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EFFECT OF BENDING AND GIRDLING SHOOTS ON GROWTH AND FRUITING OF "ANNA" APPLE TREES GRAFTED ON TWO APPLE ROOTSTOCKS

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ABSTRACT

The present investigation was carried out in private orchard at Khatatba region, Monoufia Governorate, on 2-years old Anna apple trees budded on two rootstocks *(Malus domestica* and Maling Morton 106) during the two successive seasons (2001-2002 and 2002-2003). The aim of this research was to study the effect of bending and girdling on fruit set, spurs and shoots number, leaf area, dry matter % and fruit characters. In addition to the endogenous ABA, IAA, total carbohydrates %, nitrogen and C/N ratio.

The results indicated that all investigated treatments except those concerning girdling young shoots on mid-April gave significant increment in fruit set %, spurs number, leaf area, dry matter %, fruit weight, volume, diameter and length, TSS%, total carbohydrates %, C/N ratio, ABA, IAA and reduction in fruit firmness, acidity % and total nitrogen over the control in the 1st and 2nd seasons. Bending on first November treatment of Anna apple trees budded on Malus rootstock and girdling old shoots on mid-March treatment of the same trees onto MM 106 rootstock significantly gave the highest increase of fruit set %, spurs number, leaf area, dry matter %, fruit weight, volume, diameter and length, total soluble solids (TSS %) and total carbohydrates %, C/N ratio, ABA and IAA, while gave significant decrease in fruit firmness, acidity, leaf N content in the 1st and 2nd seasons.

Chemical analysis of the treated trees by bending shoots of Anna apple budded on Malus rootstock on first November and girdling old shoots of Anna apple trees budded on MM 106 rootstock on mid-March revealed that higher contents of total carbohydrates %, C/N ratio, abscisic acid and indole acetic acid, beside low of total nitrogen % may be in favor of spurs formation. Bending on first November of apple shoots budded on Malus rootstock and girdling old shoots on mid-March of Anna apple trees budded on M.M. 106 rootstock treatments could be recommended as regard the above mentioned results.

INTRODUCTION

Bending and girdling techniques reduce shoot growth and increase spurs, fruit set, and improve fruit quality of different deciduous fruits (Arakawa, *et al.*, 1997; El-Shikh, *et al.*, 1999; El-Beacy, 2001; Abdel-Rahaman, 2002; Ahmed, *et al.*, 2002; Said, *et al.*, 2003 and Fayek, *et al.*, 2004).

It is fact that shoot bending increased the shoot angle by bending , lateral flower number in the Japanese pear Hosui cv. (Banno, *et al.*, 1985 and Ito, *et al.*, 2001). Banno, *et al.* (1986) revealed that bending led to a decrease in IAA content in the shoot tips but increased it in the axillary buds. Abd El-Wahab, *et al.* (2002) noticed that bending stimulated spur formation at the medium part of branches, but girdling enhanced it at the basal part of branches of apple cvs. George , *et al.* (1996) mentioned that sunlight distribution influences on flower initiation and fruit set, also Lakso and Corelli

(1994) noticed that low light reduced fruit set and growth. Abd El-Rahman (2002)found that bending in winter increased percentage of pear flowering spurs, fruit set %, leaf area, dry matter and C/N ratio of trees, fruit weight, volume, length (L), diameter (D), total soluble solids, TSS/acidity and also found significantly decrease in firmness.

Moreover, bending in winter reduced lateral growth of apple trees and redistributed the shoots more bastionically (Lauri and Laspinasse, 2001). Ferre and Schmid (1999) suggested that bending in the spring had no effect on total shoot growth of Red Cort, but in Galla cultivar , bending early in spring caused great reduction in total shoot growth than bending later in the spring (June). Ahmed *et al.* (2002) found that bending shoots in Golden Delicious produced maximum fruit wight (244.51 g per apple fruit and TSS (13.32%), whereas the control (shoots without bending) produced more seeds per fruit (10.2).

Girdling treatment at full bloom increased total carbohydrates % in shoots and leaves compared with the control. There is significant improvement of fruit weight, size and total soluble solids (TSS %). On the other hand, there was insignificant effect on acidity and fruit colour of persimmon (El-Shaikh, *et al.*, 1999). Monselise, *et al.* (1972) reported that girdling increased endogenous gibberellin 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 the 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 45° 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.

This study was designed to indicate the effects of bending and girdling on fruit set, number of spurs and shoots, leaf area, percentage of dry matter in leaves, fruit quality, total carbohydrate, total nitrogen, C/N ratio and endogenous hormones (ABA, IAA) in leaves of "Anna" apple variety trees budded on *Malus domestica* and MM. 106 rootstocks.

MATERIALS AND METHODS

This study was conducted during the 2001-2002 and 2002-2003 seasons in a private orchard at Khatatba region, Menofia governorate on 2-year-old Anna apple trees budded on MM 106 (Malling Merton 106) and Malus (*Malus domestica* Boek) rootstocks planted at 3 x 3.5 m apart for MM 106 and 4x3 m for Malus , grown in sandy soil.

Bending and girdling treatments were as follow:

Bended shoots were made by an angle of 45° from the 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 15 in the two seasons of study. Girdling treatments were made on Jan. 8, March 15 and April 15 in both season by removing about 0.5 cm-wide-ring at 10 cm above the base of branches of both one-year old shoots and old ones (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 30 trees. Different trees were used in the two seasons of study.

Fruit set percentage was counted on April 6th in the two seasons. Leaf measurements were recorded during mid-July of the 2002 and 2003 seasons, respectively. Leaf area using a leaf area meter (Model C/203 area meter, CID, Inc., USA) and dry matter percentage was counted in dry leaves. Also, leaf total nitrogen, total carbohydrates % and endogenous hormones content (abscisic acid and indole acetic acid) were determined. Leaf analysis were used the Kjeldahl digestion method for N as described by AOAC (1990), the colorimeteric method for total carbohydrates % as outlined by Dubois *et al.* (1956) and for some endogenous hormones (abscisic acid "ABA' and indole acetic acid "IAA") using Gas Liquid Chromatography (GLC) as adopted by Davis *et al.* (1968). Each of the leaf measurements was based on 30-leaf- sample taken from an intermediate position on shoots per tree. Number of shoots formation on young shoots or old shoots and average number of spurs formation on the selected shoots as well as their distribution on shoots were recorded at the end of the growing season (December15th). Ten fruits from each tree were randomly picked at the commercial harvested time to determine fruit quality, viz, average fruit weight, volume, length, diameter, firmness (using Advance Force Gauge RH 13, UK), TSS % content (using a hand refractometer) and total acidity percentage (expressed as gram of malic acid/100 ml juice).

Data were tabulated and statistically analyzed according to Snedecor and Cochran (1972). Means were compared using New LSD values at 5% level (Waller and Duncan,1969).

RESULTS AND DISCUSSION

Fruit set percentage

Table (1) clearly indicated that all the tested treatments of Anna apple trees onto Malus rootstock except those concerning girdling of young shoots and old shoots on mid-April gave fruit set percentage higher than the control. Bending on first and mid-November the tested trees recorded higher fruit set percentage reached 24.20 & 26.93% and 12.16 & 14.67% in the 1st and 2nd seasons, respectively.

On the contrary each of girdling of young and old shoots on January 8th and girdling of young and old shoots on mid-March gave better and significant increase in fruit set compared to the control. The lowest average fruit set percentages were obtained from girdling of young and old shoots on mid-April.

These results agreed with those obtained by Abd El-Rahman (2002) reported that winter bending significantly increased fruit set % in the 1st and 2nd seasons.

Table (2) clearly indicated that all the practices of Anna apple trees budded on MM 106 rootstock except those concerning girdling of young and old shoots on mid-April gave fruit set percentage higher than the control. Each of girdling of young and old shoots on mid-March gave the same effect with percentages reached 35.48 & 33.20 and 19.20 & 18.0 in the 1st and 2nd seasons, respectively.

On the contrary each of bending on first, mid-November and girdling of young and old shoots on January 8th gave better and significant increase in fruit set compared to the control. The lowest average fruit set percentage obtained from girdling of young and old shoots on mid-April. These results are in harmony with those of Monselise, *et al.* (1972) who reported that girdling increased endogenous gibberellin contents and their activity. These may act in a dual way, causing both abortion of late flowers which are in the first stages of differentiation and increasing setting of ovaries of earlier flower.

Spurs number per shoots

Data in Table (1) clearly showed that all applied treatments of Anna apple trees budded on Malus rootstock except girdling of young shoots on January 8th and mid-April gave a high number of spurs on young and old shoots compared with the control. Contrary to that, girdling of young and old shoots on January 8th increased spurs number on young and old shoots. Furthermore, girdling of young and old shoots on mid-March gave high and significant increase in this respect. The highest significant increase was obtained from bending on first November and girdling old shoots on January 8th since these values reached 26.56 & 38.17 and 25.50 & 31.33 in the 1st and 2nd seasons, respectively.

Concerning Anna apple trees budded on MM 106 rootstock, data of Table (2) clearly showed that all applied treatments except girdling of young shoots on mid-April gave high number of spurs on young shoots compared with the control. Contrary to that, girdling of young and old shoots on January 8th increased spurs number of both shoots. Furthermore, bending on first and mid-November gave high and significant increase in this respect. The highest significant increase was obtained from girdling of young and old shoots on mid-March. Since they valued 23.17 & 27.67 and 17.48 & 21.98 in the 1st and 2nd seasons, respectively.

Similar results were obtained by Abd El-Rahaman (2002) who mentioned that winter shoot bending of Le'Conte pear trees (1,, 2 and 3-year-old shoots) significantly induced spurs formation. Bending and girdling treatments stimulated spurs formation at the basal parts of shoots of Japanese pear (Fayek, *et al.*, 2004).

Shoot number

Table (1) clearly indicated that all the practices of Anna apple trees budded on Malus rootstock except those concerning girdling of young shoots on January 8th gave a lower number of shoots than the control. Each of bending on first and mid-November gave a lower number of shoots and these numbers reached 1.0, 2.0 and 2.34, 2.89 in the 1st and 2nd seasons, respectively. On the contrary, each of girdling old shoots on mid-March and girdling of young and old shoots on mid-April did not give any shoots in the first season. The highest number of shoots obtained from control (young and old shoots) in the 1st and 2nd seasons and girdling of young shoots on mid-April in the second season.

Table (2) clearly indicated that all the practices of Anna apple trees budded on MM. 106 rootstock did not give any shoots except bending on mid-November and girdling old shoots on mid march and April gave a higher number of shoots than the control in the first season.

In the second season, all the practices gave a lower number of shoots than the control. Each of girdling old shoots on mid March and April gave a lower number of shoots. On the contrary, each of girdling of young shoots on mid-April and bending on first November gave a low insignificant decrease in number shoots compared with control in the second season.

Similar results were obtained by Feree and Schnid (1994 and 1999) who reported that shoot formation and trunk growth were unaffected by bending techniques. Bending reduced terminal shoot growth on the laterals of both apple cultivars. Lauri and Lespinasse (2001) found that bending in winter reduced lateral growth and redistributed the shoots more bastionically. Also, 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 "Independence" nectarine".

Leaf area

Data in Table (1) clearly showed that all the practices of Anna apple trees budded on Malus rootstock except those concerning girdling of young and old shoots on mid-April gave leaf area larger than the control. Each of bending on first November and girdling old shoots on January 8th gave a larger leaf area that reached 24.15 & 34.42 for the first treatment and 22.34 & 32.27 for the later one in the 1st and 2nd seasons, respectively. On the contrary, each of girdling young shoots on January 8th and girdling of young and old shoots on mid march gave better and significant increase in leaf area compared to the control. The lowest leaf area obtained from girdling of young and old shoots at mid April. These results agreed with those obtained by Khattab *et al* (2001) who detected that open vase trees recorded a significantly high mean individual leaf area compared to control leaders and untrained controls, between which insignificant differences were noticed. Morover, Abd El-RAhman (2002) reported that winter bending significantly increased leaf area of one-year-old shoots of pear in the two tested seasons.

Data in Table (2) clearly showed that all practices of Anna apple trees budded on MM 106 rootstock except those concerning bending on first November and girdling of young shoots on mid-April gave leaf area larger than the control. Each of girdling old shoots on mid march and April gave a larger leaf area that reached 21.04 & 29.24 and 18.83 & 27.89 in the 1st and 2nd seasons, respectively. On the contrary, each of bending on mid-November and girdling old shoots on January 8th gave better and significant increase in leaf area compared to the control. The lowest leaf area obtained from girdling of young shoots on mid-April ,January 8^{th} and bending on first November . In this respect, Gaber and Ibrahim (2005) found that punching 33% of shoot number with ringing or girdling resulted in the largest leaf area of "Florda Prince" peach trees.

Dry matter percentage

Table (1) clearly indicated that all the practices of Anna apple trees budded on Malus rootstock except those concerning girdling of young shoots on January 8th and mid-April gave a higher dry matter percentage than the control. Each of bending on first and mid November gave a higher dry matter percentage that reached 56.34 & 76.28 and 53.46 & 62.39 in the 1st and 2nd seasons, respectively. On the contrary, each of girdling old shoots on January 8th and mid-April gave better and significant increase in dry matter percentage compared to the control. The lowest average dry matter percentage was obtained from girdling of young shoots on January 8th and mid-April. In this respect, Abd El-Rahaman (2002) found that bending significantly increased dry matter % content in "Le'Conte" pear leaves of one-year- old shoot.

Table (2) clearly indicated that all the practices of Anna apple trees budded on MM. 106 rootstock except those concerning bending on first November and girdling of young shoots on mid-April gave dry matter percentage higher than the control. Each of girdling old shoots on mid march and April gave higher dry matter percentage that reached 57.37 & 69.28 and 55.20 & 65.75 in the 1st and 2nd seasons, respectively. On the contrary each of bending on mid November, girdling of young shoots on January 8th and mid-March and girdling old shoots on January 8th gave better and insignificant increase in dry matter % compared to the control. The lowest average dry mater percentage was obtained from bending on first November and girdling of young shoots on mid-April.

Fruit quality

a. Physical characters

Parameters used to measure fruit quality of apple trees budded on Malus and MM 106 rootstocks were. fruit weight, volume, length, diameter and fruit firmness as affected by bending and girdling treatments in the two seasons is presented in Tables (3 and 4).

Fruit weight and volume

Data presented in Table (3) indicated that all the applied practices gave fruit weight and volume values higher than the control. A high significant increase in fruit weight and volume was found from girdling old shoots on mid march and April and bending on mid-November. The highest significant increase in fruit weight and volume was found from bending on first November and girdling old shoots on January 8th.

Table (1):Effect of bending and girdling treatments on fruit set % , spurs number per shoot, shoots number, leaf area and dry matter % of "Anna" apple trees budded on Malus rootstock in 2002 and 2003 seasons.

Treatments	Fruit set (%)		Spurs number		Shoots number		Leaf area (cm^2)		Dry matter (%)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Bending (1/11)	24.20	26.93	26.56	38.17	1.00	2.00	24.15	34.42	56.34	76.28
Bending (15/11)	12.16	14.67	21.56	23.33	2.34	2.89	18.29	27.34	53.46	62.39
Girdling young* shoots (8/1)	5.03	5.79	12.17	15.00	7.50	6.17	16.44	24.49	50.44	56.27
Girdling old** shoots (8/1)	23.33	25.36	25.50	31.33	2.33	2.00	22.34	32.27	54.44	70.31
Girdling young shoots (15/3)	9.55	10.47	15.67	19.22	5.67	5.55	18.18	26.73	52.16	59.66
Girdling old shoots (15/3)	13.27	13.77	23.5	25.67	0.0	2.25	21.50	31.74	54.11	65.31
Girdling young shoots (15/4)	4.00	4.34	5.84	12.67	0.0	9.00	15.83	22.17	48.36	53.90
Girdling old shoots (15/4)	8.62	9.20	22.83	24.67	0.0	2.59	21.48	29.59	53.66	63.25
Control (young shoots)	4.0	4.34	4.00	10.34	6.25	6.0	14.22	20.05	46.11	50.18
Control (old shoots)	8.62	9.20	14.67	15.17	7.78	12.67	16.64	25.81	51.16	58.68
New L.S.D. at (0.05)	**0.49**	**1.35**	**1.81**	**2.62**	**1.04**	**1.20**	**1.30**	**1.48**	**1.26**	**1.14**

* young shoots = one-year-old shoots. ** old shoots = bearing branches.

Table (2):Effect of bending and girdling treatments on fruit set % , spurs number per shoot, shoots number, leaf area and dry matter % of "Anna" apple trees budded on M.M. 106 rootstock in 2002 and 2003 seasons.

Treatments	Fruit set (%)		Spurs number		Shoots number		Leaf area (cm^2)		Dry matter (%)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Bending (1/11)	12.19	11.27	12.78	17.28	0.0	5.0	15.41	22.75	52.34	54.11
Bending (15/11)	30.10	28.19	19.0	23.50	6.00	3.19	18.16	26.94	55.18	59.36
Girdling young* shoots (8/1)	16.61	15.50	14.17	18.67	0.0	4.33	15.81	23.35	53.68	56.33
Girdling old** shoots (8/1)	25.19	23.50	18.75	23.25	0.0	3.29	16.71	25.81	54.34	58.66
Girdling young shoots (15/3)	19.20	18.00	17.48	21.98	0.0	3.67	16.35	25.33	53.98	58.18
Girdling old shoots (15/3)	35.48	33.20	23.17	27.67	1.33	3.00	21.04	29.24	57.37	69.28
Girdling young shoots (15/4)	6.25	5.25	9.50	14.0	0.0	6.0	13.49	20.56	49.45	50.37
Girdling old shoots (15/4)	7.75	7.75	19.34	23.84	1.50	3.0	18.83	27.89	55.20	65.75
Control (young shoots)	6.25	5.25	8.00	13.50	0.0	5.24	13.00	18.34	47.98	48.67
Control (old shoots)	7.75	7.95	10.67	15.17	0.0	8.36	15.27	21.27	52.02	51.56
New L.S.D. at (0.05)	1.16	0.70	2.99	1.48	0.26	1.09	1.13	1.51	1.53	1.50

* young shoots = one-year-old shoots. * old shoots = bearing branches.

Table (3):Effect of bending and girdling treatments on certain fruit physical and chemical characters of "Anna" apple trees budded on Malus rootstock in 2002 and 2003 seasons.

Treatments	Fruit weight (gm)		Fruit volume (cm^3)		Fruit diameter (cm)		Fruit length (cm)		Fruit Firmness ($lb/Inch^2$)		TSS% %		Acidity %	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Bending (1/11)	170.64	173.98	215.30	225.14	7.00	7.02	6.97	7.47	8.67	8.47	12.00	12.83	0.50	0.39
Bending (15/11)	140.50	143.99	170.50	175.00	6.47	6.60	6.57	6.97	10.21	9.88	11.33	11.67	0.55	0.50
Girdling young* shoots (8/1)	137.00	140.25	150.15	162.50	6.38	6.42	6.40	6.85	11.67	10.20	11.00	10.20	0.60	0.51
Girdling old** shoots (8/1)	161.25	163.64	199.89	205.67	6.90	6.98	6.90	7.42	8.92	9.0	11.67	12.33	0.51	0.45
Girdling young shoots (15/3)	139.02	142.50	155.31	163.05	6.43	6.50	6.42	7.02	10.50	10.03	11.33	11.50	0.55	0.50
Girdling old shoots (15/3)	149.98	153.04	180.41	191.67	6.57	6.78	6.67	7.33	9.67	9.32	11.67	12.17	0.51	0.46
Girdling young shoots (15/4)	136.89	140.16	149.0	157.14	6.20	6.30	6.27	6.85	12.33	11.17	10.50	10.17	0.62	0.56
Girdling old shoots (15/4)	149.67	153.02	180.05	187.14	6.53	6.63	6.57	7.17	9.92	9.58	11.50	11.67	0.55	0.50
Control (young shoots)	112.33	115.43	128.33	138.08	5.98	5.98	6.13	6.80	12.59	13.38	9.93	9.50	0.67	0.62
Control (old shoots)	1.68	1.66	1.08	1.00	0.30	0.40	0.32	0.30	0.81	0.63	0.62	0.74	0.05	0.05

* young shoots = one-year-old shoots. * old shoots = bearing branches.

Table (4):Effect of bending and girdling treatments on certain fruit physical and chemical characters of "Anna" apple trees budded on M.M. 106 rootstock in 2002 and 2003 seasons.

Treatments	Fruit weight (gm)		Fruit volume (cm^3)		Fruit diameter (cm)		Fruit length (cm)		Fruit Firmness ($lb/Inch^2$)		TSS% %		Acidity %	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Bending (1/11)	135.32	138.57	150.55	154.11	6.47	6.28	6.60	6.40	10.67	12.17	10.17	10.17	0.56	0.58
Bending (15/11)	148.09	151.15	176.95	186.89	6.73	6.78	6.87	7.17	10.33	10.67	10.83	11.33	0.49	0.50
Girdling young* shoots (8/1)	137.35	140.83	152.67	160.33	6.53	6.43	6.73	6.57	10.58	11.37	10.33	10.50	0.56	0.58
Girdling old** shoots (8/1)	144.94	148.29	164.34	177.45	6.63	6.73	6.83	6.87	10.46	11.08	10.50	11.17	0.54	0.56
Girdling young shoots (15/3)	141.80	145.29	162.15	166.67	6.60	6.47	6.73	6.87	10.50	11.25	10.33	10.83	0.56	0.58
Girdling old shoots (15/3)	166.49	169.83	207.00	213.28	6.87	7.23	7.17	6.87	8.92	9.66	11.67	11.83	0.45	0.46
Girdling young shoots (15/4)	135.03	138.30	150.00	154.05	6.43	6.33	6.57	6.22	11.58	12.67	10.17	10.0	0.63	0.60
Girdling old shoots (15/4)	165.92	168.31	205.87	210.67	6.87	7.03	7.07	6.90	10.08	9.98	11.17	11.33	0.45	0.46
Control (young shoots)	110.22	113.31	125.66	133.43	6.00	6.03	6.23	6.10	12.79	13.79	9.33	9.67	0.67	0.65
Control (old shoots)	1.63	1.19	1.32	0.88	0.36	0.33	0.35	0.31	1.01	0.76	0.41	0.42	0.06	0.02

* young shoots = one-year-old shoots. * old shoots = bearing branches.

Since these values averaged 170.64 & 215.30 & 161.25 & 199.89 for the first season on both characters and 173.98 & 225.14; 163.64 & 205.67 in the second one, respectively. The data of both seasons were almost similar. Data of Anna apple trees budded on MM. 106 rootstock presented in Table (4) indicated that the all applied practices gave a higher fruit weight and volume than the control. A high significant increase in fruit weight and volume was found from bending on first and mid November and girdling of young and old shoots on January 8th . The highest significant increase in fruit weight and volume was found from girdling old shoots on mid march and April. Since these averages reached 166.49, 207.0; 165.92, 205.87 for the first season on both characters and 169.83, 213.28; 168.31, 210.67 for the second one, respectively. The data of both seasons were almost similar

Fruit diameter and length

Data of Anna apple trees budded on Malus rootstock as presented in Table (3) indicated that all the applied practices gave fruit diameter and length higher than the control. A high insignificant increase in fruit diameter and length was found from girdling old shoots on mid march and April and bending on mid November. The highest insignificant increase in fruit diameter and length was found from bending on first November and girdling old shoots on January 8th. They averaged the values 7.0, 6.97; 6.90, 6.9 for the first season on both characters and 7.02, 7.47; 6.98, 7.42 for the second one , respectively. The data of both seasons were almost similar.

Considering Anna apple trees budded on MM. 106 rootstock, data in Table (4) showed that all the applied practices gave fruit diameter and length higher than the control. A high insignificant increase in fruit diameter and length was found from bending on first and mid November and girdling on shoots and old shoots on January 8th. The highest insignificant increase in fruit diameter and length was found from girdling old shoots on mid march and April. Since these values reached 6.87, 7.17; 6.87, 7.07 for the first season on both characters and 7.23, 6.87; 7.03, 6.90 for the second one seasons, respectively. The data of both seasons were almost similar.

Fruit firmness

Data of Anna apple trees budded on Malus rootstock as presented in Table (3) indicated that the control gave fruit firmness higher than all the applied practices. A low insignificant averages of fruit firmness was found from girdling old shoots on mid march and April and bending on mid-November. The least insignificant averages of fruit firmness were found from bending on first November and girdling old shoots on January 8th. Since these averages reached 8.67, 8.92 for the first season and 8.47, 9.0 for the second one, respectively. The data of both seasons were almost similar.

Concerning Anna apple trees budded on MM. 106 rootstock, data as presented in Table (4) indicated that the control gave fruit firmness values higher than all the applied practices. An insignificant averages of fruit firmness were found from bending on first and mid-November and girdling of young and old shoots on January 8th . The lowest significant averages of fruit firmness were found from girdling old shoots on mid march and April. Since these averages reached 8.92, 10.08 for the first season and 9.66, 9.98

for the second one, respectively. The data of both seasons were almost similar.

The present results are in harmony with George, *et al.* (1996); Abd El-Rahman (2002); and Ahmed, *et al.* (2002) who found that bending significantly increased fruit weight, volume, diameter, length and decreased fruit firmness. Also, girdling affected on increasing fruit weight and size (volume and dimensions) and reducing fruit firmness as has been found in apple (Wilton, 2000); "Canino" apricot (Said, *et al.*, 2003) and certain peach cvs (De villiers, *et al.*, 1990; Allan, *et al.*, 1993 and 1995; August, *et al.* 1998; De Vaio, *et al.* 2001 and El-Beacy, 2001) and persimmon cvs (El-Shikh, *et al.*, 1999).

b. Chemical characters

Data in Table (3) indicated that all the applied practices gave total soluble solids in fruit juice of Anna apple trees budded on Malus rootstock higher than the control. Insignificant increase of T.S.S. % was found from girdling old shoots on mid-April and bending on mid-November. The highest insignificant increase was found from bending on first November and girdling old shoots on January 8th. Since these percentages reached 12.0, 11.67 for the first season and 12.83, 12.33 for the second one, respectively. The data of both seasons were almost similar.

Concerning T.S.S. % in fruit juice of Anna apple trees budded on MM. 106 rootstock, data in Table (4) indicated that all the applied practices gave higher values than the control. Insignificant increase was found from bending on first and mid-November and girdling of young and old shoots at January8th. The highest significant increase in values of T.S.S.% was found from girdling old shoots on mid-March and April. Since these percentages reached 11.67, 11.17 for the first season and 11.83, 11.33 for the second one, respectively. The data of both seasons were almost similar.

Data in Table (3) indicated that all the applied practices gave acidity in fruit juice of Anna apple trees budded on Malus rootstock lower than the control. A low insignificant decrease in juice acidity was found from girdling old shoots on mid-April and bending on mid-November. The lowest insignificant decrease was found from bending on first November and girdling old shoots on January 8th. Since these averages reached 0.50, 0.51 for the first season and 0.39, 0.45 for the second one, respectively. The data of the two seasons showed insignificant differences.

Concerning acidity in fruit juice of Anna apple trees budded on MM. 106 rootstock, data presented in Table (4) indicated that all the applied practices gave values of juice acidity lower than the control. A low significant decrease in juice acidity was found from bending on first and mid November and girdling of young and old shoots on January 8th. The lowest insignificant decrease in values of juice acidity was found from girdling old shoots on mid-March and April. Since these averages reached 0.45, 0.45 for the first season and 0.46, 0.46 for the second one in the two seasons, respectively. The data of both seasons took the same trend.

The present results are in harmony with Marini, *et al.* (1991) and George, *et al.* (1996) who mentioned that sunlight distribution influences soluble solids content depending on the seasonal trend of sunlight availability.Abd El-Rahman (2002) reported that bending shoots increased total soluble solid content of "LeConte" pear fruit, while it decreased acidity. Also, Arakawa, *et al.* (1997) mentioned that the apple fruits had significantly higher T.S.S. concentration by girdling treatment. Said, *et al.* (2003) found that secondary branch girdling increased TSS% content in fruits however, decreased titratable acidity of "Canino" apricot.

Chemical Analysis

a. Total carbohydrates:

Total carbohydrates content were determined in leaves of apple trees budded on Malus rootstocks in the two seasons of study. The concerned data are presented in Table (5).The data indicated that all treatments gave high values of total carbohydrate in the 1st and 2nd seasons compared with control.The same table showed that the high increasing in total carbohydrates % was obtained from bending old shoots on mid-November, girdling of young shoots on mid-March.Furthermore, girdling old shoots on mid-March and mid-April gave a high and significant increase in this respect.The highest significant increase was obtained from bending young shoots on first November and girdling old shoots on January 8^{th}, since they tabulated values 31.488, 30.386 for the first treatment and 30.058, 30.005 for the second one in the both seasons, respectively.The data in the two seasons showed no great differences.These results confirm those obtained by Abd El-Rahamn (2002) who reported that winter bending significantly increased carbohydrate content of pear leaves on current shoots and spurs.

Considering total carbohydrates % content in leaves of apple trees budded on MM 106 rootstock in the two seasons as presented in Table (6), it is cleared nearly all treatments gave high values of total carbohydrates in the 1st and 2nd seasons compared with the control. Data in Table (6) showed that the high increasing in total carbohydrates was obtained from girdling young shoots on mid-March, January 8^{th} and bending on first of November. Furthermore, bending on old shoots on mid-November and girdling old shoots on January 8th gave higher and significant increase in this respect.The highest significant increase was obtained from girdling old shoots on mid-March and mid-April, since they reached the values 22.194, 24.194 for the first treatment and 21.467, 23.467 for the second one in the both seasons, respectively. The data in the two seasons showed no great differences. In this respect, Allan, *et al.* (1993) reported that starch level increased in leaves and shoots of girdled "Florda Prince" peach trees. Starch accumulation increased in leaves and shoots of girdled peach trees (Jordan, *et al.*, 2001). Also El-Shikh, *et al.* (1999) mentioned that total carbohydrates content increased in leaves and shoots of girdled "Costata" persimmon. 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.

b. Total Nitrogen

Total nitrogen content in leaves of apple trees budded on Malus rootstock are presented in Table (5). It is clear that total N content decreased by all treatments compared to the control. Data in Table (5) showed that the low decreasing in total nitrogen were obtained from bending on old shoots on mid-November and girdling of young shoots on mid-March. Furthermore, girdling old shoots on mid-March and mid-April gave lower and significant decrease in this respect.

The lowest significant decrease was obtained from bending young shoots on first November and girdling old shoots on January 8th, since they reached the values 2.28, 1.22 and for the first season 2.29, 1.63 for the second one, respectively. The data in the two seasons showed no great differences. In this respect, Terekhova (1976) noted that a marked reduction in total (N) content was detected in bent shoots. Also, Kilany (1982) mentioned that nitrogen content markedly decreased in all plant tissues during the period of active growth up to May or early June.

Considering total nitrogen contents in leaves of apple trees budded on MM. 106 rootstock during the two seasons as presented in Table (6). It was cleared that total nitrogen contents in the treated shoots decrease than the control. Data in Table (6) showed that the low decreasing in total nitrogen was obtained from girdling young shoots on mid-March, January 8th and bending on first November. Furthermore, bending on mid-November and girdling old shoots on January 8th gave lower and significant decrease in this respect.

The lowest significant decrease was obtained from girdling old shoots on mid-March and April, since these values reached 1.82, 2.0 of the first treatment and 2.36, 2.40 for the second one in the both seasons, respectively. The data in the two seasons showed no great differences. These results are in harmony with those reported by Jordan, *et al.* (1998) who indicated that girdling of "Suncrest" peach affected the distribution of absorbed N within the main plant parts, as it was allocated to the organs which continued to be well provided with current photosynthesis, mostly the trunk and shoots. Also, Said, *et al.* (2003) indicated that girdling treatments decreased "Canino" leaves N content.

c. C/N Ratio

C/N ratio for leaves of apple trees budded on Malus rootstock during the two seasons were presented in Table (5). It was cleared that C/N ratio was increased in all treatments than the control. Data in Table (5) showed also that the high increasing in C/N ratio was obtained from bending old shoots on mid-November and girdling young shoots on mid-March. Furthermore, girdling old shoots on mid-March and mid-April gave higher and significant increase in this respect. The highest significant increase was obtained from bending young shoots on first November and girdling old shoots on January 8th, since they averaged the values 13.81, 24.91 for the first treatment and 13.13, 18.41 for the second one in both seasons, respectively. The data of both seasons were almost similar.

Concerning C/N ratio for leaves of apple trees budded on MM 106 rootstocks during the two seasons were presented in Table (6). It was cleared that C/N ratio was increased by all treatment than the control.

Table (5): Effect of bending and girdling treatments on leaf total carbohydrates %, nitrogen, C/N ratio, ABA and IAA of "Anna" apple trees budded on Malus rootstock in 2002 and 2003 seasons.

Treatments	Total carbohydrates %		Nitrogen %		C/N ratio		ABA (mg/100g)		IAA (mg/100g)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Bending (1/11)	31.488	30.386	2.28	1.22	13.81	24.91	13.712	14.475	3.372	4.077
Bending (15/11)	27.956	29.381	2.61	2.37	10.71	12.40	7.897	8.064	1.532	1.867
Girdling young* shoots (8/1)	24.046	23.308	2.86	3.10	8.41	7.52	2.746	4.972	0.732	1.331
Girdling old** shoots (8/1)	30.058	30.005	2.29	1.63	13.13	18.41	13.121	13.861	3.132	3.611
Girdling young shoots (15/3)	27.622	26.602	2.70	2.45	10.23	10.86	4.985	7.737	1.344	1.372
Girdling old shoots (15/3)	28.778	29.726	2.37	1.88	12.14	15.81	8.398	13.405	2.192	3.416
Girdling young shoots (15/4)	19.776	19.949	3.24	4.04	6.10	4.94	1.601	2.786	0.386	0.772
Girdling old shoots (15/4)	28.386	29.424	2.45	2.04	11.59	14.42	7.968	10.221	1.603	2.576
Control (young shoots)	18.346	18.837	3.26	4.45	5.63	4.23	1.117	1.320	0.263	0.538
Control (old shoots)	26.633	25.873	2.70	3.03	9.86	8.54	3.338	4.985	1.148	1.364
New L.S.D. at (0.05)	0.001	0.001	0.01	0.01	0.04	0.08	0.001	0.001	0.001	0.001

* young shoots = one-year-old shoots. ** old shoots = bearing branches.

Table (6): Effect of bending and girdling treatments on leaf total carbohydrates %, nitrogen, C/N ratio, ABA and IAA of "Anna" apple trees budded on M.M. 106 rootstock in 2002 and 2003 seasons.

Treatments	Total carbohydrates %		Nitrogen %		C/N ratio		ABA (mg/100g)		IAA (mg/100g)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Bending (1/11)	19.361	20.084	2.69	2.73	7.20	7.36	2.836	5.249	0.785	0.962
Bending (15/11)	20.545	22.545	2.37	2.41	8.67	9.35	7.742	8.125	1.661	1.928
Girdling young* shoots (8/1)	19.602	21.361	2.54	2.61	7.72	8.18	4.231	6.124	1.017	1.312
Girdling old** shoots (8/1)	20.229	22.229	2.37	2.42	8.54	9.19	6.204	8.052	1.392	1.855
Girdling young shoots (15/3)	20.084	21.602	2.53	2.58	7.94	8.37	5.353	7.675	1.066	1.610
Girdling old shoots (15/3)	22.194	24.194	1.82	2.00	12.19	12.12	8.003	13.797	1.806	3.588
Girdling young shoots (15/4)	14.343	16.343	4.56	4.62	3.15	3.54	2.012	4.531	0.717	0.658
Girdling old shoots (15/4)	21.467	23.467	2.36	2.40	9.10	9.78	7.742	8.465	1.677	2.268
Control (young shoots)	13.421	16.188	4.58	4.70	2.93	3.44	1.986	4.127	0.676	0.645
Control (old shoots)	14.742	16.743	3.44	3.50	4.29	4.78	2.396	4.968	0.744	0.687
New L.S.D. at (0.05)	0.001	0.001	0.01	0.03	0.03	0.18	0.001	0.001	0.001	0.001

* young shoots = one-year-old shoots ** old shoots = bearing branches.

Data in Table (6) showed that the high increasing in C/N ratio were obtained from girdling young shoots on mid-March, January 8[th] and bending on first November, furthermore, bending on mid-November and girdling old shoots on January 8th gave higher and significant increase in this respect.

The highest significant increase was obtained from girdling old shoots on mid-March and mid-April. Since they recorded the 12.19, 12.12 for the first treatment and 9.10, 9.78 for the second one in both seasons, respectively. The data of both seasons were almost similar.

d. Endogenous hormones (ABA and IAA)

Data in Table (5) indicated that the endogenous auxins (ABA and IAA) in leaves of apple trees budded on Malus rootstock in the 1st and 2nd seasons were increased after practices application. All applied treatments gave an increase of endogenous auxins (ABA and IAA) higher than the control in the two seasons, The data also showed higher content of endogenous auxin from bending on mid-November, girdling old shoots on mid-March and mid-April. The lowest content of endogenous auxin was obtained from girdling young shoots on mid-April, January 8[th] and mid-March in both seasons. The highest significant increase in endogenous auxins was obtained from bending on first November and girdling old shoots on January 8th as compared with control, this amount of ABA reached 13.712, 14.475 for the first treatment and 13.121, 13.861 for the second one the two seasons, respectively. As for IAA the corresponding values were 3.372, 4.077 and 3.132 , 3.611.

Data in Table (6) indicated that the endogenous auxins (ABA and IAA) in leaves of apple trees budded on MM. 106 rootstock in the 1st and 2nd seasons were increased after practices application. All applied treatments gave high increase of endogenous auxin (ABA and IAA) than the control in the two seasons. The data also showed higher content of endogenous auxin from girdling old shoots on January 8th and girdling young shoots on mid-March. The lowest content of endogenous auxin was obtained from girdling young shcots on mid-April and bending on first November in both seasons. The highest significant increase in endogenous auxins was obtained from girdling old shoots on mid-March, mid-April and bending on mid-November as compared with control. These amounts of ABA were 8.003, 13.797; 7.742, 8.465; and 7.742, 8.125 for the 3 treatments. As for IAA the corresponding values were 1.806, 3.588; 1.677, 2.268 and 1.661, 1.928 in the two seasons, respectively.

The results were more or less agreed with those obtained by Joann and Kannedy (1985) who indicated that hormone induced increases in photosynthetic rates, especially during the flowering period suggesting a possible role for hormones. Banno, *et al.* (1986)found that bending led to a decrease in IAA content in the shoot tips and increase of this substances in the axillary buds. Fayek, *et al.* (2004) revealed that tetra combined treatment (tipping + bending ± girdling +PP333) increased ABA and IAA in flowering spurs compared with that in buds of control treatment. On the other hand, the amount of diffusible indolle-3-acetic (IAA) in shoots of Japanese pear decreased when the vertical shoots were bent at an angle of 45° and IAA transport inhibited is known to increase flower bud formation in Kosui cv. (Ito, *et al.*, 2001).

Chemical analysis for treatments (bending on first November of shoots apple budded on Malus rootstock and girdling on mid-March of old shoots from the same trees onto MM. 106 rootstock) revealed that higher contents of total carbohydrates %, C/N ratio, abscisic acid and indole acetic acid , besides low total nitrogen may be favour of spurs' formation.

Conclusion

Generally, results showed that bending on first November of apple shoots budded on Malus rootstock and girdling old shoots on mid-March of Anna apple trees budded on M.M. 106 rootstock treatments could be recommended as they increased fruit set %, spurs number, leaf area, dry matter and improved fruit quality.

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تأثير الثنى والتحليق على نمو وإثمار أشجار من تفاح "الأنا" طعمت على أصلين من أصول التفاح

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أجرى هذا البحث خلال موسمي (٢٠٠١-٢٠٠٢ و ٢٠٠٢-٢٠٠٣) على أشجار "أنا" مطعومة على أصلين من أصول التفاح (مالص ، م.م. ١٠٦) عمرها سنتان بمزرعة فى منطقة الخطاطبة بمحافظة المنوفية بهدف دراسة تأثير معاملات الثنى والتحليق على نسبة العقد، عدد الدوابر المتكونة، عدد الأفرع، المساحة الورقية، نسبة المادة الجافة والصفات الثمرية. علاوة على ذلك تم دراسة تأثير المعاملات على محتوى الأوراق الداخلى من الكربوهيدرات الكلية ، والنيتروجين، نسبة الكربوهيدرات إلى النيتروجين والمستوى الداخلى لبعض للهرمونات (ABA , IAA).

أظهرت النتائج أن جميع معاملات الثنى والتحليق فيما عدا تحليق الأفرع فى منتصف أبريل أعطت زيادة معنوية فى نسبة العقد، عدد الدوابر، مساحة الورقة، نسبة المادة الجافة، وزن وحجم الثمار كذلك عرض وطول الثمرة ونسبة المواد الصلبة الذائبة والكربوهيدرات الكلية ونسبة الكربوهيدرات إلى النيتروجين ، IAA، ABA ، كما أدت إلى انخفاض الحموضة وقلة الصلابة وانخفاض النيتروجين فى الأوراق مقارنة بالكنترول فى كلا الموسمين.

أوضحت النتائج أيضا أن إجراء ثنى الأفرع فى أول نوفمبر للأشجار المختبرة المطعومة على أصل المالص كذلك تحليق الأفرع القديمة "عمر سنتين" فى منتصف شهر مارس لمثيلاتها المطعومة على أصل م.م. ١٠٦ ، أعطت أعلى زيادة معنوية لنسبة العقد، عدد الدوابر، مساحة الورقة ونسبة المادة الجافة ، كما أدت أيضاً إلى زيادة وزن وحجم الثمار كذلك طول وعرض الثمرة، وزيادة المواد الصلبة الذائبة، ولكن قللت من صلابتها وحموضتها، كما أدت إلى زيادة نسبة الكربوهيدرات الكلية ونسبة C/N وانخفاض نسبة النيتروجين فى الأوراق وزيادة مستوى الهرمونات المقدرة (IAA, ABA) فى كلا الموسمين.

أوضح التحليل الكيمائي للمعاملات أن معاملة الثني فى أول نوفمبر لأفرع الأشجار المطعومة على أصل مالص ومعاملة التحليق للأفرع القديمة فى منتصف مارس الأشجار المطعومة على م.م. ١٠٦، أعطت أعلى محتوى فى الأوراق من الكربوهيدرات الكلية ونسبة الكربوهيدرات للنيتروجين ، حمض الأبسيسك وإندول حمض الخليك بالإضافة إلى نقص النيتروجين وهذا أدى إلى زيادة تكوين الدوابر.

ولذا يوصى بإجراء الثني لأفرع تفاح "الأنا" المطعوم على أصل مالص فى أول نوفمبر وإجراء التحليق فى منتصف مارس للأفرع القديمة لأشجار "الأنا" المطعومة على م.م. ١٠٦ بغرض زيادة عدد الدوابر وعقد الثمار وتحسين جودة الثمار.