Soils are Alive Newsletter

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The University of Western Australia

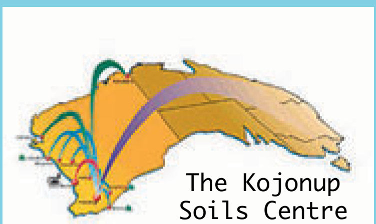
Welcome...

Mycorrhizal fungi form symbiotic associations with plants and in this newsletter, we learn about their relationship with olive trees. Further research will help us to discover more about the possible benefits of these organisms that have been living under our feet for thousands of years.

Lyn Abbott

The Kojonup Soils Centre NEWS

The Kojonup Soils Centre is being established to promote knowledge of soil to the farming community and others interested in this important natural resource.



Acknowledgements

This Newsletter was established with support from the Ian Potter Foundation which is also supporting the development of a website on soil health:

http://ice.agric.uwa.edu.au/soils/soilhealth/

The Land Management Society (LMS) initiated the *Know Your Soil Biology:Soils are Alive* workshops that we present throughout Western Australia.

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Mycorrhizas and Olive Trees: Letting Nature take its course

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How has the European olive (*Olea europaea)* been successfully grown on marginal soils in the Mediterranean basin for over 5000 years without added fertiliser?

The answer lies in the soil, where the olive trees form strong relationships with arbuscular mycorrhizal (AM) fungi that increase phosphate (P) uptake and plant growth under low phosphate conditions.

In Western Australia, there are about 1.6 million olive trees, making up about 21 % of the Australian total of 7.65 million.

The levels of P required for optimal olive growth and production have not been fully established due to the relatively recent start of the industry in Australia, and would be dependent on soil type and fertility. In general, olives in Australia are fertilised with an all-purpose fertiliser given either directly to the trees or through irrigation. These fertilisers contain all the essential minerals for plant growth including P.

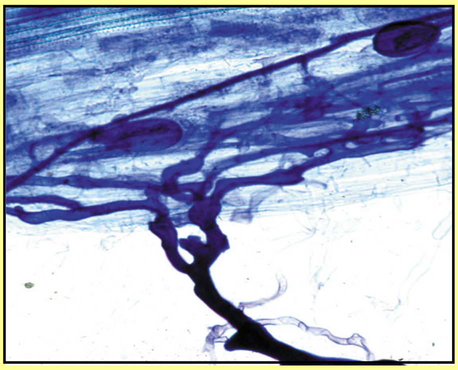
Recent study

Studies done on other woody species such as mulberry, citrus and grape that have shown that phosphate uptake is greater in plants with roots colonised by AM fungi, especially at low soil phosphate levels. In a recent study, the degree of AM colonisation in the European olive was determined to assess the effect on phosphate uptake, plant growth and tissue phenolic content.

Experiment details (see over......)

What are arbuscular mycorrhizas?

Arbuscular mycorrhizas (AM) are associations between soil fungi and plant roots. The fungi live inside and around the roots of the plants and both partners benefit from the relationship. The host plants usually receive mineral nutrients obtained from the soil, while the fungus obtains food from the plant in the form of carbon compounds produced via photosynthesis.



* "Mycorrhizal colonisation and its effect on growth, phosphorus uptake and tissue phenolic content in the European olive (*Olea europaea L.*)" Adv.Hort.Sci., 2002 16(3-4):109-116

The soil used to grow the cuttings in this experiment had been treated to remove any inherent AM fungi and all plants were given the same amount of nutrients (other than P) required for healthy growth.

Cuttings of the olive cultivar Frantio were grown in pots. The treatment plants were inoculated with AM fungi and both the treatment and the control pots received P at the following levels: 0, 6.7, 20, 60, 180 mg P/kg soil.

Mycorrhizal colonisation

In the inoculated plants, AM colonisation was high across the first three rates of applied P and the roots were denser and more branched (see Fig. 1.). At the highest rate, however, colonisation decreased significantly. This may have been due to the rate of root growth being faster than the rate of fungal colonisation or that at high P levels, the plants increase the amount of phenolics in their roots, effectively restricting mycorrhizal colonisation. Alternatively, when the plant phosphate status is low, the plant roots may exude specific signalling compounds that encourage colonisation.

No mycorrhizal colonisation was found in any of the non-inoculated plants.

Plant growth

Maximum plant growth was actually reached without the addition of any extra P to the soil in the inoculated plants. (see Fig. 2). This showed that the fungi were able to extract enough P from the soil to sustain maximum growth of leaves, shoots and roots without the need for any added P. At low P levels, inoculated plants had greater growth above ground than the non-inoculated plants. The likely reason for this is that enhanced P nutrition in mycorrhizal plants leads to increased shoot growth and a change in allocation of resources to roots.

Fig. 1 - A comparison of the root systems of inoculated (left) and non-inoculated (right) self rooted olive cuttings (cv Frantoio) under the zero applied phosphate treatment.

At the highest rate of applied P, as well as reduced AMF colonisation, plant growth was also reduced and to a greater extent in the inoculated olive plants. This suggests that mycorrhizal colonisation may increase the toxic effects of high soil P levels.

Phenolic concentrations in the leaves

The levels of leaf phenolics in the inoculated plants did not change significantly over the different levels of applied P. In the non-inoculated plants, increasing P levels resulted in a decrease in the total phenolics found in the leaves. Enhancing nutrient status would result in increased plant growth and vigour and a decreased need to produce defence compounds.

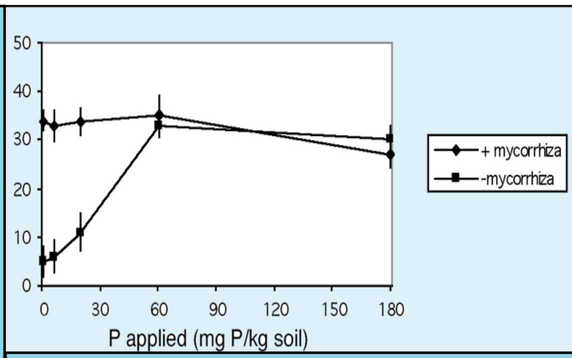


Fig. 2 - Increase in the average number of leaves per cutting (vertical scale) at 20 weeks of growth over applied phosphate levels (0-180 mg P/kg soil, horizontal scale) for mycorrhizal inoculated and non-inoculated, self rooted olive cuttings (cv Frantoio). Bars on graph indicate standard error of mean (S.E.M.).

What are Phenolics?

Phenolics are compounds produced by plants that often have antimicrobial and antifungal properties. They are commonly produced in times of stress, such as when the plant is affected by disease or low nutrient availability and could be a survival strategy against attack by herbivores or pathogens. When nutrients are deficient, growth is restricted because the plants produce more compounds like phenolics and lower amounts of protein and carbohydrate needed for growth.

Phenolic concentrations in the roots

With increasing P, total phenolics in the inoculated roots remained relatively stable, but specific phenolics in the cell walls did increase. This would effectively create a barrier to further mycorrhizal infection of the roots. The reason for this may be that at higher phosphate levels, the plants do not require the mycorrhizas to extract P from the soil, in fact the presence of fungi in their systems at this level may result in an unwanted drain of photosynthates.

Enhancing AM fungi in the soil

Studies have shown that soil disturbance leads to lower levels of AM fungi. In addition, high applications of fertilisers, in particular P, can result in lower levels as will some pesticides, fungicides and herbicides. Increasing soil organic matter has been shown to increase levels. There are now several products on the market that contain AM fungi. The fungi in these products tend to be non-specific in terms of host plant species, so their effects on olives are unknown. More research would need to be carried out to determine what species or strains and what amount of fungi would be most optimal, especially given that different olive varieties show different levels of root colonisation by AM in the field. It is therefore likely that certain olive varieties will respond differently, and this also needs further investigation.

Summary

Under conditions of low soil P, mycorrhizal associations are highly effective at increasing plant P levels and above ground plant growth and maintaining the level of phenolics in the leaves and roots. AMF effectively increase the absorptive surface of a section of root over one hundred times.

Enhancing natural plant-fungi interactions may lead to other environmental benefits as well. With reduced need for fertiliser, leaching of P into groundwater and waterways will be reduced, decreasing the chance of algal blooms. This knowledge also makes the olive easier to integrate into the organic system.