by (Wasfy and Orrin, 1975).

Statistical analysis:-

The obtained data were subjected to analysis of variance (ANOVA) according to (Snedecor and Cochran, 1972). M. Static program was used to compare between means of treatments according to (Waller and Duncan, 1969) at probability of 5%.

Results and Discussion

1-phenologecal characteristics:-

- *Spurs percentage (%):-*

Data in table (1) clearly showed that, all treatments enhanced spur formation % compared to control, specially bending + girdling was the highest % in both seasons (78.57 and 91.90) respectively. While bending alone was the lowest % compared to other treatments but bending + remove one third length of shoot and the combined three treatments were sewing in both seasons.

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 apple. Moreover, (Khattab, *et al*., 2003) reported that winter shoot bending increased lateral growth, spur number and flowering spurs of "Le-Conte" pear trees. On other hand (Sharma and Kaur 2006) found that, bending of branches in pear enhanced spur formation and precocity. Also (Kandil, *et al*., 2006) on apple. (Chen-Chung, *et al*., 1997) cleared that, shoot bending in summer of "Hosui" pears was effective in promoting lateral bud formation at the end of the year. As for, (Pierre, 2001) recorded that summer bending promoted lateral growth on 1-and 2-year-old wood in a mesotonic position whereas bending in winter reduced lateral growth and redistributed the shoots more basit conically.

Moreover, (Mohammed, 2012) on "Le-Conte" pear he mentioned that, shoot bending + girdling (two year old) increased spur number compared to control. Also Mohammadi, et. al., (2013) reported that, flower bud number and vegetative growth increased by heading back treatment of apple trees.

-*Shoots (%):-*

Data in table (1) show that, bending + girdling had the most negative effect compared to other treatments in both seasons. While in the first season the highest percentage was a result of bending + remove one third length of shoot + girdling with a percentage of 36.67 compared to other treatments.

Moreover, in the second season the highest percentage was a result of control with a percentage of 46.42 compared to other treatments.

Similar result were obtained by (Free and Schmid, 1994 and 1999) who reported that shoot formation and trunk growth were not affected by bending techniques. Bending reduced terminal shoot growth on the laterals of both apple cultivars. (Cutting and Lyne, 1993) discussed the girdling reduction of shoot growth of "Culemborg" peach trees and found that both internodal length and node number were negatively affected for about 8 weeks after girdling until the girdle healed over. (De Vaio, *et al*., 2001) found that, shoot girdling reduced development of nectarine. Moreover, Kandil *et al*., (2006) on "Anna" apple. In addition (Mohammadi, *et al*., 2013) cleared that, vegetative growth increased by heading back treatment of apple trees.

-Dormant buds %:-

All horticultural treatments reduced dormant buds compared to control that was clearly in table (1) during the first season while in the second season bending practice alone increased dormant buds compared to control and other treatments. On the other hand, bending + remove one third length of shoot and bending + remove one third length of shoot + girdling suppress dormant buds %, subsequently enhanced bud burst. Taking into consideration the opinion of (El-Sherbini, 1978) who mentioned that bending resulted in a marked reduction in the percentage of buds that remained dormant in most of the positions than control shoots. As for (Lawes, *et al*., 1997) who suggested that, tree management by bending the leader horizontally in the first season increased the number of moderately weak side shoots and floral precocity. Also, (Pierre, 2001) on apple trees and (Abd EL-Rahman, 2002) on "Le-Conte" pear trees. Contrarily (Theron, *et al*., 2000) found that, bending did not influence the acceptability of trees.

Table 1: Effect of horticultural treatments on spurs, shoots, buds percentages and shoot length and diameter (cm) on Le – Cont pear trees in the two seasons.

Treatments	Spurs (%)		Shoots (%)		Dormant buds (%)		Shoot length (cm)		Shoot diameter (cm)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Control	24.15 D	30.95 E	26.30 C	46.42 A	49.55 A	22.63 B	29.57 A	33.00 B	0.833 A	0.733 B
Bending	63.49 C	52.80 D	21.42 D	21.78 C	15.08 B	25.42 A	9.83 E	17.56 D	0.533 B	0.800 B
Bending + remove one third length of shoot	65.14 B	70.01 C	35.24 B	20.00 D	0.00 D	0.00 D	24.43 B	24.33 C	0.900 A	0.633 C
Bending + girdling	78.57 A	91.90 A	13.11 E	0.00 E	8.33 C	8.66 C	17.67 D	11.27 E	0.367 C	0.500 D
Bending + remove one third length of shoot + girdling	63.33 C	75.01 B	36.67 A	25.00 B	0.00 D	0.00 D	20.60 C	50.90 A	0.833 A	1.233 A

Means in the same column followed by the same letter (s) are not significantly ($p \geq 0.05$) different.

-Shoot length (cm):-

Data in table (1) indicated that, all horticultural treatments caused a significant decrease in shoot length compared to control and bending alone was the lowest growth in the first season. While in the second season data cleared that, all treatments reduced shoot length significantly compared to control except bending + remove one third length of shoot + girdling was the highest growth 50.90 cm compared to control and other treatments. But, bending + girdling recorded the lowest growth 11.27cm . That decreased in shoot growth was previously reported as a result of shoot bending by (Banno, *et al*., 1985); and (Bahlool, *et al*., 2000) on "Le-Conte" pear trees. Girdling by (Green and Lord 1978 and 1983).

-Shoot diameter (cm):-

The present data in table (1) show that, bending alone and bending + girdling were significantly decreased shoot diameter. While, bending + remove one third length of shoot and bending + remove one third length of shoot + girdling were unsignificantly increased shoot diameter compared to control but significantly compared to the other treatments in the first season. Regarding the second season, bending alone had no effect on shoot diameter. While, bending + remove one third length of shoot + girdling had the highest value. On the other hand, bending + remove one third length of shoot and bending + girdling were significantly decreased shoot diameter. These results are harmony with (Myers and Ferree, 1983 b) found that, orientation at 45º or 90º of young apple trees showed a decline of terminal shoot growth. Also (Pierre, 2001) reported that winter bending might be a good compromise to reduce lateral growth distributing it along the shoot, to maintain good fruiting potential.

-Flowering dates:-

-Beginning of flowering:-

Data presented in table (2) show that, all treatments significantly hastened flower bud opening compared to control. Bending + remove one third length of shoot + girdling treatment was the earliest it hastened flower bud opening by 11 days than the control followed by bending + girdling , then bending + remove one third length of shoot and the lowest value was bending. Data in the second season cleared the same effect.

-Full bloom:-

Data in table (2) of full bloom reveal that, all treatments significantly hastened full bloom day by (9-16 days) and (3-11 days) compared to control in the first and the second seasons respectively.

- Start of fruit set:-

Data in table (2) recorded earliness (10-17 days) and (5-12 days) compared to control in the first and the second seasons respectively.

A probable explanation for this was mentioned by (Tromp, 1970) who found that, shoot orientation enhanced flower bud formation. Also (Lawes *et al*., 1997) record that, bending the leader horizontally increased floral precocity. Moreover, (Ito *et al*., 1999) revealed that, bending of Japan pear trees accelerated bud development. (Abd El-Rahman, 2002) reported that bending treatments hastened full blooming date by 3-4 days and 4-5 days for both 45° and 90° angles in both seasons respectively compared to control.

Goldschmidt, (1997) revealed that only bending of lateral shoot had a weaker effect on precociousness than both bending and pinching. Also (Jana, 2015) noticed that, growth retardant chemicals like SADH and shoot bending increase ethylene synthesis in damaged cells which influence early flower bud formation in pear plant.

Table 2: Effect of horticultural treatments on beginning of flowering, Full bloom date and start of fruit set dates on Le - Cont pear trees in the two seasons (as a Julian day) *

Treatments	Beginning of flowering		Full bloom date		Start of fruit set date	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	70.00 A	76.00 A	87.00 A	90.00 A	91.00 A	95.00 A
Bending	66.00 B	72.00 B	78.00 B	87.00 B	81.00 B	90.00 B
Bending + remove one third length of shoot	64.00 C	70.00 C	77.00 B	85.00 C	80.00 B	87.00 C
Bending + girdling	61.00 D	67.00 D	74.00 C	81.00 D	76.00 C	85.00 D
Binding + remove one third length of shoot + girdling	59.00 E	65.00 E	71.00 D	79.00 E	74.00 D	83.00 E

** The system of numbering naming and ordering days introduced by Julius Caesar (1 - 365 day or 366).*
Means in the same column followed by the same letter (s) are not significantly ($p \geq 0.05$) different.

- Fruit set %:-

Data in table (3) cleared that, all treatments were significantly increased fruit set % compared to control. Bending + remove one third length of shoot + girdling was the highest fruit set % 48.04 and 20.85 followed by shoot bending + girdling then bending + remove one third length of shoot and lowest value was bending in the both seasons. These results are in harmony with (Lakso and Carelli, 1994) they found that, low light levels can reduce growth and fruit set in apple Also, (George, *et al*., 1996) they stated that, sunlight distribution influences flower initiation and fruit set in peach. Moreover, (Abd El-Rahman, 2002) and (Mohamed, 2012) on "Le-Conte"pear that bending and girdling increased fruit set percent.

- Yield (kg /tree):-

Data presented in table (3) show that, all treatments increased significantly tree yield of "Le-Conte" pear during 2014 and 2015 seasons. The combined treatments of bending + remove one third length of shoot + girdling were the best treatments. Bending + girdling were more effective than shoot bending + remove one third length of shoot and bending.

These results are in line with (Wei, 1993; Li-Tain, *et al*., 1996, and Kandil, *et al*., 2006) on apple trees also, (Bahlool, *et al*., 2000, Abd El-Rahman, 2002 and Mohamed, 2012) on "Le-Cont" pear . Also Banyal, *et al*., (2013) found that, the different pruning intensities (one third or quarter heading back and thinning) affected the plant growth and fruit yield significantly with ¼ heading back and thinning as best treatment. Sub-limb girdling performed on 15 days after flower initiation (DFI) was the best in enhancing fruit yield (162.0 kg/tree) compared to control (135.3 kg/tree) and physico-chemical composition of "Patharnakh" pear under sub-tropic of north India (Damandeep, *et al*., 2014).

Table 3: Effect of horticultural treatments on fruit set % and yield of Le-Cont pear trees in the two seasons

Treatments	Fruit set %		Yield (kg /tree)	
	1st season	2nd season	1st season	2nd season
Control	12.33 C	9.62 C	12.65 D	12.46 D
Bending	34.61 B	12.84 BC	29.12 B	33.70 B
Bending + remove one third length of shoot	33.41 B	13.59 B	24.55 C	24.97 C
Bending + girdling	46.31 A	15.63 B	29.32 B	37.40 A
Bending + remove one third length of shoot + girdling	48.04 A	20.85 A	45.99 A	40.46 A

Means in the same column followed by the same letter (s) are not significantly ($p \geq 0.05$) different.

2-Fruit characteristics:-

2-1- Physical characteristics:-

-Fruit weight (gm).

As shown in table (4) fruit weight was significantly increased by all treatments. The heaviest fruits were obtained from bending + girdling followed by bending + remove one third length of shoot, then bending + remove one third length of shoot + girdling and the lowest weight was bending compared with the control in

the first season . However , in the seconded season the heaviest fruit were obtained from bending + remove one third length of shoot + girdling followed by bending + girdling then bending + remove one third length of shoot and the lowest was bending compared with the control.

- Fruit size (cm^3)

Table (4) cleared that, all treatments were significantly increased fruit size (cm) ^{3} and bending + remove one third length of shoot + girdling was superior treatment in both seasons, followed by bending + girdling.

- Fruit length (cm):-

Data in table (4) indicated that, bending + girdling has a positive effect on fruit length 8.73 cm compared to control and other treatments, while the other treatments had no effect compared to control in the first season. While in the second season bending + remove one third length of shoot + girdling were the highest value 9.10 followed by bending remove one third length of shoot 9.07 compared to the control ,while bending alone or bending + girdling had no effect.

-Fruit diameter (cm):-

Date in table (4) show that all treatments were increased significantly fruit diameter compared to control in the first season. Moreover, bending alone was the highest value (6.76 cm) followed by bending + girdling (6.53 cm). In the second season, bending + remove one third length of shoot + girdling was the highest wide (7.37cm) followed by bending + girdling (7.27cm) while the other treatments had no effect.

These results are in harmony with (Avery *et al*., 1979) they reported that starch accumulation in leaves was found after girdling treatment.

That is may be cause of the largest fruit weight volume, diameter and height of apple. Also, (Li-Tain, *et al*., 1996) on apple, (Bahlool, *et al*., 2000) on " Le-Conte" pear trees. Contrarily, trunk ringing had no effect on fruit weight, fruit number and yield per tree (Naiema, *et al*., 2006). Moreover (Sharma, 2014) found that, fruit weight, diameter increased with the increase in pruning intensities (1/4 or 1/2 heading back and thinning out) of Starking delicious apple, also (Tombesi, *et al*., 2014) recorded that, trunk girdling in peaches is practiced primarily to stimulate fruit growth but it also tend to decrease shoot vigor for a period of time after girdling.

- Fruit firmness (Lb/inch):-

The present data in table (4) revealed that, the all treatments decreased the values of fruit firmness compared to control in the first season. Moreover, shoot bending + remove one third length of shoot + girdling were the lowest value in both seasons. In the second season, shoot bending + remove one third of shoot and bending + girdling had no effect on fruit firmness compared to control. These results are in line with, (Bahlool, *et al*., 2000, Abd El- Rahman, 2002 and Mohamed, 2012) on "Le-Conte" pear trees.

This decreased may be due to the increase in light penetration which led to an increase in IAA content. As auxin, it is known to increase wall plasticity (irreversible stretching), it has been convincingly demonstrated with the avena coleoplile. It has been shown that cell wall plasticity increases before and during auxin-induced cell elongation, which may due to the rupturing of Ca bonds in the cell wall (Klein, 1961).

Contrarily, (Benitez, *et al*., 1998) revealed that on pears fruit firmness was not affected by fruit position, in addition (Sharma, 2014) on apple.

Table 4: Effect of horticultural treatments on fruit size, diameter, length, firmness and weight of Le -Cont pear trees.

Treatments	Fruit Size (cm^3)		Fruit diameter (cm)		Fruit Length (cm)		Fruit firmness (Lb/inch)		Fruit Weight (g)	
	1st Season	1nd Season	1st Season	1nd Season	1st Season	1nd Season	1st Season	1nd Season	1st Season	1nd Season
Control	119.33 E	184.17 E	5.77 D	6.53 B	7.57 BC	8.63 B	19.75 A	19.50 AB	114.67 C	184.42 D
Bending	159.33 D	209.63 D	6.76 A	6.77 B	7.77 BC	8.77 AB	18.50 BC	18.32 CD	165.33 B	215.04 C
Bending + remove one third shoot	174.00 C	217.67 C	6.40 BC	6.57 B	7.90 B	9.07 A	18.88 B	20.47 A	169.84 B	219.22 C
Bending + girdling	188.33 B	247.53 B	6.53 AB	7.27 A	8.73 A	8.63 B	18.37 BC	19.12 BC	181.33 A	250.36 B
Bending + remove one third shoot + girdling	197.33 A	258.10 A	6.15 C	7.37 A	7.17 C	9.10 A	17.82 C	17.97 D	166.67 B	259.50 A

Means in the same column followed by the same letter (s) are not significantly ($p \geq 0.05$) different.

2-2-Chemical characteristics:-

-Total soluble solids (TSS %):-

Data in table (5) indicated a significant increased in fruit TSS due to tested treatments, (bending alone or combined) compared to control and bending + remove one third length of shoot + girdling and bending +

girdling were the highest percentage (15.18 &14.68 %) and (14.75 &14.80) in the first and the second seasons respectively .

Sharma (2014) found that total soluble solids (TSS) increased with the increase in pruning intensities (1/4 or 1/2 heading back and thinning out) of Starking delicious apple.

-Acidity (%):-

Data in table (5) found that, all treatments had no effect on acidity % except, bending + remove one third length of shoot + girdling increased and record the highest acidity % in the first season , while in the second season all treatments decreased acidity % compared to control except bending + remove one third length of shoot + girdling gave the highest percentage.

Table 5: Effect of horticultural treatments on TSS (%), Acidity (%) and TSS/acid ratio on Le -Cont pear trees in the two seasons.

Treatments	TSS (%)		Acidity (%)		TSS/acid ratio	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	12.75 C	13.51 C	0.533 B	0.310 B	23.92 B	43.58 D
Bending	14.50 AB	14.14 B	0.600 AB	0.227 C	24.17 B	62.29 B
Bending + remove one third length of shoot	14.27 B	14.63 AB	0.633 AB	0.247 C	22.54 BC	59.23 C
Bending + girdling	14.68 AB	14.80 A	0.533 B	0.190 C	27.54 A	77.89 A
Bending + remove one third length of shoot + girdling	15.18 A	14.75 A	0.733 A	0.377 A	20.71 C	39.12 E

Means in the same column followed by the same letter (s) are not significantly ($p \geq 0.05$) different.

- The ratio of TSS/acidity:-

Data in table (5) found that bending + girdling was significantly increased the ratio of TSS/acidity. While the lowest ratio recorded by bending + remove one third length of shoot + girdling, but the treatments of bending + remove one third length of shoot and bending alone had low effect on this ratio in the first season, in the second season all treatments increased TSS/acidity ratio except bending + remove one third length of shoot + girdling was the lowest significant decreased compared to the control and other treatments.

These results are in line with, (Bahlool, *et al*., 2000) on pear, (Naiema, *et al*., 2006 and Kandil, *et al*., 2006) on apple and (Kumar and Singh, 2008) on peach and (Mohamed, 2012) on pear, reported that, shoot bending, girdling and GA3 application treatments were significantly increased TSS % and decreased acidity % .Moreover significantly increased the ratio of TSS/acidity. Also (Sharma, 2014) on apple.

3- Leaf measurements and contents:-

- Leaf area (cm^2):-

The presented data in table (6) indicated that, shoot bending alone or combined with (remove one third length of shoot or girdling) increased leaf area $(cm)^2$ compared to control in both seasons and shoot bending + remove one third length of shoot + girdling was the highest value of leaf area, followed by shoot bending + remove one third length of shoot, shoot bending + girdling and shoot bending. While the control recorded the lowest leaf area.

The foregoing results agreed with the finding of (Khattab, 2001a, Pien, *et al*., 2001, Gwan, *et al*., 2004) and (Mohamed, 2012) on pear who, reported that, shoot bending of three years old at mid November was the highest leaf area.

Table 6: Effect of horticultural treatments on leaf area, chlorophyll and dry matter on Le -Cont pear trees in the two seasons.

Treatments	Leaf area (cm^2)		Chlorophyll SPAD		Dry matter (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	60.61 E	54.15 E	42.20 B	45.97 C	26.86 E	51.00 C
Bending	62.70 D	70.27 D	55.14 A	48.21 BC	28.29 D	52.95 B
Bending + remove one third length of shoot	86.09 B	79.68 B	53.99 A	49.58 AB	33.47 A	54.67 A
Bending + girdling	70.05 C	76.94 C	52.12 A	52.70 A	29.65 C	53.11 B
Bending + remove one third shoot + girdling	86.94 A	80.55 A	55.03 A	51.54 A	32.03 B	53.80 B

Means in the same column followed by the same letter (s) are not significantly ($p \geq 0.05$) different.

-Chlorophyll (SPAD):-

Table (6) cleared that, all treatments increased chlorophyll content and shoot bending + remove one third length of shoot + girdling was the highest value (55.03 and 51.54 SPAD reading) followed by bending + girdling and bending + remove one third length of shoot while, the lowest value record by control (42.20 and 45.97 SPAD reading) in both seasons respectively.

These results are in line with (Maimaiti, *et al*., 2013) showed that branch bending significantly increased the leaf chlorophyll content and blade thickness of young "Fuji" apple tree.

These results are contrarily by Peng and Rabe (1996) with apple trees, who found that, pruning or girdling was significantly decreased fruit and leaf chlorophyll content in minhowwase satsumas.

-Dry matter(%):-

Data in table (6) indicated that, all horticultural treatments were significantly increased dry matter compared to control. Moreover, bending + remove one third length of shoot and bending + remove one third length of shoot + girdling were the highest values of dry mater in both season. Followed by bending + girdling and bending alone. While the lowest value recorded with control. These results are in line with, (Abd EL-Rahman, 2002), found that bending significantly increased dry matter % content in "Le-Conte" pear leaves of one-year old shoot. Also (Kandil, *et al*., 2006), indicated that all treatment bending (1, 15/ 11), girdling (young or old shoot (8/1, 15 / 3 and 4) except those concerning girdling young shoot on mid-April gave significant increment dry matter % of leaves apple.

- Total carbohydrates(%):

Data in table (7) revealed that all treatments increased total carbohydrates % in both seasons moreover, bending + remove one third length of shoot + girdling was the most positive effect significantly compared to control and other treatments (16.44 % and 33.35) while the control record lowest significant percentage (12.50 % and 10.29 %) in both seasons respectively.

Stutte and Martin (1986) noticed that, low light treatment resulted in a lower concentration of carbohydrates than the high light of olive trees. Moreover starch level increased in leaves and shoots of girdled "Florda Prince" peach trees (Allan, *et al*., 1993). Starch accumulation increased in leaves and shoots of girdled peach trees (Jordan, et at., 2001). Furthermore (Kandil, *et al*., 2006) recorded that, shoot bending and girdling significantly gave the highest increase of total carbohydrates %, C/N ratio of leaves in apple.

- Nitrogen percentage:-

The present data in table (7) indicated that all treatments increased N % in the first season, while in the second season bending, had no effect on N % compared to control on the other hand, bending + remove one third length of shoot + girdling was the highest percentage (2.957 % and 2.260 %) in the first and the second seasons respectively .

These results are harmony with Kandil, *et al*., (2006) reported that bending on first November treatment of "Anna apple" trees and girdling old shoot on mid-March treatment gave significant decrease in leaf N content in both seasons.

Han Ming Yu, *et al*., (2008) studied the effects of branch bending angle on physiological characteristics of Fuji apple trees. They showed that there were no significant differences in leaf intercellular co_2 concentration and leaf total nitrogen content. Moreover, Pavicic, et. al., (2009). Studied the effect of combined pruning treatments on fruit quality and biennial bearing of "Elstar" apple trees (Malus domestica Borkh.). They observed that fruits of the trees, which were treated only with canopy pruning, had the highest N content. Furthermore, Mohamed (2012) found that all girdling treatments decreased leaf N content compared to control. On the other hand no significant differences were found between control or all shoot bending treatments during the both seasons of study.

Table 7: Effect of horticultural treatments on total carbohydrates, nitrogen % and C/N ratio of Le -Cont pear trees in the two seasons.

Treatments	Total carbohydrates %		Nitrogen %		C/N ratio	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	12.5 D	10.29 E	1.927 D	1.7 BC	6.49 A	6.06 BC
Bending	12.55 D	12.49 D	2.589 B	1.383 C	4.507 C	9.563 B
Bending + remove one third length of shoot	13.91 B	31.35 B	2.498 BC	2.27 AB	5.633 B	13.97 A
Bending + girdling	13.18 C	14.34 C	2.243 CD	2.577 A	5.92 AB	5.583 C
Bending + remove one third length of shoot + girdling	16.44 A	33.35 A	2.957 A	2.26 AB	5.563 B	15.09 A

Means in the same column followed by the same letter (s) are not significantly (p ≥ 0.05) different.

- C / N ratio:-

Concerning C/N ratio, the data in table (7) cleared that, all treatments decreased C/N ratio except bending + girdling had no effect during the first season compared to control while, during the second season bending + remove one third length of shoot, and bending + remove one third length of shoot + girdling were significantly increased C/N ratio while, bending alone and bending + girdling had no effect on C/N ratio compared to control. In the same trend (Kandil, *et al*., 2006) recorded that, shoot bending and girdling significantly gave the highest C/N ratio of apple leaves.

4 -The effect of horticultural treatments on hormone level (IAA, GA3 and ABA mg/100g):-

Data in table (8) revealed that, all treatments reduced the level of ABA but increased GA3 level significantly compared to control. While, the treatments had no effect on IAA level except bending recorded the highest significantly value of IAA level compared to control.

On the other hand, ABA level was raise during dormancy while reduce during swelling and bud burst also. IAA level was cleared the same trend.

GA3 level was reduced during dormancy while raise during swelling and bud burst. Concerning the interaction, the highest level of ABA was recorded by shoot bending + remove one third length of shoot during dormancy while shoot bending alone or combined with girdling record the lowest level during bud burst. Also the highest level of IAA was observed by shoot bending alone during dormancy while, shoot bending alone or combined with girdling during bud swelling record the lowest level. GA3 level was the highest by shoot bending + remove one third of shoot. during bud burst. While the lowest value record by control during dormancy period. The results are in line with (Monselise *et al*., 1972) reported that, girdling increased endogenous gibberellins contents and their activity. Also increase ABA and IAA, (Fayek, *et al*., 2004). On the other hand, the amount of diffusible indolle -3-acetic acid (IAA) in shoots of Japanese pear was decreased when the vertical shoots were bent at on angle of 45º which inhibited IAA transportation. It caused increasing of flower bud formation furthermore, Abd El-Rahman (2002) found that shoot bending increased IAA, GA3 and decreased ABA level of "Le-Conte" pear. In Kosui cv. (Ito, *et al*., 2001). Moreover, (Kandil, *et al*., 2006) indicated that, shoot bending alone or combined with girdling increased ABA and IAA. Also (Zhang, *et al*., 2015) observed that ABA and ZR concentration in shoot terminals increased but IAA and GA concentration decreased as the bending angle increased from 70 to 110 degrees of apple trees.

Table 8: Effect of horticultural treatments on the level of endogenous hormones in buds on Le -Cont pear trees in the two seasons.

Treatments	ABA (mg/100g)			Mean	GA3 (mg/100g)			Mean	IAA (mg/100g)			Mean
	Bud dormancy	Bud swelling	Bud burst		Bud dormancy	Bud swelling	Bud burst		Bud dormancy	Bud swelling	Bud burst	
Control	0.0288 a	0.0037 a	0.0070 bc	0.0132 A	0.42 h	0.780 gh	1.92 f	1.040 D	0.245 bc	0.025 d	0.045 cd	0.107 B
Bending.	0.0309 a	0.00005 c	0.0001 c	0.0105 B	0.92 g	2.545 e	5.07 b	2.150 C	0.740 a	0.010 d	0.060 cd	0.266 A
Bending + remove one third shoot	0.0363 a	0.0014 c	0.0002 c	0.0126 B	0.50 h	5.373 ab	5.58 a	3.816 A	0.370 b	0.066 cd	0.08 cd	0.172 AB
Bending + girdling	0.0311 a	0.0006 c	0.0017 bc	0.0111 B	0.50 h	2.647 e	4.125 c	2.823 C	0.365 b	0.016 d	0.03 cd	0.137 B
Bendind + remove one third shoot girdling	0.0216 ab	0.0008 c	0.0001 c	0.0075 B	0.46 h	3.513 d	5.145 b	3.038 B	0.205 b-d	0,053 cd	0.155 cd	0.138 B
Mean	0.0297 A	0.0013 B	0.0018 B		0.56 C	2.971 B	4.368 A		0.385 A	0.034 B	0.074 B	

Means in the same column followed by the same letter (s) are not significantly ($p \geq 0.05$) different.

Conclusion

Bending alone or combined with remove one third length of shoot or girdling increased spurs %, increased floral precocity, increased dry mater % fruit set % yield and enhanced fruit quality moreover increased leaf area, chlorophyll content, carbohydrate % N %, C/N ratio of leaves and IAA. GA3 level of buds while decreased shoot length dormant buds %, firmness and ABA level.

Bending + remove one third length of shoot + girdling was the best treatment (superior) followed by bending + girdling and bending + remove one third length of shoot Thus this investigation was recommended to use bending + remove one third length of shoot + girdling as a horticultural practice for enhancing yield and fruit quality of Le-Cont pear. The other target is to produce a suitable fruit yield of good quality with reducing the coast without harming the environment or human's health

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