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Productivity of Manzanillo olive cultivar as affected by girdling times

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Abstract: This study was conducted during two successive seasons 2009 and 2010 on ten years old "Manzanillo" olive trees, planted at 5 X 5 m and grown in sandy soil in a private orchard at Cairo–Alexandria desert road (about 50 Km from Cairo), Egypt. The present investigation aimed to study the effect of girdling times on flowering , fruit set, fruit quality , and oil content and yield of Manzanillo olive trees .Percentages of perfect flowers, initial fruit set significantly increased due to girdling treatments. The highest percentages were final obtained in girdling at February treatment during both seasons, whereas the lowest values were obtained from the control in both seasons of study. Fruit weight, size, length**,** diameter and pulp/seed ratio were increased significantly as a result of girdling treatments compared with the control. The highest values were obtained from girdling at April in both seasons of the study compared to the control trees. There were no significant differences between February, August and control girdling treatments in fruit moisture content but girdling at April gave the highest fruit moisture content during both seasons. Fruit oil content was influenced significantly as a result of girdling treatments. The highest values were observed as a result of girdling at August in both seasons of the study, whereas the lowest oil content resulted from the control during both seasons. During the two seasons of the study yield was influenced significantly as a result of girdling treatments compared with the control. Girdling at April resulted in the highest yield compared to the lowest yield produced from the control.
Key words: Girdling - flowering - fruit set- oil content and yield.

Introduction

There are many processes beyond photosynthesis which play determining roles in crop productivity, such as the way in which the plant uses and distributes photosynthetic assimilated between storage and consumption in new growth of its various organs. Girdling consists of removal of a strip of bark from the trunk or major limbs of a fruit tree, thereby blocking the downward translocation of photosynthetic and metabolites through the phloem. The best-known effects of girdling are presumably brought about by accumulation of assimilates above the girdled[1]. Girdling has been used as a usual cultural practice to promote flowering, improving fruit setting, and yield as well as physical and chemical properties of fruits in various olive cvs. because it increases the accumulation of carbohydrates and natural hormones in the parts above wounds[2, 3, 4] and enhanced flowering, percentage of perfect flowers[5], yield[6] and fruit growth[7].

The present investigation aimed to study the effect of girdling times on flowering, fruit set, fruit quality, oil content and yield of Manzanillo olive trees.

Materials and Methods

This study was conducted during two successive seasons 2009 and 2010 on ten years old "Manzanillo" olive trees, planted at 5 X 5 m and grown in sandy soil in a private orchard at Cairo–Alexandria desert road (about 50 Km from Cairo), Egypt. This experiment was designed to study the effect of girdling on flowering, yield, fruit characteristics and oil content. The experiment includes four treatments were applied in both seasons 2009 and 2010 as follows:

1. Girdling main branches in February.
2. Girdling main branches in April.
3. Girdling main branches in August.
4. Control without girdling.

Girdling treatments were applied by removing a narrow ring of the bark (10 mm) about 25 cm. from base of branching zone. The effect of the previous treatments studied by evaluating their influence on the following parameters:-

Flowering characteristics

Flowering density (average number of inflorescences/m):

On each replicate tree twenty shoots distributed on different sides were chosen randomly and tagged at the beginning of the growing season. All inflorescences on each shoot were counted and recorded to estimate as average number of inflorescences per meter.

Average number of perfect flowers:

Percentage of perfect flowers (expressed as percentage of perfect flowers to total number of flowers). One hundred inflorescences were collected randomly from each replicate tree to estimate average number of perfect flowers/inflorescences.

Initial fruit set:

Three weeks after flowering initial fruit set percentage on replicate trees of the studied treatments was calculated from the following equation: Initial fruit set (%) = FR X 100/AVF X ANF

FR = Number of fruit per meter
AVF = Average number of perfect flowers/ inflorescences
ANF = Average number of inflorescences per meter

Final fruit set:

After sixty days from flowering, final fruit set percentage was calculated in the same sequence mentioned above for the initial fruit set percentage.

Yield:

At maturity stage (early October), fruits of each replicate tree were separately harvested, then weighted and yield as Kg/tree was estimated.

Fruit characteristics and oil content percentage:

Samples of 20 fruits from each replicate tree *i.e.* 60 fruits from each of the applied treatments were picked randomly at harvest to determine:

1. Average fruit weight (g).
2. Average fruit size (cm^3).
3. Average fruit length (cm).

4. Average fruit diameter (cm).
5. Fruit shape index (L/D ratio).
6. Percentage of pulp/seed.
7. Fruit moisture percentage**:** For each replicate a proportional sample of fruit was dried at 60ºC in electric air dried oven until constant weight is obtained, then fruit moisture content was calculated.
8. Fruit oil content as a dry weight was determined according to [8] methods by extraction the oil from the dried flesh fruit with soxthelt for extraction apparatus using petroleum ether (40/60 ºC) of boiling point.

Statistical analysis:

Experiments of the present study followed randomized block design. All obtained data during both 2009 and 2010 experimental seasons were subjected to analysis of variances using (SAS/STAT). Least significant difference (L.S.D) was used to compare between means of treatments according to [9] at probability of 5%.

Results and Discussion

Effect of girdling on flowering characteristics:

The effect of girdling at various times on flowering of Manzanillo leaves during 2009 and 2010 seasons are illustrated in (Table 1).

Flowering density:

During both seasons of the study there was no significant difference between April, August and control treatments in flowering density but girdling during February gave the highest significant flowering density (19.41 and 22.33%) in 2009 and 2010 seasons respectively.

Percentage of perfect flowers:

Percentage of perfect flowers was significantly increased due to girdling treatments. The highest percentage of perfect flowers was obtained in girdling during February treatment (84.66 and 92.33%) during 2009 and 2010 seasons respectively, whereas the lowest percentage of perfect flowers in both seasons was obtained in the ungirdling trees (59.00 and 66.00%) during 2009 and 2010 seasons respectively

Percentage of initial fruit set:

It is evident through results in Table (1) that percentage of initial fruit set was significantly increased as a result of girdling treatments. The highest percentage of initial fruit set was obtained from girdling during February (11.94 and 15.09%) during 2009 and 2010 seasons respectively. Whereas the lowest percentage of initial fruit set in both seasons was obtained in the control (7.14 and 6.64%) during 2009 and 2010 seasons respectively.

Percentage of final fruit set:

It is obvious from Table 1 that percentage of final fruit set was influenced significantly as a result of girdling treatments compared with the control during both seasons of the study. The highest percentages of final fruit set were obtained in girdling during February (6.26 and 10.55%) during 2009 and 2010 seasons respectively, whereas the lowest percentages of final fruit set were obtained in the control (3.89 and 1.59%) during 2009 and 2010 seasons respectively.

These results agree with those obtained by[4,6,10,11] on olive, who found that girdling increased the number of panicles/shoot, number of flowers/panicle and the number of fruits set/panicle [7]found that the abundant availability of assimilates induced by girdling, stimulated flower induction. Lavee *et al.* [12] also found that girdling increased both inflorescence formation and fruit set when done in midwinter (December-February) and to a lesser extent in April. Brown *et al.*[13] found that girdling prior to fruit set improved final fruit set. Schechter and Proctor [14]suggested that the positive effect of girdling has been related to changes in translocation and

accumulation of carbohydrates, with changes in hormones concentration gibberellins, IAA and cytokinines[15]. All these effects may lead to promote flowering and improve fruit set.

Table 1. Effect of girdling on flowering characteristics during 2009 and 2010 seasons.

Girdling time	Flowering density (number of inflorescences/m)		Perfect flowers (%)		Initial fruit set (%)		Final fruit set (%)	
	2009	2010	2009	2010	2009	2010	2009	2010
February	19.41a	22.33a	84.66a	92.33a	11.94a	15.09a	6.26a	10.55a
April	14.63b	14.66b	77.33b	92.33a	9.40ab	10.62b	4.67ab	5.80b
August	12.56b	13.33b	70.66b	75.00b	7.22b	7.25bc	4.29ab	2.27c
Control	11.96b	11.33b	59.00c	66.00c	7.14b	6.64c	3.89b	1.59c

Means in each column with similar letters are not significantly different at 5% level.

Effect of girdling on yield:

Table (2) clears that effect of girding on yield (kg/tree) is considered a reflection of the studied treatments on fruit productivity of the examined trees. During the two seasons of the study girdling during February resulted in the highest and significant yield and it averaged (24.00kg/tree) comparing with the lowest yield produced from the control (9.84 kg/tree).

The achieved results of girdling in this respect are in harmony with reports of [12] on Manzanillo olive, who reported that girdling increased the yield when done in midwinter (December-February) and to a lesser extent in April, [6] on Gemlik olive, [16] and [17] on Le Conte pear found that girdling significantly increased yield comparing with the control.

Reynolds *et al*. [18] suggested that girdling at the correct time resulted in a 40% increase in reproductive buds. The increase in yield was due to 50% more fruits on the girdled trees than on the control trees. The increase in fruit number/ tree was due to a higher percentage of reproductive buds/ tree and the improved quality of these buds. Girdling disrupts basipetal transport in the phloem, which results in the removal of apical dominance and an increase in root-derived cytokinins. More meristems can respond to inductive conditions and the higher concentration of cytokinins during inductive conditions leads to improve flower quality. Thus girdling has often been used to manipulate flower initiation, fruit set, development yield and quality [19].

Effect of girdling on fruit characteristics and oil content:

Almost all effects of girdling treatments significantly improved fruit characteristics of Manzanillo olive fruits compared to those of the control. However there were significant differences in the enhancement effects of the treatments (Table 2).

Fruit weight:

During both seasons highest fruit weight (5.60 and 5.70g) resulted from girdling during April. Meanwhile the lowest average fruit weight was produced from control (3.33 and 3.43g) in 2009 and 2010 seasons respectively.

Fruit size:

Highest significant fruit size (5.13 and 5.16cm^3) in 2009 and 2010 seasons respectively. The highest values were observed as a result girdling during April in both seasons of study. Whereas the lowest fruit size resulted from the control (4.03 and 4.26cm^3) during 2009 and 2010 seasons respectively.

Fruit length:

In both seasons of the study, highest fruit length (2.63 and 2.80cm) in 2009 and 2010 seasons respectively were observed as a result of girdling during April in both seasons of the study. Whereas the lowest fruit length was resulted from the control (2.06 and 2.16cm) during 2009 and 2010 seasons respectively.

Table 2. Effect of girdling on yield and some fruit characteristics of Manzanillo olive trees during 2009 and 2010 seasons.

Girdling time	Yield(Kg/ tree)			Fruit weight(g)		Fruit size(cm^3)		Fruit length(cm)	
	2009	2010	Mean	2009	2010	2009	2010	2009	2010
February	14.33ab	16.66b	15.50b	4.50b	4.59b	4.76b	4.88ab	2.43a	2.50b
April	25.00a	23.00a	24.00a	5.60a	5.70a	5.13a	5.16a	2.63a	2.80a
August	10.10b	11.03bc	10.57bc	4.25bc	4.30bc	4.26c	4.63cb	2.20b	2.26bc
Control	9.35b	10.33bc	9.84bc	3.33c	3.43c	4.03c	4.26c	2.06b	2.16c

Means in each column with similar letters are not significantly different at 5% level.

Fruit diameter:

Highest and significant fruit diameter (1.96 and 2.00cm) in both seasons respectively. The highest values were observed as a result of girdling during April in both seasons of the study. Whereas the lowest fruit diameter resulted from the control (1.63 and 1.56cm) during 2009 and 2010 seasons respectively (Table 3).

Fruit shape:

Fruit shape involves fruit length, diameter and fruit shape index (L/D ratio was not significantly affected at different treatments of girdling in both seasons of the study.

Pulp/seed ratio:

In both seasons of the study girdling during April resulted in the highest and significant pulp/seed ratio (88.66%) during 2009 and 2010 seasons respectively. However the lowest pulp/seed ratio (82.90 and 71.18%) in control trees in the two seasons of the study (Table 3).

Fruit moisture content:

Concerning fruit moisture content during both seasons of the study, there were no significant differences between girdling during February, August and control but girdling during April gave the highest fruit moisture content (68.06 and 75.00%) in 2009 and 2010 seasons respectively (Table 3).

Fruit oil content:

It is obvious from Table (3) that oil content was influenced significantly as a result of girdling treatments. The highest values were observed as a result of girdling during August (19.99 and 19.92%) in both seasons of the study respectively. Whereas the lowest oil content resulted from the control (15.71 and 16.08%) during 2009 and 2010 seasons respectively.

These results are in agreement with those of [20] who reported that girdling Manzanillo olive trees at 30 days before full bloom increased individual fruit weight from 3.9 to 4.7g compared with controls. Girdling is considered an important practice responsible for improving fruit setting, yield as well as physical and chemical properties of fruits in various olive cvs. through accumulation of organic foods and natural hormones above rings [3]. Proietti *et al.* [21] found that girdling able to increase the availability of assimilates and increase the amount of pulp and oil accumulation in the fruits. Treatments made after the beginning of August were more effective, influencing the phases of fruit development in which the mesocarp exhibits the most intense growth. Also, Proietti [11] found that girdling at the beginning of August and September, compared to the control, increased the pulp dry mass and the percentage of oil in the fruit, on a dry mass basis. The large availability of assimilates seems to cause an earlier fruit ripening. Earlier study by [22, 23, 24] showed that the time of girdling has an effect on fruit size

and ripening also, they found that girdling advanced harvest (3-10 days), increased fruit size (10-25 %) and yield (10-15 Kg/tree). Moreover, girdling may enhance ethylene production[25] and results in a promotion of ripening [26]. Proietti *et al.* [7] also found that fruit growth was significantly increased with girdling and [4] found that girdling Manzanillo branches at one week before full bloom significantly improved mean fruit weight, pulp weight percentage and oil percentage in the pulp compared to control treatment.

Girdling at the correct time is very important, girdling prior to fruit set improves the berry set [13] and girdling after fruit set resulted in positive effect on berry size and girdling at the beginning of the ripening phase enhances skin color and berry ripening [27]. The immediate effect of a complete girdle is to interrupt the movement through the phloem of photosynthetic assimilates produced by leaves. This increases foliar carbohydrates (sugars and starch) and plant hormones in parts above the girdled position at the expense of the trunk and root system [28].

Table 3. Effect of girdling on some fruit characteristics, fruit moisture and oil content of Manzanillo olive trees during 2009 and 2010 seasons.

Girdling time	Fruit diameter(cm)		Fruit shape L/D		Pulp/seed ratio		Fruit moisture content		Oil content (%)	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
February	1.83b	1.86b	1.32a	1.38a	86.26a	84.74a	62.00b	62.66b	15.96bc	16.84b
April	1.96a	2.00a	1.34a	1.40a	88.66a	88.66a	68.06a	75.00a	17.72b	19.00ab
August	1.70c	1.63c	1.29a	1.38a	85.83ab	79.16b	60.72b	55.33b	19.99a	19.92a
Control	1.63c	1.56c	1.26a	1.33a	82.90b	71.18c	60.35b	52.33b	15.71c	16.08c

Means in each column with similar letters are not significantly different at 5% level.

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