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Preliminary results of types of girdling at different period in olive trees

Resultados preliminares de tipos de anelamento em diferentes épocas em plantas de oliveira

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ABSTRACT

Girdling consists of elimination of a small part of the cortex around a pre-selected branch, this technique being successfully applied in fruit trees. The aim of this study was to assess the effect of girdling period and types on branches of olive cultivars on their vegetative development and fructification. The study was conducted at the Epamig Experimental Farm, located in the municipality of Maria da Fé, MG, Brazil. Activities began in March 2012, with use of 7-year-old plants of the Ascolano 315, Grappolo 541 and Maria da Fé cultivars. Three periods were assessed (March, April and May/12) and two types of girdling (10 and 15 mm), plus the control (without girdling). A randomized block experimental design was used with a split plot, three replications and one plant per plot. After girdling, the branches of the plants were assessed, with mean branch length (m), branch diameter near the girdle (mm), diameter of the branch base (mm) and fruit harvest (kg) as variables. It was concluded that the girdling technique did not affect the length and diameter of the branches of the three cultivars. Superior results were found in olive tree branches girdling in March and May. The fruits collected were positively affected by girdling of the branches.

KEYWORDS: *Olea europaea*, cultivars, management technique.

RESUMO

O anelamento consiste na eliminação de uma pequena porção de córtex ao redor de um ramo pré-selecionado, sendo esta técnica empregada com sucesso em frutíferas. O trabalho teve por objetivo avaliar a influência de épocas e tipos de anelamento em ramos de cultivares de oliveira no desenvolvimento vegetativo e na frutificação. O estudo foi conduzido na Fazenda Experimental da Epamig localizada no município de Maria da Fé, MG. As atividades iniciaram-se em março de 2012, sendo utilizadas plantas de 7 anos de idade das cultivares Ascolano 315, Grappolo 541 e Maria da Fé. Foram avaliadas três épocas (março, abril e maio/12) e dois tipos de anelamento (10 e 15 mm) mais testemunha (sem anelamento). O delineamento experimental utilizado foi blocos ao acaso com parcelas subdivididas, com três repetições e uma planta por parcela. Após o anelamento, os ramos das plantas foram avaliados, tomando-se como variáveis o comprimento médio dos ramos (m), diâmetro do ramo próximo ao anelamento (mm), diâmetro da base do ramo (mm) e colheita dos frutos (kg). Concluiu-se que a técnica de anelamento não influenciou no comprimento e diâmetro de ramos das três cultivares. Resultados superiores foram encontrados em ramos de oliveira anelados em março e maio. Os frutos colhidos foram influenciados positivamente pelo anelamento dos ramos.

PALAVRAS-CHAVE: *Olea europaea*, cultivares, técnica de manejo.

INTRODUCTION

The olive tree (*Olea europaea* L., Oleaceae) began to be cultivated around four thousand B.C. near the Dead Sea, a region that includes Syria, Lebanon and Israel, expanding to the West through the

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Mediterranean Basin. It is currently grown in nearly all continents; nevertheless, its commercial production is concentrated in countries of the European Union, and this region is the world's largest producer (VILLA & OLIVEIRA 2012).

The growing of olive trees in Brazil for commercial purposes is a recent agricultural activity and is expanding. Based on the volume of olives imported in 2010, 214 thousand tons (BRASIL 2015), a potential seedling market of approximately 11 million units is estimated, requiring technical information from research for its production, for example, the propagation type and the alternate bearing (VIEIRA NETO et al. 2011).

The alternate bearing appears in all olive tree cultivars, including those for table olives and for olive oil. This fact generates important problems for the grower, as well as for processing industries, especially in regard to table olives (AL-SHDIEFAT & QRUNFLEH 2008, BARONE et al. 2014), because in strong harvest years, the commercial caliber of the fruits decreases drastically, with notable depreciation of the product (MOREIRA et al. 2016).

Among the studies performed to obtain greater control over fructification, which leads to more homogeneous annual production, girdling of trunks and branches of fruit bearing species stands out (JASROTIA et al. 2013). This technique consists of elimination of a small portion of the cortex around the trunk or branch of the tree so as to interrupt transport of assimilates by the phloem, thus allowing the exchange of water and mineral nutrients through the xylem (SARTORI & ILHA 2005). According to the same author, through this technique, the carbohydrates produced in the leaves accumulate in the parts above the girdled region, directly influencing the development of inflorescence and fructification. The stage in which girdling is performed is probably the single main factor in determining the nature and magnitude of the effect obtained.

Studies in other fruit bearing plants prove that this practice, among other things, increases the size of peach and nectarine fruit (SARTORI & ILHA 2005) and leads to earlier maturation of fine table grapes and American varieties (ROBERTO et al. 2002, CATO et al. 2005). In olive trees, studies show superior results with an increase of 50 per cent in flowering in low harvest years (off years) (LEVIN & LAVEE 2005) and a significant effect on production with successive girdlings (EL KHAWAGA 2007, AHMAD et al. 2009).

In light of the above, the aim of this paper was to study the period and types of girdling in olive trees for the purpose of generating future information regarding flowering and fructification.

MATERIAL AD METHODS

The study was conducted beginning in March/2012 to May/2012 at the Epamig Experimental Farm (FEMF), located in the municipality of Maria da Fé, a micro-region of the Serra da Mantiqueira (Mantiqueira Mountains) in the south of Minas Gerais.

The municipality of Maria da Fé has a Cwb climate in the Köppen classification; i.e., a rainy temperate climate (mesothermal), also known as subtropical highland. It is characterized as having a mean annual temperature of around 17 °C, a mean maximum temperature of 23.3 °C and a mean minimum temperature of 10.1 °C, annual rainfall of 1,738.6 mm and mean altitude of 1,276 m, with predominance of rolling hills (ALMG 2015).

The experiment was conducted in 7-year-old plants grown at the Maria da Fé Experimental Farm, in an area previously amended, according to fertility analysis, for pH of around 6.0, using dolomitic limestone (PRNT 100%). Three olive cultivars (Grappolo 541, Ascolano 315 and Maria da Fé) were assessed in this area at three girdling periods (March, April and May) and two types of girdling (10 and 15 mm) plus the control (without girdling). A randomized block experimental design with split plots was used, with three replications. The experimental plots consisted of one plant of each cultivar.

The Grappolo 541 and Maria da Fé cultivars were obtained from cuttings, and the Ascolano 315 cultivar from grafting (VIEIRA NETO et al. 2011). Girdlings were performed with a pocketknife in pre-determined braches of each variety studied. The girdled branches and the control were labeled with colored ribbons and the wounds wetted with cupric fungicide for protection until total healing.

In all the experimental plots, macro- and micronutrient fertilization were applied monthly through leaf spraying. The plants received localized irrigation whenever necessary at quantities sufficient to keep the soil moist. The usual plant health treatments were performed using specific products according to need, also keeping the areas free of weeds.

The data collected was analyzed statistically

using the Sisvar program (FERREIRA 2011) and the Tukey test was applied to compare the mean values. For the number of racemes per branch, the transformation $(x+0.5)^{1/2}$ was applied. In all analyses, 5% probability of error was adopted.

RESULTS AND DISCUSSION

The results of analysis of variance indicated a significant effect on the olive tree cultivars studied, the period and types of girdling separately, and for the period x girdling double interaction (Table 1).

Interrupted girdled vascular continuity favors the accumulation of assimilates in the distal/apical position of the branch, which is situated above the location in which girdling was practiced, and impedes their passage to the lower part of the branch, to the stem and roots. The effect of formation of different bands depends on the width of the interrupted continuity. After some period, the wound heals and restores vascular continuity in the branch, and its effect disappears (MOREIRA et al. 2016).

In Table 2, significant results are observed only for the period of girdling in relation to branch diameter near insertion in the truck, with the best period for performing girdling being the month of March, possibly due to the climatic conditions. In the months of March and May 2012, the branch diameters were greater, in relation to the month of April.

An oscillation was observed in the diameters of the branches in relation to the girdling period. One hypothesis for this variation would be the large amount of rainfall which occurred in April 2012 in the region.

The period in which girdling was performed is probably the single main factor in determination of the nature and magnitude of the effect obtained. The responses to girdling of the branches are generally affected by the period performed, environmental conditions and orchard management (NAFEA & ABDULFATAH 2014).

In Table 3 are shown the results of the diameter of the branches near the girdling performed on the olive trees. A greater diameter of the branches (mm) was observed in the plants that did not receive any type of girdling.

Greater branch length was observed in 'Ascolano 315' plants in the first three months of 2012 (Table 4). This behavior of differentiated responses may be explained by the genetic difference among the cultivars that are observed in *in situ* management of the orchard.

Table 1. Analysis of variance for branch diameter near insertion (BDNI), branch diameter near girdling (BDNG) and length of olive tree branches (LOTB). Epamig, Maria da Fé, MG, Brazil, 2016.

FV	GL	QM		
		BDNI	BDNG	LOTB
T Period (E)	2	0.428*	$0.069^{n.s.}$	$0.015^{n.s.}$
Block Replication	2	0.028	0.106	0.029
Cultivar	2	$0.169^{n.s.}$	$0.048^{n.s.}$	0.081*
Girdling (A)	2	$0.294^{n.s.}$	4.173*	0.122*
E x C	4	$0.019^{n.s.}$	$0.013^{n.s.}$	$0.012^{n.s.}$
E x A	4	$0.042^{n.s.}$	0.109*	$0.006^{n.s.}$
V x A	4	$0.057^{n.s.}$	$0.019^{n.s.}$	$0.009^{n.s.}$
E x V x A	8	$0.035^{n.s.}$	$0.061^{n.s.}$	$0.099^{n.s.}$
Error	52	0.096	0.034	0.010
Total	80			
CV (%)		8.45	5.58	7.73

FV = factor of variation, GL = degrees of freedom, QM = mean squares, E = period of girdling, V = varieties, A = types of girdling. *significant at 5% probability, ^{ns} not significant.

Table 2. Diameter (mm) of the branches near insertion of the tree. Epamig, Maria da Fé, MG, Brazil, 2016.

Period	Mean Values
March/12	3.766a*
May/12	3.697a
April/12	3.522b

*Small letters differ among themselves in the column by the Tukey test at 5% probability.

Table 3. Diameter (mm) of the branches near the girdling in three olive tree varieties. Epamig, Maria da Fé, MG, Brazil, 2016.

Girdling (diameter)	Period		
	March/12	April/12	May/12
Without girdling	3.841a*	3.657a	3.786a
15 mm	3.207b	3.302b	3.029b
10 mm	2.993c	3.081c	2.964b

*Small letters differ among themselves in the column by the Tukey test at 5% probability.

The 'Ascolano 315' cultivar exhibits a more intense growth habit when compared to the cultivars 'Grappolo 541' and 'Maria da Fé', differing statistically. These results corroborate OLIVEIRA et al. (2006) who, working with characterization of olive trees, observed that of all the varieties analyzed, the Ascolano variety is one that stands out and is able to reach mean values of 5.73 m, and is thus considered to be very vigorous. Recent adaptation studies of cultivars in Minas Gerais, showed better agronomic yield in one-year-old plants of the cv. Ascolano (OLIVEIRA et al. 2010).

In Table 5, the results are shown for length of branches in relation to the girdling performed. In this case, the best results were seen in plants without girdling.

Results discussed here on the length of branches disagree with FONFRÍA et al. (1999) where they affirm that girdling always leads to a reduction of vegetative growth of the girdled branches. This possibly occurred because vegetative development is not explained exclusively in nutritional terms, but the mechanism is also regulated hormonally, thus depending on the species and cultivars studied. In addition, the effects of girdling on olive tree branches have not yet been fully elucidated, with the plants being assessed only in one year of vegetative and productive growth. Future studies should ensure the effect of girdling on the diameter and length of these branches.

Healing of the wounds produced by girdling was satisfactory in 'Grappolo 541' and 'Ascolano 315' plants and occurred immediately after the cut, corroborating LÓPEZ-RIVARES & GARCÍA (1990), who observed better healing of the wounds made in March and April in "Manzanilla" plants. Good healing of plants of the Maria da Fé variety was not observed, as some branches of this variety were dried out, with the presence of yellowed leaves. Few studies register this technique in olive trees, indicating that healing is due to, among other factors, the period of girdling, the cultivar and the type of branch girdled (SONBATY et al. 2012).

It may be observed that the cv. that showed the greatest longitudinal and transversal length was 'Ascolano 315' in relation to the mean value of the group (or set of cvs.). On the other hand, the cv. Maria da Fé was that which showed lowest values for length (cm) in relation to the other varieties (Table 6).

According to OLIVEIRA et al. (2010), the morphological characteristics, such as leaves, fruit and seeds, are practically the only criteria used in determination of the main varieties of olive trees, while, in relation to the fruit, some main elements for their determination are observed, such as longitudinal and transversal lengths (perimeters), and weight of the fruits. It is noteworthy that the general mean value for the dimensions of the varieties analyzed in this study

Table 4. Length (cm) of branches of three olive varieties. Epamig, Maria da Fé, MG, Brazil, 2016.

Olive varieties	Mean values
Ascolano 315	1.325a*
Maria da Fé	1.245b
Grappolo 541	1.221b

*Small letters differ among themselves in the column by the Tukey test at 5% probability.

Table 5. Length (cm) of the branches of three olive trees. Epamig, Maria da Fé, MG, Brazil, 2016.

Girdling	Mean Values
Without girdling	1.336a*
15 mm	1.252b
10 mm	1.203b

*Small letters differ among themselves in the column by the Tukey test at 5% probability.

Table 6. Variables analyzed of fruit collected from three olive tree varieties. Epamig, Maria da Fé, MG, Brazil, 2016.

Varieties	Plt.*	LL	TL	LLS	TLS	FW	FV	SW	SV	TW
Grappolo 541	1	13.18	8.55	11.48	8.41	280.40	280	8.21	2.57	552.85
	2	17.15	14.20	11.82	7.10	217.84	104	6.38	2	268.83
Mean		15.17	11.38	11.65	7.76	249.12	192	7.30	2.29	410.84
Maria da Fé	1	11.73	9.45	7.71	4.83	95.94	100	2.44	2	--------
	2	13.51	10.66	9.91	6.07	58.26	100	2.3	2	2326.0
	3	13.15	10.30	9.14	5.77	84.14	80	2.3	2	2390.0
Mean		12.80	10.14	8.92	5.56	79.45	93.33	2.35	2	2358.0
Ascolano 315	1	22.65	18.71	14.50	9.03	239.02	236	7.4	6	1752.0
	2	22.83	18.30	15.98	9.45	233.4	230	8.9	8	42.76
	3	22.08	18.04	15.64	8.29	218.74	216	7.5	7	1892.9
Means		22.52	18.35	15.37	8.92	230.39	227.33	7.93	7	1229.2

*Plt = plants, LL = longitudinal length of 80 fruits, TL = transversal length of 80 fruits, LLS = longitudinal length of 10 seeds, TLS = transversal length of 10 seeds, FW = 100 fruit weight, FV = 100 fruit volume, SW = 10 seed weight, SV = 10 seed volume, TW = total weight.

exhibit values within the interval found in European producer countries.

According to VIEIRA et al. (2008), the study of physical characteristics serves to differentiate the olive tree cultivars, relating these variables to oil content/olive oil yield. The same authors affirm that the variety Grappolo 541 and Maria da Fé contain high oil content and high olive oil yield.

It is also observed that the length of the seeds obtained from olives collected in previous years on the Epamig Experimental Farm were 8.5% greater in relation to the mean values observed in the assessments made in 2009. In regard to 100 fruit weight, the values did not undergo alterations (VIEIRA NETO et al. 2008). DEL RIO & CABALLERO (2006) comment that the physical parameters of the olives, in addition to being inherent to the variety, are also affected by the management techniques adopted and by the climate in the growing region, and they may furthermore vary from one crop season to another.

Many aspects involving girdling of trunks and branches still need to be clarified so that the physiological mechanisms involved in the reaction of the plants to this technique may be better understood.

In contrast to other practices with a view toward earlier fruit harvest, such as application of chemical products for anticipating sprouting and flowering, girdling does not anticipate flowering period because it is performed after that stage. In addition, the possibility of using girdling together with the application of plant regulators or other orchard management techniques like fertilization and pruning should not be disregarded.

Nevertheless, we highlight that the behavior of the three cultivars studied here concerns the various characteristics (intrinsic or otherwise) of the genotypes studied, not a reason for exclusion of one in favor of another. The three materials are important for implementation of commercial olive growing in the south of Minas Gerais because the cvs studied are directed to table olives and olive oil production. With the preliminary results of the current study, there is the intention of using this technique associated with other management techniques in Brazilian commercial olive plantings.

CONCLUSIONS

In the first year of girdling of olive tree branches, it may be concluded that:

The girdling technique did not affect the length and diameter of branches of 'Grappolo 541', 'Ascolano 315' and 'Maria da Fé.

Superior results were found in olive tree branches girdled in March and May.

The fruit collected from the three olive cultivars studied were affected by girdling of the branches.

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