Volume CSIEA (6). Published November, 01, 2017
www.jnsciences.org
E-ISSN 2286-5314

JOURNAL OF NEW SCIENCES
WWW.JNSCIENCES.ORG

The effect of crop load on the one-year-old shoot architecture and growth of the olive tree

Conférence Scientifique Internationale sur l'Environnement et l'Agriculture

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Abstract - The purpose of the current study was to evaluate the influence of the crop load level on the architectural parameters of the olive tree conducted in semi-intensive system without irrigation. Different morphological and architectural parameters of one-year-old shoots from two groups of trees, one with high crop load ('ON' trees) and the second with low crop load ('OFF' trees), were evaluated. Results founded in this study showed an important influence of the crop load level on the architectural characteristics of the one-year-old shoots in the olive tree. The shoot length and its tapering, the number and the proportion of lateral and apical shoots are the most affected traits by the crop load. The proportion and the number of the lateral shoots seems to have a critical role on the alternate bearing behavior, higher are higher is the productive potential of the tree. In addition, the shoot tapering may be having a key role on the shoot fertility, which needs a more deep investigation.

Keywords: Olea europaea, shoot growth, alternate bearing, crop load

1. Introduction

The alternate bearing, is a specific phenomenon of the fruit species, which characterized by an interannual variation of crop load. The level of this variation varied greatly among species (Monselise and Goldschmidt, 1982). In olive tree the high variation of the production between years is considered one of the most critical problems in this crop, causing important economical loss for growers and difficult crop management. However, this variation is not constant within the specie, but depend on others several factors, such as the variety, the cultural practices and the environmental conditions (Rallo et al. 1994).

Olive tree is one of the most important fruit tree species in the Mediterranean region characterized by low rainfall and high evapotranspiration. Olive orchards are generally conducted without irrigation, which aggravates the alternate bearing behavior (Lodolini et al. 2016). The biennal cycle of olive tree, typified by the alternation of vegetative and reproductive growths, is considered as an adaptation mechanism to the water resource scarcity (rainfall) and its inadequate distribution with the olive developmental phases (Monselise and Goldschmidt, 1982; Connor, 2005). The reduction of the photosynthetic activity, caused by the water stress under the rainfall conditions, increases the competition between vegetative and reproductive for assimilates and limits their availability.

In addition to the competition for assimilates under water stress condition, many other factors are suggested as determinant in the alternate bearing behavior in olive tree, such as the nutritional status and the hormonal balance. Turktas et al. (2013) have evoked a key role of nutritional control on the alternate bearing of olive, as shown by the differential expression of transcripts under different temporal phases and organs. In this sense, a clear effect of crop load on the nutritional status of olive tree has been reported. The N, P, K and Mg contents in leaves are lower following the 'ON' year (Fernandez et al., 1999). The hormonal factor is attributed principally to the olive seed development, which inhibit floral induction by a hormonal signal (Fernandez-Escobar et al., 1992; Baktir et al., 2004). However, little attention has been paid to the morphological and architectural features of the one-year-old shoots, which are the principal structure supporting production. In several species, the architectural characteristics are considered critical for the shoot fertility and production (Costes et al., 2006).

The purpose of the current study was to evaluate the influence of the crop load level on the architectural parameters of the olive tree conducted in semi-intensive system without irrigation.

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2. Material et methods

2.1. Plant material and site of the study

This study was conducted in the experimental farm of the National Agronomic Institute of Tunisia (INAT) situated in Mornag at north of Tunisia with a semi-arid climate. The orchard was planted with the 'Picholine' cultivar at the density of 200 trees/ and conducted without irrigation under standardized cultivation conditions. The trees were formed in vase form with uniform canopy volume, and maintenance pruning was minimal due to tree age and dryland growing conditions.

2.2. Experimental design and measurement

Eight trees with similar vigor were chosen during the November 2015, distributed randomly within the orchard, from which four with a high crop load (year 'ON') and four with low crop load (year 'OFF'). To assess growth and fructification, five units of ramification with similar size, were selected randomly around the canopy of each tree.

According to their position on the parent-shoot two types of shoot were considered, that are from lateral bud (Lateral shoots) or the shoot apex (Apical shoots). For each unit the total number of lateral and apical shoots developed on 2015 was counted. To assess the rest of the parameters eight shoots, four laterals and four apical, were randomly select within each unit. The length, the distance between the base and the extremity, the basal and the distal diameters, the angle with the vertical and the number of nodes of each shoot were recorded. Basing on these measurements we calculated three other parameters. The curvature index of the shoot is determined by dividing the shoot length by the distance between its base and extremity. The taper index of the shoot is calculated by subtract the distal diameter from the basal diameter of the shoot and dividing the result by the shoot length. The internodes length is determined by dividing the length of the shoot by its node number. In addition, to determine the influence of the crop load on the shoot fertility, the number of inflorescences was recorded the flowing year (April 2016) for each shoot.

2.3. Statistical analysis

To determine the influence of the crop load on the architectural parameters ANOVA analysis, for completely randomized design, were performed and means compared at P value$\leq$0.05 using LSD test. All statistical analyses were carried out using the analytical software Statistix v 8.0 Tallahassee, FL USA.

3. Results and Discussion

Results showed a significant influence of crop load on total number of shoots. Trees with high crop load present a higher number of shoots, than those with low crop load. In addition, the proportion of shoots type differ clearly according crop load. In fact, for 'OFF' tress two-thirds of the one-year-old shoots are growing from lateral buds and the reverse occurs for the 'ON' trees (Fig. 1).

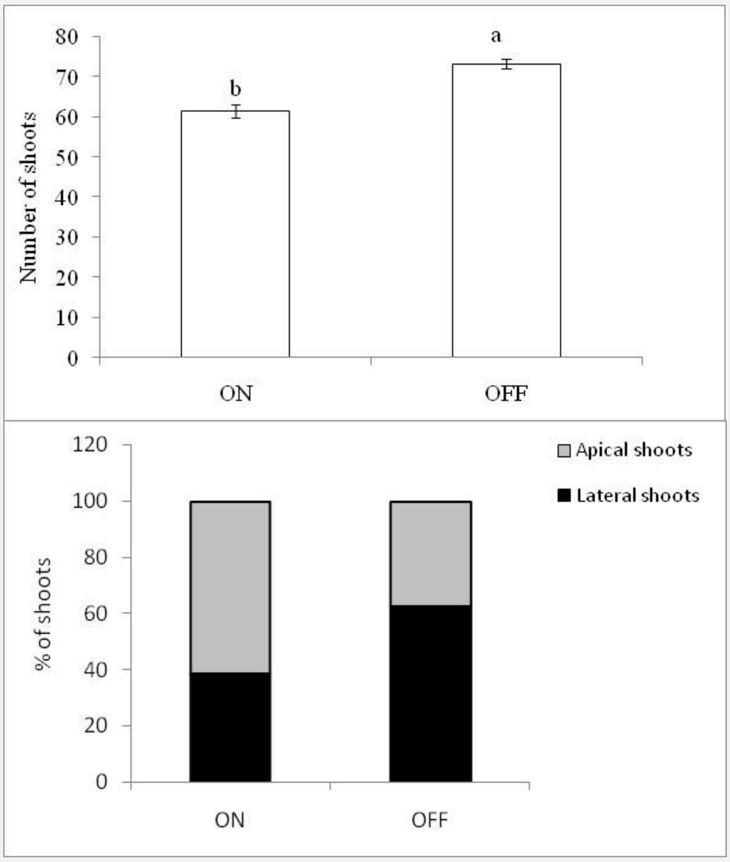

Figure 1. Number and percentage of apical and lateral shoots per unit of ramification for high (ON) and low (OFF) crop load olive trees. Two different letters indicate significant differences between means at $P \leq 0.05$.

The founded results revels the possibility to use the lateral and apical shoots proportions in determine the tree crop load historic. The low number of lateral one-year-old shoots and the important proportion of apical one-year-old shoots on the tree indicate that tree had a high crop load the previous year (the year of shoot development). In fact, Castillo-Llanque and Rapoport (2011) have been found during the 'ON' year in olive tree, the new shoots are growing mainly from the apical buds, because the lateral buds are growing in inflorescences. This suggestion matches with those obtained for the shoot growth. Indeed, shoots developed on trees with low crop load are longer and have longer internodes than those observed on high crop load trees, but both presented a similar number of nodes (Fig. 2).

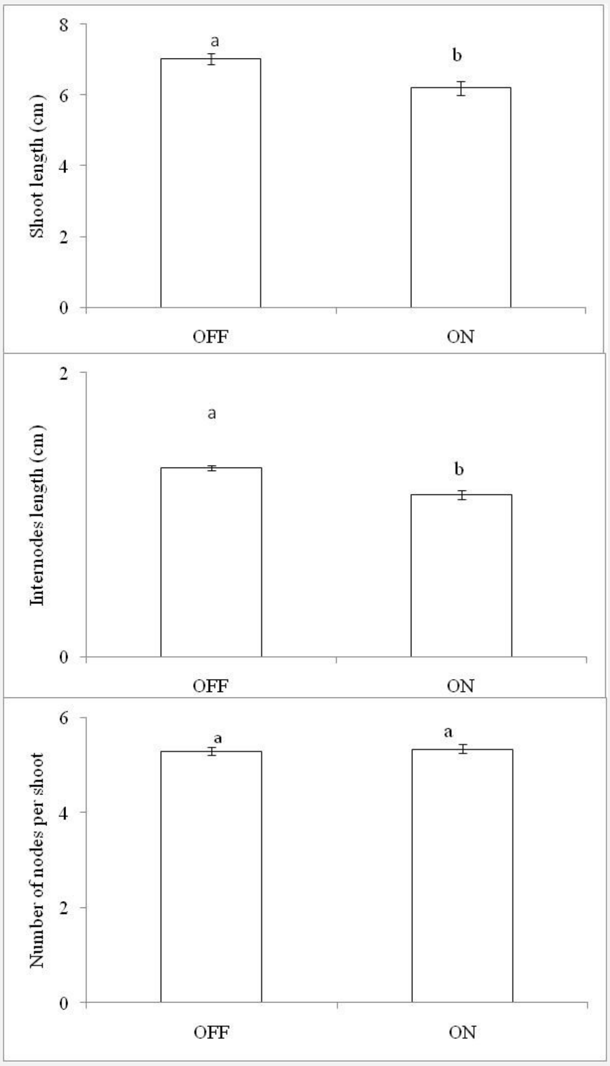

Figure 2. Number of nodes per shoot, internodes length and shoot length for high (ON) and low (OFF) crop load olive trees. Two different letters indicate significant differences between means at P≤0.05.

During the 'OFF' year a higher availability of assimilates privileged the vegetative growth and we can observe a longer shoots than those developed during 'ON' year, during which the competition for assimilates at their maximum due to the fruits development (Monselise and Goldschmidt, 1982).
The shoot curvature and its inclination regarding the vertical were not affected by the crop load (Fig. 3). This result may be indicating the strong genetic component of both parameters. In fact, Hammami et al (2012), studying young olive progenies architecture, have been founded a high heritability of the shoot orientation and curvature. In other hand, in olive tree, fertile shoots with high number of fruits tend to be more horizontal and curved as the fruits grow. Thereby, shoot orientation and curvature may be change after the reproductive development of the buds. In contrast to the shoot curvature and orientation, shoots developed on the 'ON' trees are more conic than those developed on the 'OFF' trees (Fig. 3).

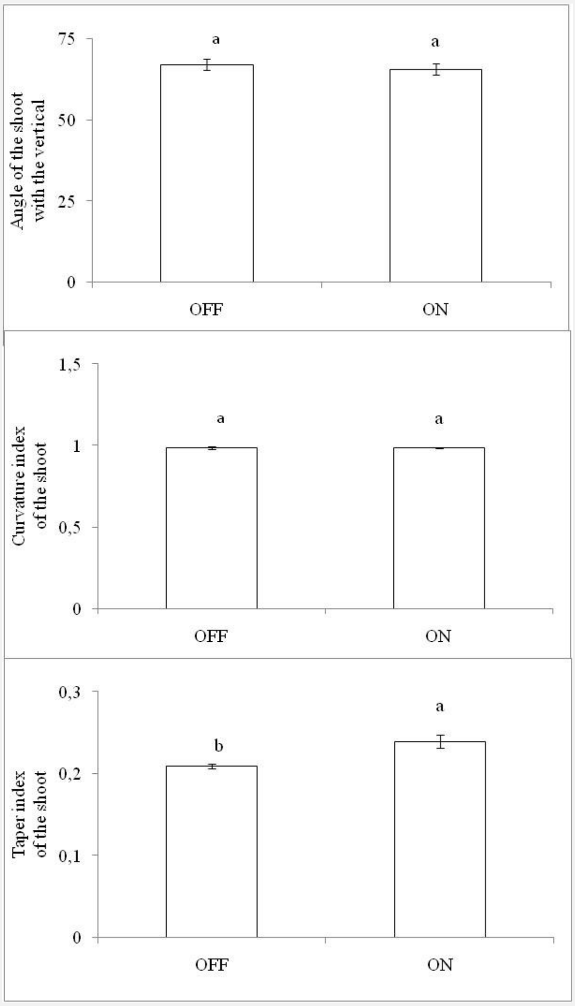

Figure 3. Taper and curvature indexes of the shoot and shoot angle with the vertical for high (ON) and low (OFF) crop load olive trees. Two different letters indicate significant differences between means at P≤0.05.

Until now the role of the shoot tapering on the physiological and morphogenetic process of the buds was unknown. However, the rapid change in the shoot diameter may be able to affect the sap flow and consequently the bud alimentation and fertility as occur for shoot curvature. In this sense, variation in conduit diameter is a compromise between hydraulic efficiency, safety, and the maximization of conductivity per growth investment due to conduit tapering (Sperry et al., 2008; Kotowska, 2015).

The crop load not only affects shoots growth, but also their fertility. The number of inflorescences per node of shoots was seven times higher for 'ON' trees in comparison with 'OFF' trees (Fig. 4).

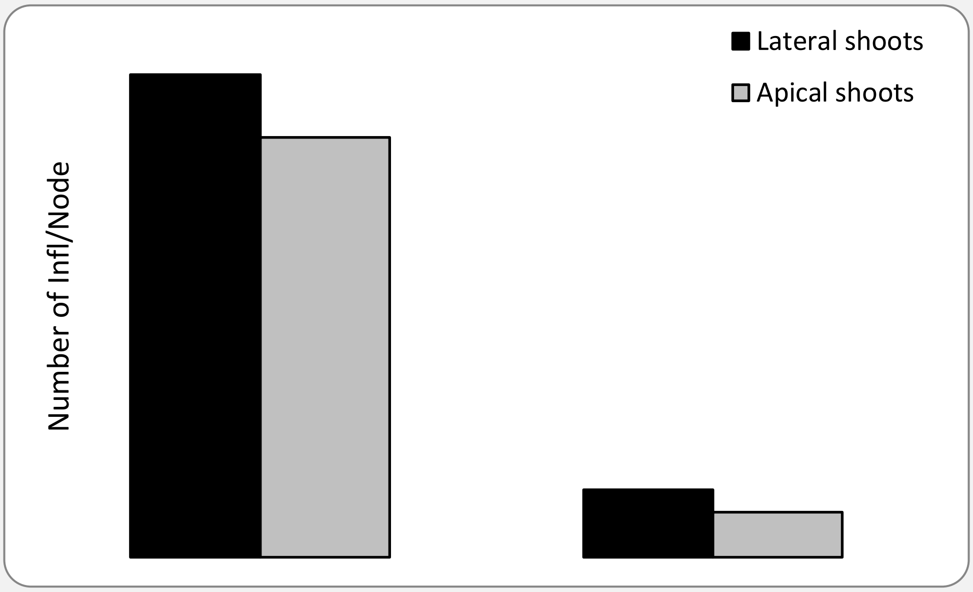

Figure 4. Number of inflorescences per shoot node of lateral and apical shoots for high (ON) and low (OFF) crop load olive trees. Two different letters indicate significant differences between means at P≤0.05.

Those results are consistent with other studies of the olive tree (Cimato and Fiorino 1986; Fernandez-Escobar et al. 1992; Ramos et al. 2000), which allows concluding that the high crop load on 'ON' trees, in comparison with 'OFF' trees, is not only due to the number of fertile shoots but also to their level of fertility. In addition, results showed differences on shoot fertility according to their position on the parent-shoot (Lateral or apical) for trees with high crop load. In fact, for 'ON' trees lateral shoots showed a greater number of inflorescence per node, so the difference on inflorescences number between 'ON' and 'OFF' trees was intensify, because the 'ON' have more lateral shoots than 'OFF' trees.

4. Conclusion

Results founded in this study showed an important influence of the crop load level on the architectural characteristics of the one-year-old shoots in the olive tree. The shoot length and its tapering, the number and the proportion of lateral and terminal shoots are the most affected traits by the crop load. The architectural characteristics of the shoots can provide information about the crop load history of the tree and also of its productive potential. In fact, the proportion and the number of the lateral shoots have a critical role on the alternate bearing behavior, higher are higher is the productive potential. In addition, the shoot tapering may be having a key role on the shoot fertility, which needs a more deep investigation.

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