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Short communication

Vegetative structure and distribution of oil yield components and fruit characteristics within olive hedgerows (cv. Arbosana) mechanically pruned annually on alternating sides in San Juan, Argentina

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A R T I C L E I N F O

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A B S T R A C T

In olive hedgerows mechanical pruning is needed to control hedgerow dimensions for canopy illumination and access by harvesting machinery but yield responses to pruning strategies remain unclear. This study records the impact of annual mechanical topping with pruning on alternating sides of hedgerows on the internal distribution of fruit characteristics and oil yield. Hedging was applied in winter at 0.4 m from the trunk on West and East sides in 2015–16 and 2016–17 seasons, respectively, along with topping at 3.0 m height. Hedgerow width, height and porosity were characterized after pruning and before harvest. Oil production, fruit number and fruit characteristics were evaluated in 20 positions within the hedgerows defined by two sides (East and West), two depths per side (inner and outer) and 5 heights. West-unpruned sides in 2015–16 and East-unpruned sides in 2016–17 produced 70 and 80% of the total oil, respectively. Within each season, fruit oil and water concentration and pulp/pit ratio were similar on opposing sides. In contrast, fruit weight and maturity were similar between sides in 2015–16 but not in 2016–17 where greater fruit weight and more advanced maturity were observed on West-pruned. In both seasons, inner positions (within 0.5 m of trunk) produced 65% of total oil production and fruit numbers. Fruits showed similar characteristics between hedgerow depths. In contrast, oil production and fruit characteristics showed a marked gradient with height. Oil production and fruit number were greatest from 1.0 to 2.0 m height, decreasing to the top and to the base. Fruit weight, oil concentration and maturity decreased from hedgerow top to base, while fruit water concentration showed the opposite pattern. Mechanical pruning applied annually to alternating sides maintained both hedgerow dimensions and oil yield in successive years.

1. Introduction

In Argentina, new olive plantations are large (> 100 ha) with high tree density (> 300 trees/ha) and tall hedgerows (> 4.0 m) (Gómez-del-Campo et al., 2010). Hedgerows are important because they allow full mechanization of pruning and harvest which is required to contain costs of management and manpower, while offering additional advantages of much faster and more efficient management interventions, important in large orchards (Trentacoste et al., 2015a). Mechanical pruning is an efficient tool to maintain hedgerow dimensions and form compatible with harvesting machinery and also for the branch renewal necessary to sustain and locate shoot growth, flowering and subsequent productivity (Connor et al., 2014).

Two studies have recorded the effect of simultaneous mechanical hedging of both sides of olive hedgerows (Albarracín et al., 2017; Vivaldi et al., 2015). In the first case, oil yield was reduced in the current pruning season but recovered to that of the un-pruned control in the following season. Over three consecutive seasons, cumulative oil yield was non-significantly different between the unpruned control and hedgerows pruned on both sides. In the second case, hedging and topping reduced oil yield for three years in high- but not in low-vigor cultivars such as Arbequina and Arbosana, explicable because in these cultivars fruiting shoots were mainly located near the trunk. In contrast, few published studies have examined the productive response to hedging of alternating sides (Cherbiy-Hoffmann et al., 2012; Tombesi et al., 2014). Cherbiy-Hoffmann et al. (2012) in Northwest Argentina

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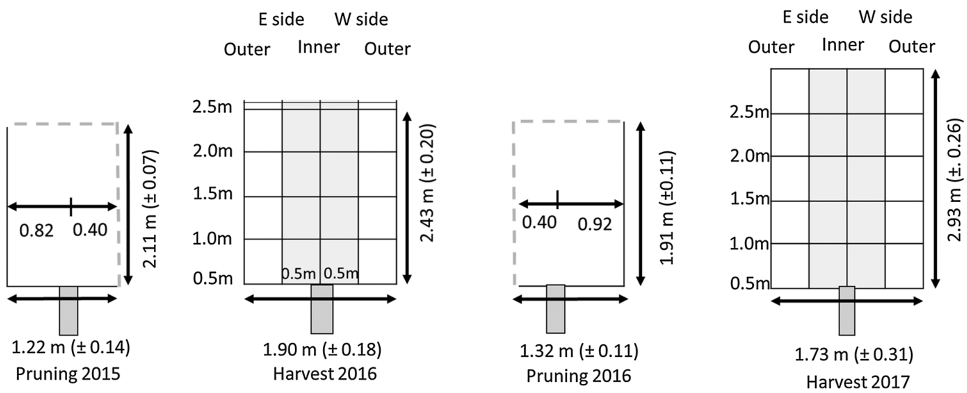

Fig. 1. Representative scheme of hedgerow structure and dimensions (width and height) after mechanical lateral pruning of West side in winter 2015 and on East side in winter 2016. In 2016 and 2017, hedgerows were harvested in 20 canopy positions, as shown. The vertical scale (column) on the right indicates the boundary heights (m above ground).

observed that fruit load retained on unpruned sides in large olive hedgerows (cv. Arbequina) prevented vigorous and nonproductive regrowth on pruned sides that can result from severe pruning. In walnut hedgerows, Ramos et al. (1992) found greater cumulative fruit yield during five years in hedgerows that were hedged annually on alternating sides compared with others hedged simultaneously on both-sides in alternating years.

In mechanized olive hedgerows the distribution of oil yield, its components and fruit characteristics are also important to establishing hedgerow design, harvest time, mechanical efficiency and modeling hedgerow performance and yield (Connor and Gómez-del-Campo, 2013; Trentacoste et al., 2015b). The distribution of oil yield components within hedgerows has been evaluated in narrow, porous (20%) olive hedgerows cv. Arbequina (width 1.20 m × height 2.5 m) under low vigor growing conditions of central Spain. There, fruits were concentrated towards the canopy periphery (Trentacoste et al., 2015b) in contrast to the central zones of lower irradiance in wider (~5.0 m) hedgerows in Argentina (Cherbiy-Hoffmann et al., 2012). Hedging alternating sides of hedgerows causes the development of asymmetric canopies with potential for different fruit load, shoot growth and irradiance environment between canopy sides (Wood and Stahmann, 2004) and opportunities for management to control production and its components at whole hedgerow level.

This work was undertaken to determine the impact of annual lateral pruning of alternating sides of hedgerows, cv. Arbosana, on canopy dimensions (width, height and porosity) and distribution of oil yield, its components and fruit characteristics within hedgerows.

2. Material and methods

2.1. Site and orchard

The experiment was carried out during the 2015–2016 and 2016–2017 seasons in a commercial olive (cv. Arbosana) orchard at Cañada Honda Valley (31° 58´S, 68° 32´ W, 614 m.a.s.l.), San Juan, Argentina. The hedgerows were established in 2011 with rows oriented N-S and trees spaced 1.75 m x 3.5 m (1632 trees/ha). The climate of the region is arid with annual rainfall of 195 mm concentrated during summer months, and average annual temperature of 18.5 °C. The soil is sandy-loam with high content of gravel below 0.8 m of depth. Daily meteorological data, recorded at an automated weather station located near to the experimental site, included maximum and minimum temperatures, relative humidity and rainfall.

Trees were irrigated with emitters of 2.0 L/h spaced at 0.8 m intervals along a single drip line per hedgerow. Irrigation, corrected for rainfall, was applied to restore 70% of crop evapotranspiration over the whole growing season. Crop evapotranspiration was calculated as:

$$ETc = ETo \times Kc \times Kr \quad (1)$$

where ETo is reference evapotranspiration calculated with Penman-Monteith modified by FAO (Allen et al., 1998), Kc is a seasonally constant crop coefficient = 0.70 estimated for olive trees by Girona et al. (2002) and Kr is an empirical coefficient to account for changing crop cover. It was calculated as 2 x crop cover %/100 with a limit of Kr = 1 for cover fraction > 50% (Fereres et al., 1981) at the beginning (September) and mid growth season (January). Fertilizer was applied with irrigation water to supply 58.2 kg/ha of N, 10.4 kg/ha of P, 22.0 kg/ha of K, and 8.7 kg/ha of Mg in both growing seasons.

2.2. Mechanical pruning and plot selection

At the beginning of the experiment, tree canopies formed continuous hedgerow walls that exceeded the target dimensions compatible to harvesters. Pruning, comprising topping and single-side hedging, was applied by machine with four rotating disks assembled on two rotating booms (see graphical abstract) in winter. Topping was set at 3.0 m height and hedging at 0.4 m from the trunk in single passes on 5 July 2015 and 25 June 2016 for West and East sides, respectively (Fig. 1). Both, hedging distance from the trunk and topping height were selected in relation to dimensions of the intended harvesters.

Trees for measurement were selected from a section of 6 adjacent rows with 50 trees per row following measurements of trunk perimeter and crown volume of all trees (300 trees). From these, nine subplots (replicates) each consisting of two contiguous trees were chosen with similar trunk perimeter and crown volume. The same 18 trees (i.e. 9 subplots per two trees) were evaluated in both seasons.

2.3. Hedgerow vegetative structure

Hedgerow structure was described on both trees per subplot immediately after pruning and before harvest in 2015–16 and 2016–17 growing seasons. For this, height of top and bottom foliage was measured in 3 positions per tree, near the trunk and at 0.5 m on each side. Hedgerow width was measured at 0.5, 1.0 and 1.5 m height at 3 positions of the same trees. Canopy porosity (%) was estimated according Trentacoste et al. (2015b).

2.4. Definition of canopy positions

At harvest, the canopies of the two contiguous trees per replicate were divided into 20 positions based on two vertical layers of canopy depth (inner and outer) on both sides (East and West) divided into 5 horizontal height intervals (see Fig. 1). The inner layer was the first 0.5 m measured outwards from the trunk while the outer layer was the remainder of the external canopy. The five height intervals above ground were 0.5–1.0 m, 1.0–1.5 m, 1.5–2.0 m, 2.0–2.5 m, and > 2.5 m aboveground.