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Trunk Constriction Effects on Vegetative Vigour and Yield Efficiency in Olive Tree (*Olea europaea* L.)

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ABSTRACT

Tree vigour is one of the most important issues in super-high density olive orchards (~1,600 tree ha^{-1}). Tree vigour could be limited by horticultural practices such as pruning and fertilization but such practices have a limited effect and increase growing costs. The aim of this work was to test a new technique based on the application of a constriction to the trunk in order to obstruct the flow of sap in xylem and phloem. To this end, on 5 cultivars trained in a super-high density olive orchard in Central Italy, constrictions were applied by a plastic strap in 2009 and 2010, and were removed at the end of the following year. At the end of the experiment, constricted trees had smaller vegetative growth than the control trees. During the first experiment (2009), in the constriction year, yield efficiency was higher in constricted trees. In the second year, low vigour cultivars ('Arbequina', 'Maurino' and 'Moraiolo') had a consistent reduction of yield, while vigorous cultivars ('Leccino' and 'Frantoio') had similar yield but a slightly increased yield efficiency. No effect was detected in fruit characteristics, but the oil phenol content was higher in the constricted trees. In the second year experiment (2010), similar results were obtained, but yield efficiency increase and vegetative growth reduction were lighter because the trees were one year older than those of 2009 experiment. Trunk constriction was a successful technique for reducing tree vigour and enhancing tree yield efficiency, especially in vigorous cultivars.

Keywords: Arbequina, Hedgerow, Productivity, Wiring.

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INTRODUCTION

In super-high density olive orchards tree density is ~1,600 trees per hectare. In this sort of plantation, allotted space per tree is quite limited in comparison with traditional orchards in which maximum tree density is ~500 trees per hectare. New plantation systems based on increasing the number of trees per hectare have caused new challenge for crop management in olive growing (Tous *et al.*, 1999). Super-high density orchards require high level of technology and the appropriate know-how to carry out crop management (Weber, 2001). Increasing tree density can lead to increased canopy reciprocal shading (Tombesi, 1988; Tous *et al.*, 1999; Tombesi and Farinelli, 2014a; Tombesi *et al.*, 2014a and b). Reciprocal shading causes competition for light among trees which can progressively lead to loss of efficiency (Sansavini *et al.*, 1981).

Dwarfing trees allow orchard density to be increased because of their low vigour and limited crown development. Dwarfing behaviour is generally used in other horticultural crops by grafting on dwarfing genotypes used as rootstocks. Dwarfing rootstocks increased yield efficiency in relation to canopy volume (Larsen *et al.*, 1987, 1992; Wheaton *et al.*, 1995) and pruning material (DeJong *et al.*, 2004). In olive, Hartman and Whisler (1970) observed tree vigour reduction due to rootstock and

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inter-stock use. However, dwarfing rootstocks are not currently used in commercial orchards. Therefore, in super-high density olive orchards, only cultivars with low vigour and high yield efficiency can be successfully used (Tous *et al.*, 1999; Godini *et al.*, 2009; Tombesi and Farinelli, 2014b; Tombesi *et al.*, 2014c; Farinelli and Tombesi, 2015). Thus, few cultivars are currently available for super high density orchard. Horticultural techniques capable of reducing tree vigour and increasing yield efficiency of traditional cultivars should allow increasing the number of cultivars that can be grown in this planting system.

Because of the high plantation density, super high density olive orchards have an estimated economical life of about 15 years but, considering the high planting cost, increasing orchard life is desirable (Tous *et al.*, 1999; Tombesi, 2011). Horticultural practice could help to control tree vigour and to increase yield efficiency. Many authors studied the possibility of influencing the carbohydrate partitioning by root apparatus restriction (Richards and Rowe, 1977; Poni *et al.*, 1992) or by regulated deficit irrigation and/or partial root drying (Fernandez *et al.*, 2006; Lavee *et al.*, 2007; Aganchich *et al.*, 2007). Some authors proposed the use of hormone inhibitors to increase flowering and decrease vegetative growth (Porlingis and Voyiatzis, 1986; Meilan, 1997; Schneider *et al.*, 2012), but their use is difficult and results were not consistent over years (Leonardi *et al.*, 1999). Girdling was proposed by some authors as a method to increase crop yield and to decrease vegetative growth (Hartmann, 1950; Lavee *et al.*, 1983), but it was not recommended as a general practice for the arduousness of the technique that requires the application of sealing materials to favour the cicatrisation of the wound and to prevent the entering of pathogens (Hartmann, 1950; Lavee *et al.*, 1983). However, the balance between vegetative and fruiting activity is a primary factor to optimize and increase tree yield (Grossman and DeJong, 1994). In peach, shoot elongation and tree vigour is related to stem water potential and hydraulic conductance (Basile *et al.*, 2003; Motisi *et al.*, 2004; Solari *et al.*, 2006a, b; Tombesi *et al.*, 2010a, b and 2011). On the other hand, the physiological mechanism subtending vigour reduction in olive tree is still unclear (Nardini *et al.*, 2006; Trifilò *et al.*, 2007).

The possibility of regulating the vegetative growth and increasing the availability of carbohydrates for fruiting could be useful for olive growers. Such limitation could be obtained by applying a constriction to the trunk by a plastic strap that obstructs the natural secondary growth of the trunk. Differing from girdling, it does not imply wounds and it avoids the penetration of pathogens. Strap constriction is time saving in relation to girdling and theoretically easier to apply.

The aim of this work was to test if trunk constriction would influence horticultural performances, such as vegetative growth and yield efficiency, of five olive cultivars grown in super-high intensive olive orchards.

MATERIALS AND METHODS

In December 2008, a constriction (of about 5 cm of height) was applied on the trunk of 5 trees of 5 olive cultivars (‘Arbequina’, ‘Frantoio’, ‘Leccino’ ‘Maurino’, ‘Moraiolo’), using a commercial plastic strap (15×0.6 mm) sealed by means of steel seals (BIR 16 of 16 mm) (Figure 1). It was then removed in December 2009. Time required for strap application was between 1 minute per tree and material cost was less than 0.1 Euro. Trees were 4 years old and they were located in the experimental olive orchard in Deruta (Perugia) (+42° 57' 38.88" N, +12° 25' 3.95" E). They were trained as central leader and were planted at 1.5 m spacing along the row, and 4.0 meter between rows (1,666 tree ha^{-1}). Another 5 trees per each cultivar of the same age were taken as the control. The orchard was irrigated and all trees received normal horticultural cares.

The experiment was replicated using the same material and the same methodology on other 5 trees per cultivar in 2010, in the

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(a) (b)

Figure 1. Application of the plastic strap before girth growth (a) and after girth growth (b).

same orchard; constriction strap was applied in early January 2010 and removed in December 2010

At mid-January 2009, trunk diameter was taken by a calliper (Haglof, Langsele, Sweeden) measuring the diameter at the height of the constriction, 5 cm below the constriction and 5 cm above the constriction. The same operation was made in December 2009 and 2010 in order to measure the effect of constriction after tree annual vegetative growth. In the same dates (January 15th and December 1st), canopy volume was measured. The same was performed in January 2010, December 2010 and December 2011 in the trees constricted in 2010. Tree canopy diameter was measured at four heights: At the base of the canopy, at 50 cm, at 150 cm, and at the top of the canopy. Canopy diameter and height was used to calculate canopy volume as the sum of three truncated pyramids laid one on the top of the other. Fruit set was measured in the experiment of 2009 by counting the number of inflorescence on two one-year-old shoots per tree during full bloom. The number of fruits was then counted at the end of July on the same shoots. On October 20th, 2009, October 27th, 2010, and November 16th, 2011, fruits were harvested and weighted for each tree. A sample of about 1 kg was taken per tree. Oil content (Foss-let 1531, Foss electronics, Denmark) and dry weight were measured. On January 15th, 2009, 50 leaves per tree were sampled and kiln-dried. They were grinded and 0.2 g was sampled to measure simple sugars and starch content by the Anthrone method (Morris, 1948; Loewus, 1952).

In January 2010, wood samples (~2 cm height ×1 cm wide ×1 cm depth) were collected from trunks of the constricted (2009 experiment) and control trees of 'Leccino', 'Maurino' and 'Arbequina' in three different parts: at the constriction zone and ~5 cm below and above the constriction zone. Samples were sectioned with a freezing microtome (2700 Frigocut, Reichert-Jung, Nossloch, Germany) at ~20 µm of thickness in order to obtain 4 sections per sample. Sections were stained with iodine green to increase the contrast. Photographs of the cross-sections were taken with a camera (Leica ICCA, Leica Microsystems Wetzlar GmbH, Wetzlar, Germany) mounted on a light microscope (Leica DMLB, Leica Microsystems Wetzlar GmbH, Wetzlar, Germany). Images were then acquired with Leica IM1000 software (Leica Microsystems Digital Imaging, Cambridge, United Kingdom). One photograph was taken from each cross-section slide at 50 magnifications to measure the thickness of phloem and the xylem tissue of the outermost ring. Measurements were made by Sigmascan pro 5.0 (Systat Software Inc., San Jose, CA, USA).

Differences between the control and constricted trees were assessed by Student t-test and P value was set to 0.05.

RESULTS

Trunk cross-sectional area and tree canopy volume were similar when the constriction strap was applied in December 2008 (2009 experiment) and in January 2010 (2010 experiment) in the constricted and the control trees in all 5 cultivars (data not shown). At the end of 2009, canopy volume as well as trunk cross sectional area varied between the treatment and the control (Figures 2-a and -c). The same was observed in 2010 with the exception of 'Frantoio' in which trunk cross-sectional area was not different (P> 0.05) (Figures 2-b and -d). Similar results were obtained in the 2010 experiment (Figure 3). In all five cultivars in 2009, the canopy volume of constricted trees was lower than that of the control trees. Canopy volume reduction varied from 33.6% for 'Frantoio' to 51.1% for 'Maurino'. In 2010, canopy volume reduction varied between 60.6% of 'Leccino' to 70.7 of 'Moraiolo'. In 2010 experiment, canopy volume reduction in treated trees was consistent only in 'Arbequina', 'Leccino' and 'Moraiolo', while in the other two cultivars no significant difference was observed. In the following year, trees constricted in 2010 had smaller canopy than the control trees in all tested cultivars. Regarding Trunk Cross sectional Area (TCA), a pattern similar to that of canopy volume occurred (Figures 2c and 3c). In 2009, the reduction varied from 23.5% in 'Arbequina' and 55% in 'Maurino'. In 2010, TCA reduction varied between 18.7% for 'Frantoio' to 48.3% for 'Arbequina'. In 2010 experiment, TCA reduction in treated trees was consistent only in 'Arbequina', 'Leccino' and 'Moraiolo', while in the other two cultivars no significant difference was observed. In the following year, trees constricted in 2010 had smaller TCA than the control trees in all tested cultivars.

Yield per tree (kg of olives tree^{-1}) did not vary between the constricted and the control trees in 2009 (Figure 4-a). Only 'Maurino' and 'Moraiolo' had different yields in the

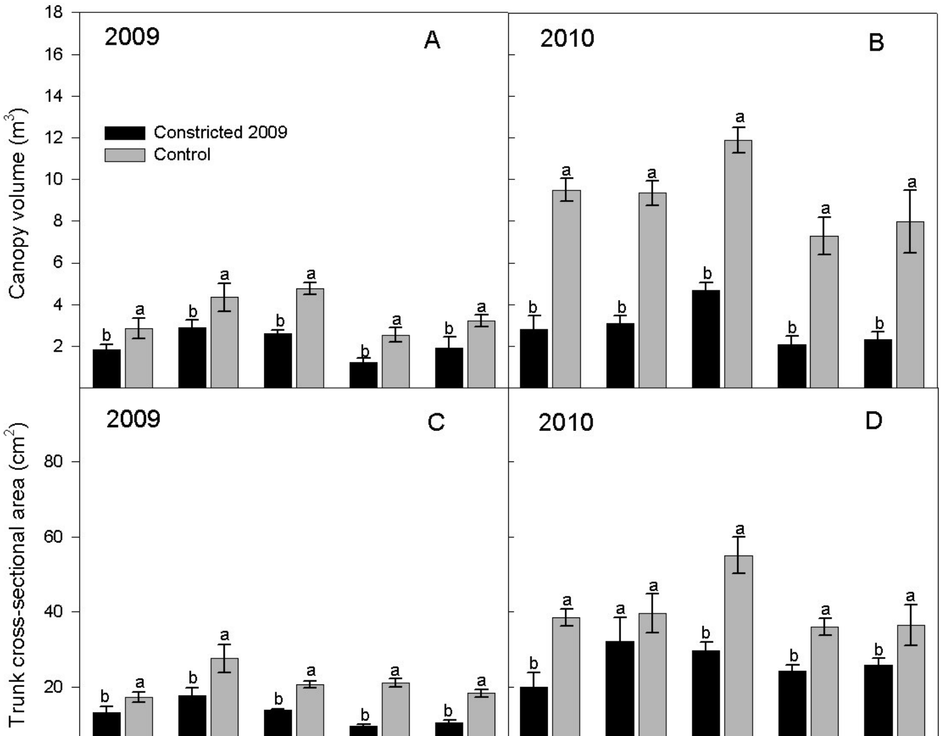

Figure 2. Canopy volume in 2009 (A) and 2010 (B) and trunk cross sectional area in the same years (C and D) of the constricted (2009 experiment) and the control trees of 'Arbequina', 'Frantoio', 'Leccino', 'Maurino' and 'Moraiolo'. Each value is the mean±*SE* of five trees (n= 5). Means with different lower-case letters are significantly different at *P*< 0.05 (Student t-test).

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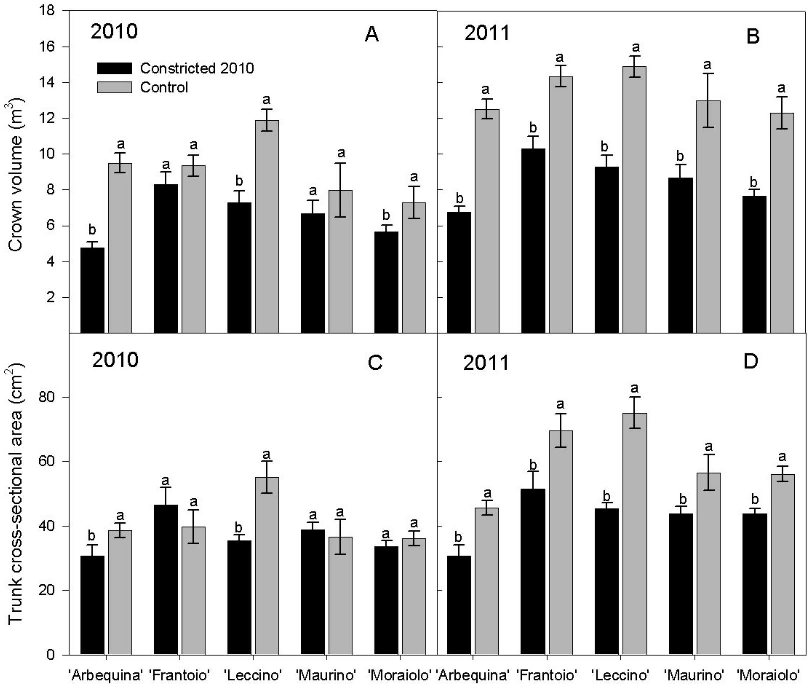

Figure 3. Canopy volume in 2010 (A) and 2011 (B) and trunk cross sectional area in the same years (C and D) of the constricted (2010 experiment) and the control trees of 'Arbequina', 'Frantoio', 'Leccino', 'Maurino' and 'Moraiolo'. Each value is the mean±S*E* of five trees (n= 5). Means with different lower-case letters are significantly different at *P*< 0.05 (Student t-test).

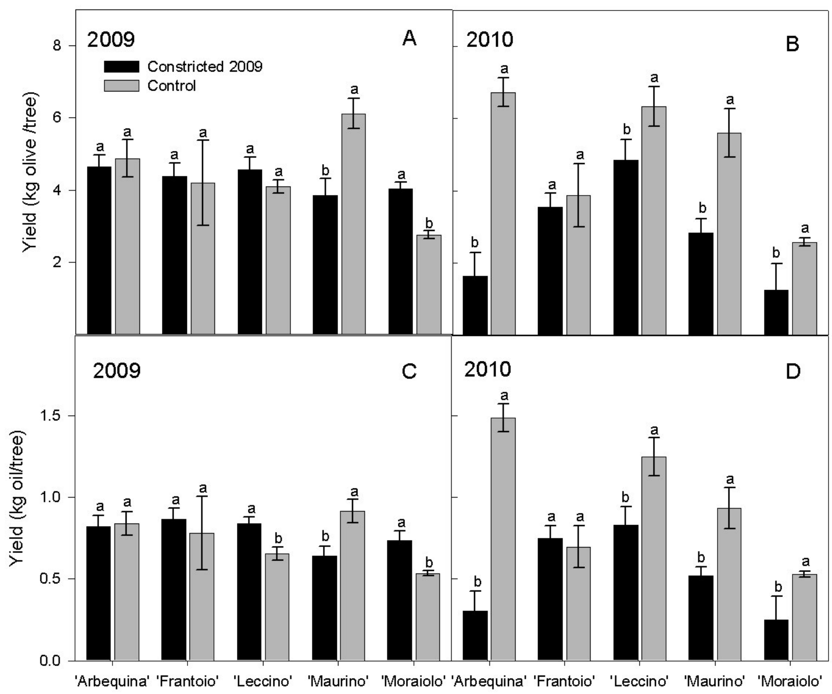

Figure 4. Yield of olive per tree (kg) in 2009 (A) and 2010 (B) and of oil per tree (kg) in the same years (C and D) of the constricted (2009 experiment) and the control trees of 'Arbequina', 'Frantoio', 'Leccino', 'Maurino' and 'Moraiolo'. Each value is the mean±*SE* of five trees (n= 5). Means with different lower-case letters are significantly different at *P*< 0.05 (Student t-test).

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two treatments: 'Maurino' had lower yield in the constricted trees rather than in the control. 'Moraiolo' case was exactly the opposite: the constricted trees had higher yield than the control trees. In 2010, the control trees bore more olives in all cultivars, except in 'Frantoio' (Figure 4-b). Yield per tree, expressed as kg of oil per tree, had approximately the same trend (Figure 4-c). Constricted trees had a slight non-significant increase in oil content in relation to the control trees (data not shown). Constricted trees in 'Leccino' and 'Moraiolo' had higher yield per tree than the control trees. There was no difference between treatments in 'Arbequina' and 'Frantoio'. Constricted trees of 'Maurino' had lower yields (kg oil $tree^{-1}$) than the control trees of the same cultivar. In 2010, the control trees yielded significantly less oil per tree (P< 0.05) in all cultivars, except 'Frantoio', where no significant difference was observed (Figure 4d). In 2010 experiment, in 'Frantoio' and 'Moraiolo', constricted trees had larger olive yield than control trees, while in 'Maurino there was no difference between treatments and in 'Arbequina' and in 'Leccino' control trees bore more than constricted trees (Figure 5-a). Similar results were obtained for tree oil yield (Figure 5-c). In the following year, treated trees of all cvs with the exception of 'Arbequina' bore more fruits than control trees (Figure 5-b). Regarding oil yield per tree, there were no significant differences between treatments in all cultivars excluding in 'Arbequina' where control trees bore significantly more oil per tree than constricted trees (Figure 5-d).

In 2009, yield efficiency calculated as kg of oil per canopy volume as well as kg of oil per trunk cross-sectional area was larger in constricted trees than in control ones in all cultivars (Figures 6-a and -b). In 2010 yield efficiency was similar in 'Arbequina' and 'Moraiolo' and greater in constricted trees of

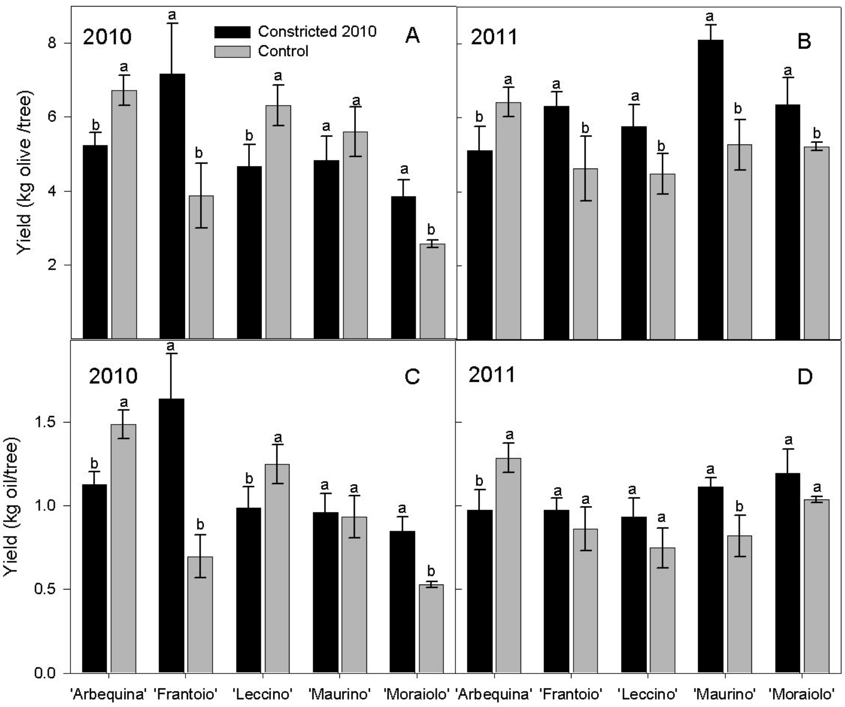

Figure 5. Yield of olive per tree (kg) in 2010 (A) and 2011 (B) and of oil per tree (kg) in the same years (C and D) of the constricted (2010 experiment) and the control trees of 'Arbequina', 'Frantoio', 'Leccino', 'Maurino' and 'Moraiolo'. Means with different lower-case letters are significantly different at *P*< 0.05 (Student t-test).

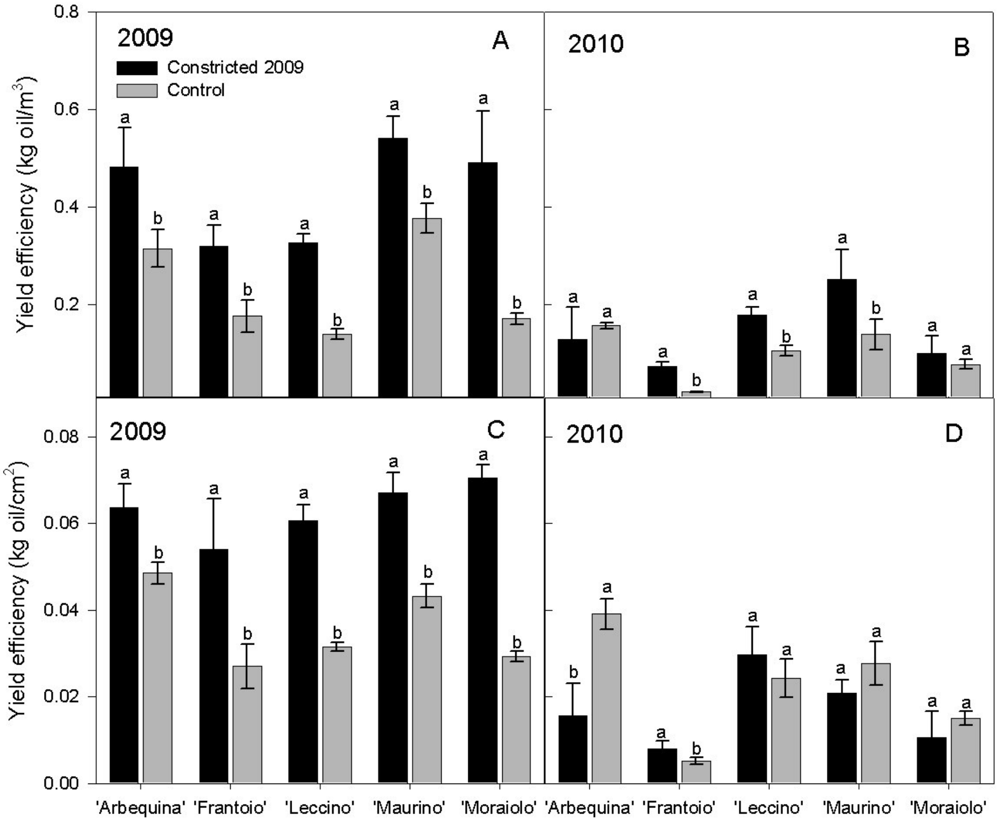

Figure 6. Yield efficiency expressed as oil per canopy volume (kg m^{-3}) in 2009 (A) and 2010 (B) and as oil per trunk cross-sectional area (kg cm^{-2}) in the same years (C and D) of the constricted (2009 experiment) and the control trees of ‘Arbequina’, ‘Frantoio’, ‘Leccino’, ‘Maurino’ and ‘Moraiolo’. Each value is the mean±*SE* of five trees (n= 5). Means with different lower-case letters are significantly different at $P< 0.05$ (Student t-test).

‘Frantoio’, ‘Leccino’ and ‘Maurino’ when calculated as oil/canopy volume. Yield efficiency, calculated as yielded oil per trunk cross-sectional area, was similar between the control and constricted trees in ‘Leccino’, ‘Maurino’ and ‘Moraiolo’ and smaller in constricted ‘Arbequina’ and in the control ‘Frantoio’ trees. In 2010 constricted trees, yield efficiency (calculated as oil per canopy volume) was consistently larger in both years in all cultivars, except in ‘Moraiolo’ in 2010 (Figures 7-a and -b). In yield efficiency, calculated as oil per trunk cross-sectional area, there was no difference between the constricted and control trees in 2010, while in 2011, the constricted trees of all cultivars, except those of ‘Arbequina’, had larger yield efficiency than the control trees (Figures 7-c and -d). Trunk tissue section indicated that annual growth of xylem in the constriction point was reduced in comparison with the part above constriction (Figure 8) and measurements on ‘Leccino’, ‘Maurino’ and ‘Arbequina’ confirmed such observation (Table 1). Constricted trees set more fruits in the year of constriction (2009) than the control trees (Table 2). In 2010, no difference in fruit set was observed between the constricted and control trees in all cultivars. Excluding ‘Frantoio’ and ‘Moraiolo’, there was no difference between treatments in soluble sugars in leaves at the end of 2009 (Figure 9-a). On the other hand, starch content was larger in constricted trees of all cultivars (Figure 9-b).

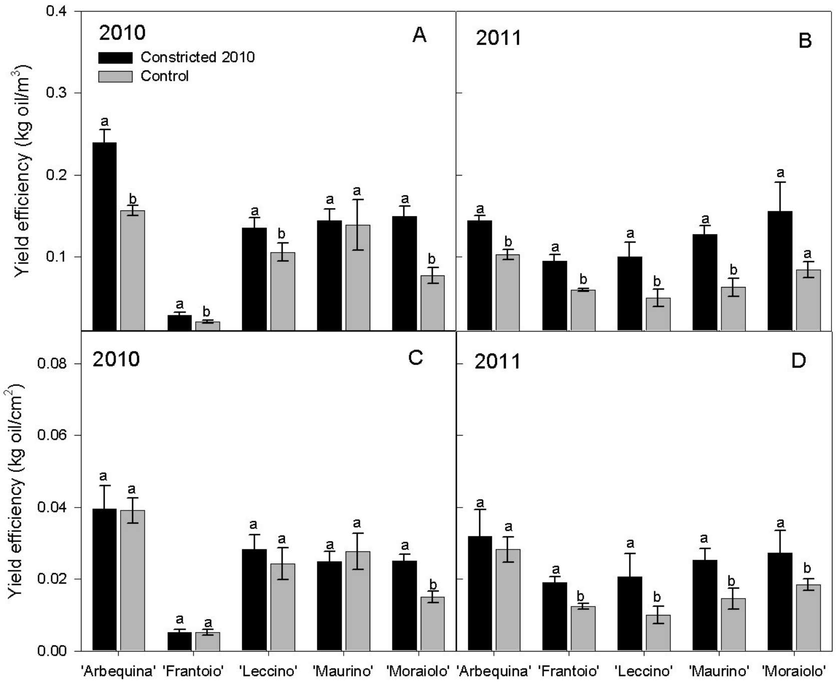

Figure 7. Yield efficiency expressed as oil per canopy volume (kg m^{-3}) in 2010 (A) and 2011 (B) and as oil per trunk cross-sectional area (kg cm^{-2}) in the same years (C and D) of constricted (2010 experiment) and control trees of 'Arbequina', 'Frantoio', 'Leccino', 'Maurino' and 'Moraiolo'. Each value is the mean±*SE* of five trees (n= 5). Means with different lower-case letters are significantly different at $P< 0.05$ (Student t-test).

Table 1. Xylem growth during the year of constriction (2009) and total phloem thickness in the constricted zone, below and above the constricted zone in three cultivars of olive trees.[a]

Cultivar	Xylem growth (mm)			
	Constriction zone	Below	Above	Control
'Leccino'	0.54±0.04 b	2.42±0.23 a	2.56±0.09 a	2.53±0.23 a
'Maurino'	0.29±0.06 b	2.25±0.21 a	2.1±0.25 a	2.2±0.15 a
'Arbequina'	0.41±0.10 b	2.29±0.27 a	2.36±0.15 a	2.31±0.13 a
	Phloem thickness (mm)			
'Leccino'	1.61±0.07 b	2.42±0.06 a	2.36±0.02 a	2.43±0.17 a
'Maurino'	1.4±0.06 d	1.69±0.04 c	1.91±0.05 b	2.19±0.07 a
'Arbequina'	1.29±0.02 c	1.92±0.06 b	2.34±0.20 a	2.2±0.12 a

[a] Xylem and phloem thickness in the control trees is provided in the far right column. Each value is the mean of 5 trees±*SE* (n= 5). Means were separated by Student *t*-test (P< 0.05).

DISCUSSION

Strap constriction is aimed to create an obstacle to transport of solutes and water between root apparatus and crown and vice versa. This is partly the same target of a common horticultural practice such as girdling. In spite of the beneficiary effect reported about such practice in olive, it has not been generally applied in commercial

Table 2. Fruit set (fruits/inflorescence) in 2009 and 2010 of constricted (2009) and the control trees of 'Arbequina', 'Frantoio', 'Leccino', 'Maurino' and 'Moraiolo'.[a]

		Constricted	Control
2009	Arbequina	1.34±0.07 a	1.17±0.06 b
	Frantoio	1.19±0.09 a	0.85±0.10 b
	Leccino	0.93±0.08 a	0.69±0.07 b
	Maurino	1.66±0.13 a	0.98±0.09 b
	Moraiolo	0.94±0.09 a	0.47±0.12 b
2010	Arbequina	1.34±0.28 a	1.77±0.16 a
	Frantoio	1.21±0.15 a	1.2±0.11 a
	Leccino	1.31±0.12 a	1.16±0.14 a
	Maurino	1.1±0.17 a	0.94±0.15 a
	Moraiolo	0.8±0.15 a	0.58±0.13 a

[a] Each value is the mean±*SE* of five trees (n=5). Means with different lower-case letters are significantly different at $P< 0.05$ (t-student test).

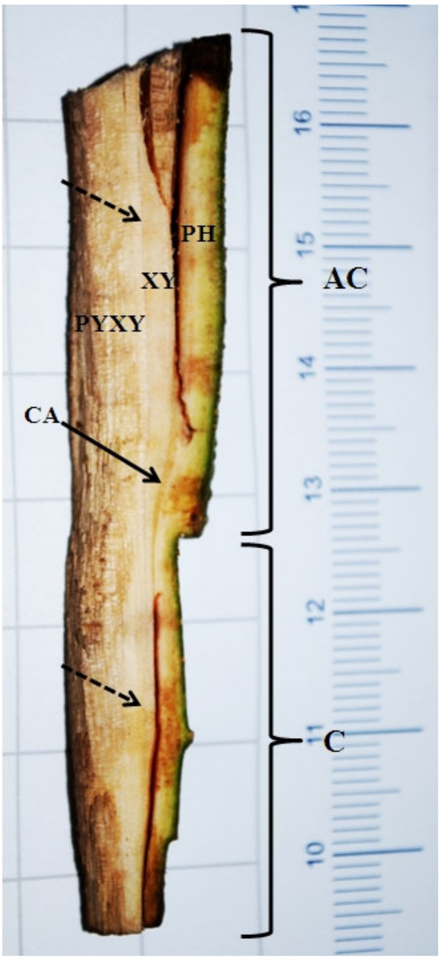

Figure 8. Longitudinal section of trunk in the zone of Constriction application (C) and Above Constriction zone (AC). PYXY: Previous Year Xylem; XY: Last year formed Xylem, PH: Phloem.

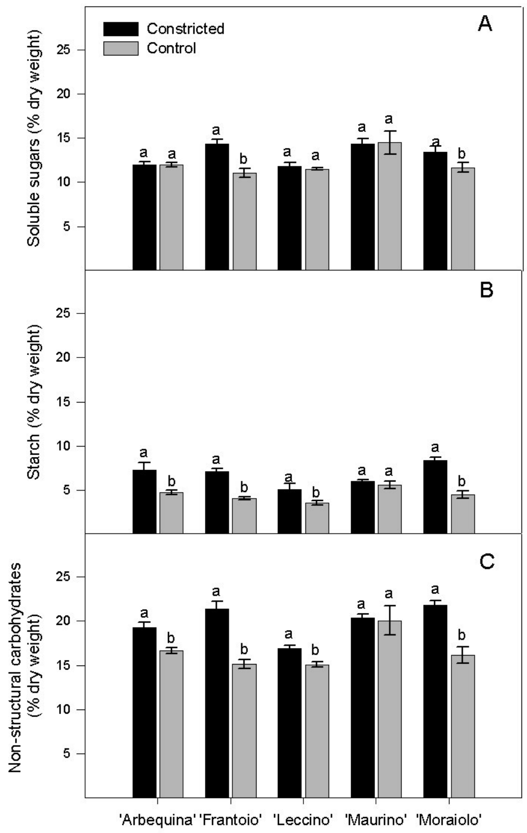

Figure 9. Simple sugars (A), starch (B) and non-structural sugars in leaves of the constricted (2009) and the control trees of 'Arbequina', 'Frantoio', 'Leccino', 'Maurino' and 'Moraiolo'. Each value is the mean±*SE* of five trees (n= 5). Means with different lower-case letters are significantly different at $P< 0.05$ (Student t-test).

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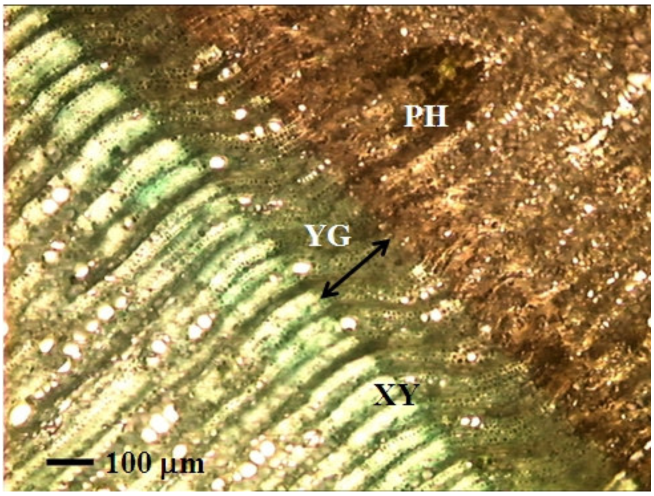

Figure 10. Cross section of trunk tissue at the height of the constriction in 'Arbequina' where, PH: Phloem; YG: Growth of xylem during the year of constriction, XY: Xylem that grew during the year previous to application of the constriction.

orchards due to the arduousness of its execution. Furthermore, it causes open wound which may lead to pathogens' infection (Hartmann, 1950). Clamping trunk by plastic strap does not cause hurts and allows cambium to stay alive (Figure 8). Xylem tissue growth was reduced as well as phloem tissue width (Table 1). Such phenomenon could lead to a reduction in xylem and phloem conductance. Vegetative growth is strongly reduced in all cultivars and non-structural carbohydrates were more abundant in the constricted trees than in the control ones (Figure 9-c). The scarce vegetative growth in trees with high non-structural carbohydrate levels suggests that shoot growth is limited by factors other than carbohydrates availability. In peach, vegetative growth has been linked to tree hydraulic conductance which is determined by anatomical factors such as xylem vessel diameter and functional sap area (Solari *et al.*, 2006b; Tombesi *et al.*, 2010a; Tombesi *et al.*, 2014d). In deciduous trees such as elm, Ellmore and Ewers (1985) reported that 90% of sap flow passed through the most external ring of xylem. In apple, the flow-active part of xylem was the most external part whereas the xylem vessels located in the inner part were not conductive (Atkinson *et al.*, 2003). In olive, Lopez-Bernal *et al.* (2010) reported that xylem tissue stay active for more than 5 years. In our experiment, we observed a significant decrease in xylem growth and phloem thickness in the constricted zone of the trunk. Further investigations are needed to assess whether the whole plant hydraulic conductance decreases in constricted trees.

The vegetative growth reduction was coupled with the increase in yield efficiency. This could be due to increased availability of non-structural carbohydrates in the aerial part of the tree, which caused larger fruit set than the control trees (Table 2). On the other hand, the high efficiency and the scarce vegetative growth caused alternate bearing in the subsequent years. Such phenomenon was more intense in the less vigorous cultivars in which vegetative growth was scarcer. The lack of formation in 2009 of new shoots able to bear fruits in the following year could be, therefore, the cause of depression of yield in 2010. Such effect could suggest that the constriction was too severe and, therefore, it excessively limited the vegetative growth. In fact, anatomical observations pointed out that, in the point of application, this practice caused the almost complete lack of formation of the last year xylem girth. This means that constricted trees were deficient in one year out of four of xylem growth in comparison with the control trees (Figures 6 and 7). When the experiment was replicated in the following year on trees that were a year older (4-year-old trees), the constriction effects on vegetative growth and on yield efficiency were less marked than in the previous experiment. In particular, canopy growth reduction was significant in the year after constriction removal, while in the year of constriction minor effects were observed on canopy growth. These results coupled with the general increase of yield efficiency in the second year let us conclude that the constriction caused softer and delayed effects on vegetative and reproductive activity depending on the age of the tree. Furthermore, the constriction applied in 2010 induced no alternate bearing and kept the trees more equilibrated. Results of this experiment are partly in accordance with those reported in previous papers on persimmon and peach, where the effects of cable-constriction were similar to that of branch girdling (Hasegawa and Nakajima, 1992; Taylor, 2004). Contrary to the results reported by Taylor (2004) on peach, in olive we observed tree vigour reduction as the major effect of tree trunk constriction.

CONCLUSIONS

Trunk constriction seems to be a technique able to influence vegetative growth and indirectly favour fruiting activity. This could be useful to generate an effect similar to that of girdling or grafting on dwarfing rootstocks. However, constriction applied for 12 months when trees were three years old resulted in too severe vigour reduction, especially in relation to the formation of new bearing shoots; the same practice applied on 4-year-old trees produced lighter results on vegetative growth and yield efficiency, but did not induce alternate bearing and kept the trees more equilibrated. These results indicate that trunk constriction is an effective technique to reduce olive tree vigour and that its use could favour cultivation of local vigorous cultivar in super-high density orchards. Further studies are needed to understand: (1) The best time length of application in order to provide the right vegetative growth to trees in relation with cultivar vigour and tree age; (2) The best turn of application over years; (3) The possible mechanization of this technique in order to propose it as common practice in commercial olive orchards, and (4) The impact of tree age on effectiveness of the technique.

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اثر بست زدن و انقباض تنه درخت روی رشد سبزینه ای و کارآیی عملکرد درختان زیتون(*Olea europaea* L.)

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چکیده

در باغ های زیتون با تراکم فرا زیاد(تقریبا ۱۶۰۰ درخت در هکتار)، رشد و نمو درخت از موضوع های مهم است. در این شرایط، می توان رشد درختان را با عملیات باغداری مانند هرس کردن و کود دهی محدود کرد ولی این عملیات اثر محدودی دارند و نیز هزینه تولید را افزایش می دهند. هدف پژوهش حاضر آزمودن روش جدیدی است بر پایه انقباض و تنگ کردن تنه درخت به منظور ایجاد مانع در جریان شیره گیاهی در آوندهای چوبی و آبکش. به این منظور، طی سال های ۲۰۰۹ و۲۰۱۰، روی تنه ۵ کولتیوار زیتون که در باغی با تراکم فرا زیاد در بخش مرکزی ایتالیا پیرایش شده بودند بست های(گیره های) پلاستیکی نصب شد و این بست ها در آخر سال بعد برداشته شد. در آخر آزمایش، رشد سبزینه ای درختان بست زده کمتر از درختان شاهد بود. طی آزمایش نخست (۲۰۰۹)، در سالی که تنه درخت بست داشت، کار آیی عملکرد بیشتر ازشاهد بود. در سال دوم، کولتیوارهای دارای رشد کمتر (کولتیوارهای 'Arbequina'و 'Maurino' و'Moraiolo') به طور همآهنگی کاهش عملکرد نشان دادند در حالی که کولتیوارهایی که رشد قوی داشتند('Leccino'و 'Frantoio') عملکرد مشابهی(با سال اول) نشان دادند ولی کارآیی عملکردشان اندکی افزایش داشت. همچنین، هیچ اثری روی خصوصیات میوه مشاهده نشد ولی فنول موجود در روغن میوه درختانی که روی آن ها بست نصب شده بود بیشتر بود. در آزمایش سال دوم (2010) نتایج مشابهی به دست آمد ولی کارآیی عملکرد و کاهش رشد سبزینه ای کمتر بود زیرا درختان یک سال مسن تر از درختان آزمایش سال ۲۰۰۹ بودند. بر این اساس می توان گفت که برای کاهش رشد سبزینه ای درختان و افزایش کارآیی عملکرد به ویژه در مورد کولتیوارها دارای رشد قوی، بست زدن به تنه درختان روش موفقی است.

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