Olive Root Growth with Different Organic Matters

V. Giorgi, C. Ponzio and D. Neri
Dept. of Environment and Crop Science
Polytechnics University of Marche
Via Brecce Bianche 60131, Ancona
Italy

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Abstract

The addition of organic residues from plant and/or animal origin in organic and biodynamic farming represents the basic practice to enhance overall soil fertility, thereby greatly influencing root development. The objective of our experimental work was to investigate the response of plant roots, in terms of growth and distribution, to the presence of different kinds of organic matter. Self-rooted plants of *Olea europaea* L. ('Tortiglione') were grown for 90 days in Plexiglas bench rhizotrons of 30 x 80 x 2 cm. The four treatments were: i) control (basic peat-vermiculite-sand substrate); ii) olive husks (O) (control + 10% in volume of dry olive husks); iii) hay (H) (control + 10% in volume of dry mixed grass hay); iv) olive husks and hay (OH) [control + husks (2%) and dry mixed grass hay (10%)]. After one year, the H treatment showed the highest root growth, number of roots and root dry weight, whereas the O treatment showed reduced root development, equivalent to the control, which produced the lowest root response. The OH treatment showed an intermediate degree of root growth between H and control. Mean root length and relative root growth rate were not influenced by the treatments. It can be argued that the controversial effect of olive husk (likely source of nutrients and cause of toxicity) resulted neutral to olive plant growth because of root plasticity. The hay amendment played a mitigatory role, likely reducing the phytotoxicity caused by the olive husks.

INTRODUCTION

Field observations of root dynamics are often resource demanding, tedious and time consuming, which is likely to somehow limit the investigation: in fact, roots typically are considered the "hidden half" of the plant, yet represent a constituent part of the plant system, in terms of biomass, functionality and energy consumption. Especially in organic farming, crop quality and productivity strictly depend on efficient soil-plant relationships as mediated by organic matter and soil biological activity (Raupp, 1997), and roots play a crucial role in these interactions.

Nutrients and phytotoxicity from organic matter decomposition represent driving factors for root development and diversification (Zucconi et al., 1981; Johnson and Biondini, 2001), making it essential to understand the dynamic of crop residues, particularly when they are used as soil conditioners, through a permanent or seasonal green cover or exogenous application.

Organic residues in the soil are variously re-elaborated by soil microrganisms through processes of progressive mineralization and humification during which some metabolic compounds are likely to become toxic for plants. The degree and duration of the toxic effect depend on the nature of the original matter (composition and physical properties), microorganism diversity and oxygen content (Zucconi, 2003; Neri et al., 2005).

Olive husks are by-products with conflicting characteristics: on one hand, they correspond to organic residues that are likely to pollute the environment if not well-managed, and because of that, its spreading in the field is strictly limited or even forbidden in some countries. On the other hand, husks often represent the only available source of organic matter in many rain-fed Mediterranean farming systems, which makes it very important not to neglect their full use in the olive orchards for fertilization purposes.

The multi-functional role played in organic orchards by the seasonal green cover (i.e., erosion control, green manuring, enhancement of above- and underground biodiversity, pest alleviation) is widely reported (Nicholls et al., 2000). In a recent experiment using split-pots, Giorgi et al. (2008) investigated the potential role that mulch coming from grass (hay) may exhibit in mitigating toxic effects of olive husks. Husks reduced shoot growth, whereas the addition of hay mitigated the husks' negative effect, significantly improving plant growth. In addition, the results indicated that olives were able to exert a selective placement of roots, depending on the bio-physical-chemical characteristics of the patches in the substrate. When the root could not find patches free from olive husks, root and shoot growth diminished greatly or even stopped completely, causing plant death before any kind of acclimation could occur.

In the present paper, we report an experimental work which was meant to investigate the architecture of olive roots in terms of growth and distribution against a non-uniform concentration of different organic matters, namely olive husks and dried grass, along bench-rhizotron profiles.

MATERIALS AND METHODS

Self-rooted plants of *Olea europaea* L. ('Tortiglione') were grown for one year in bench rhizotrons of 30 x 80 x 2 cm (Fig. 1). At the beginning of the second year of growth (March 2007), each rhizotron was opened and roots were cut at 30 cm from the upper edge. All the material in the lower part of the rhizotron was removed and sieved to separate the roots from the original substrate: root fresh weight and dry weight were recorded.

The lower part of the rhizotron was then replaced with a fresh mixture of peat, vermiculite and sand, to which different organic matters were added, according to the following four treatments (Fig. 1): 1) Control (C): peat, vermiculite and sand (1:1:1 in volume); 2) Olive husks (O): control + 10% (in volume) of olive husks powder (oven dried husks, grounded and sieved at 1 mm); 3) Hay (H): control + 10% (in volume) of hay (dry mixed grass), thinly ground; and 4) Olive husks and hay (OH): control + husks (2%) and hay (10%).

Then the rhizotrons were placed with an inclination of 25° from the vertical plane. Five replicates per treatment were tested for a total of 20 plants. Plants were maintained in a warm greenhouse for 90 days. Water was supplied twice a week by tap water both from the bottom and the top side of the rhizotron.

During the 90 days of the trial, digital pictures of each rhizotron were taken and analyzed with image analysis software (ImageJ). The length of each root and the number of roots per rhizotron were recorded. The mean length of a single root per plant and the relative root growth rate (Δ root length between two measurements/initial length) were calculated.

At the end of the trial, all plants were separated from the substrate and divided into aerial part (A), roots of the upper layer (R-up) and roots of the lower layer (R-low). Fresh weights were recorded at harvest, and dry weights were recorded after drying the material at 50°C for 48 hours.

All data were compared using analysis of variance (ANOVA) for all the parameters. The data were also checked for deviations from normality and homogeneity of variances. Means were reported by Duncan's multiple comparison test.

RESULTS

Root weight at the beginning of the experiment was similar in all the plants (data not shown). During the first two months after the new substrates application, all the plants were growing in the same pace. After the second month, the hay substrate induced a significant increase in root growth, while the olive husks treatment reduced root development to the level that was found in the control treatment, which was the lowest at the end of the experiment. The mixture of olive husk with hay substrate induced an intermediate level of growth (Fig. 2).

The number of roots was significantly higher in the substrate with hay, compared with the control and the olive husks alone. The addition of O and H in the same substrate induced an intermediate number of roots (Fig. 3). It is worth noting that two months after the addition of the new substrate, root proliferation in H was 1.8 times higher than in the control, and after three months it was 2.67 times higher, on average.

The average length of a single root was not significantly changed by the treatment (Fig. 4), even though the addition of olive husks to the substrate induced the minimal final root length (5 cm on average).

Relative root growth rate sharply decreased in all the treatments over the first two months of the experiment; during the third month, however, plant roots in the hay substrate showed a higher recovery (Fig. 5) while the control and olive treatments were similarly stunting, and OH showed an intermediate value.

Dry weight of roots collected in the lower sector of the rhizotrons at the end of the experiment was not significantly different, with the maximum value for the H treatment and the lowest for the control and O application. The OH mixture presented an intermediate root dry matter accumulation (Fig. 6).

Roots collected in the upper sector of the rhizotrons (the original substrate) did not show any significant difference in dry weight, while the husks induced the minimum value (Fig. 6).

Above ground dry weight did not show any significant difference. Hay induced the highest value at the end of the experiment and control the lowest (Fig. 6).

DISCUSSION

Limited root growth for the control substrate could be partly due to its poor nutrient content or the low pH of the original peat, which was not optimal for olive growing. Root growth in the O substrate behaved in a similar manner, likely coupling the positive effects of higher nutrient content with the phytotoxicity which was demonstrated by previous experiments (Giorgi et al., 2008). Hay application produced a positive effect on the roots. We assumed that this positive effect completely counterbalanced the toxic effect of olive husks, as it was demonstrated by the mixed treatment (OH), even though this treatment had a lower husk application per plant (2% vs. 10% in the O treatment).

The root architecture was modified and the two layers of the rhizotrons were occupied differently, depending on the type of organic residues present. The root growth in the layer with hay residues (alone or with olive husk residues) was higher, indicating a possibly better exploitation of organic matter by the roots. The presence of olive husk residues alone definitely reduced the amount of roots in the amended layer; however roots in the upper layer seemed to better cope with the stress factor, revealing possible acclimation capacity by the plant in the substrate without organic matter.

Above-ground production at the end of the trial period followed this pattern as well. Although it was not supported by statistical evidence, olive plants responded best when hay was applied alone. The presence of olive husk residues showed a slight increase in comparison with the control, but never reached the maximum value of the hay amendment. This could mean that the olive plant was able to acclimate its root system to the olive husk residues, changing architecture and growth rate to counterbalance the possible root stress and produce a likely positive exploitation of the organic residues in the long run. Once decomposed, olive husks are likely to become a very fertile substrate, provided the plant is able to hold up to the initial phytotoxic stress by finding an area in the soil free from husks.

The presence of hay always seemed to mitigate the possible phytotoxic effect of the olive husks, suggesting there may be an appropriate field combination of agronomic practices when dealing with the issue of recycling olive oil by-products in organic olive orchards. Increasing organic matter biodiversity has been proven to accelerate decomposition processes, hence reducing toxic effects, and allowing the development of a more diverse microbial population (Zucconi et al., 1981).

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Figures

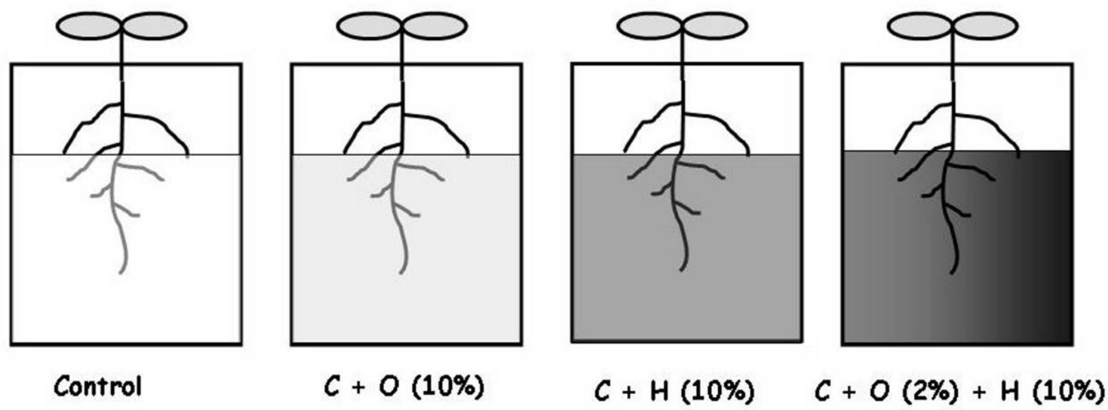

Fig. 1. Bench rhizotrons and treatments distribution. The upper sectors (0 to 30 cm) were left unchanged while the lower sectors (31 to 80 cm) received the reported treatments.

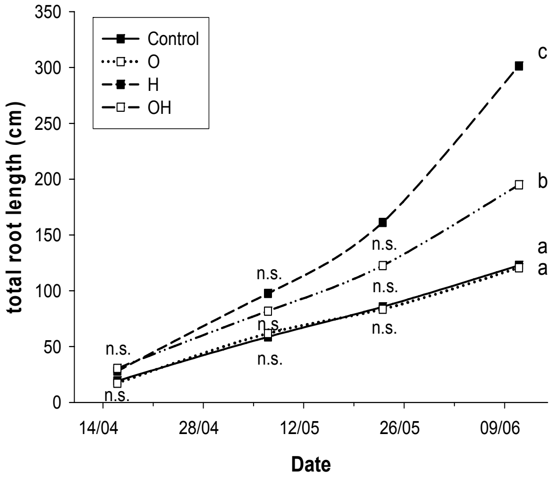

Fig. 2. Total root length. Different letters indicate significant differences between the values of the last measurement (Duncan's test P<0.05).

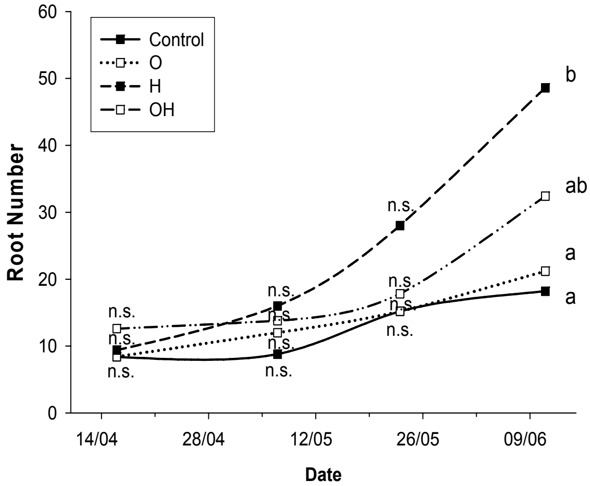

Fig. 3. Root number. Different letters indicate significant differences between the values of the last measurement (Duncan's test P<0.05).

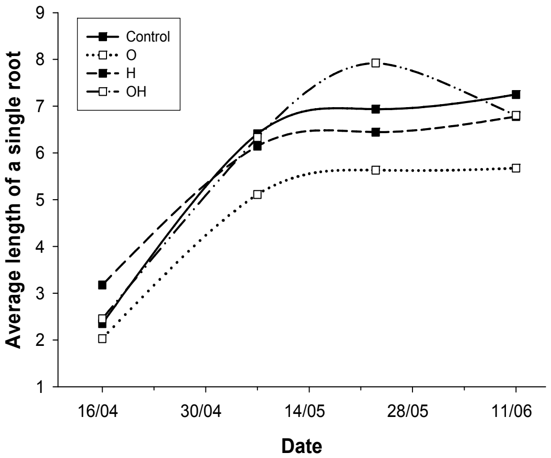

Fig. 4. Mean length of a single root. The differences were not significant.

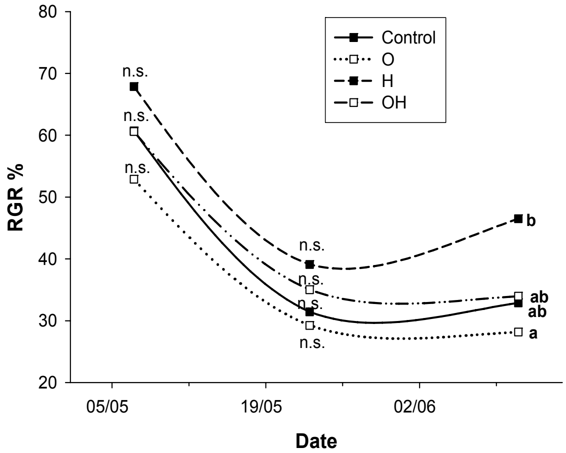

Fig. 5. Relative growth rate of the roots (RGR). Different letters indicate significant differences between the values of the last measurement (Duncan's test P<0.05).

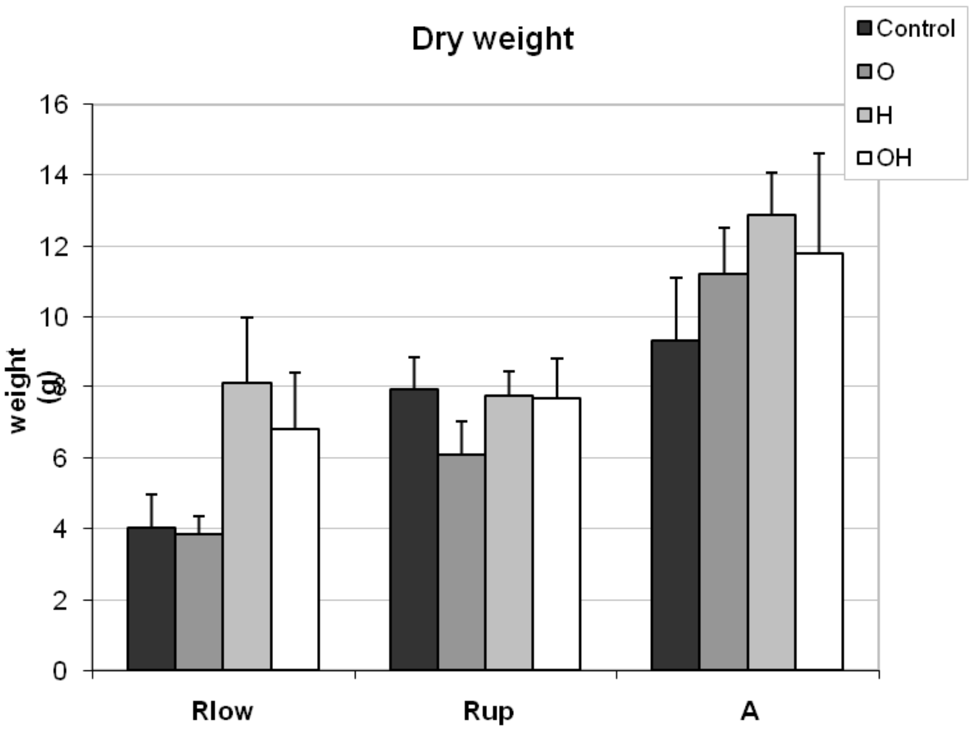

Fig. 6. Root dry weight at the end of the trial in the lower sector (Rlow - new) and in the upper sector (Rup - former). Dry weight of aerial plant part. Differences were not significant. Error bars represent SE (*n*=5).