Evaluation of Legume-Cereal Seed Mixtures for Enhancement of Soil Fertility, Carbon Storage and Biodiversity in a Low-Intensity Olive Orchard.

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Introduction

Cover crops can be used in rainfed orchards, in Mediterranean semiarid agrosystems, in order to improve and maintain soil quality. Cover plants are mainly comprised of natural vegetation or sown plants, (such as legumes to enhance nitrogen inputs) which grow during early autumn and throughout the winter in the area between the olive tree rows. The growth of cover crops is usually disrupted by tillage in late March or early April in order to avoid the competition for resources, particularly for water, which may reduce crop production. The plant residues may be left on the soil surface or mechanically mixed into the first 10 cm depth of the soil. Cover crops have great benefits such as the efficient reduction in soil erosion, the increase of soil organic matter and the improvement of several physical, chemical and biological properties of soil compared to conventional tillage. Furthermore, during plant residue decomposition, nutrient release could support some of the requirements of the olive crop.

The aim of this study was to evaluate the effects of various cover crops on inorganic forms of soil nitrogen, carbon storage and biodiversity of a low intensity olive orchard.

Methods

A six-month field experiment, from autumn 2014 to spring 2015, was carried out in Chania Prefecture (35°29'21.6"N, 24°01'53.9"E) within a 50 year-old low intensity olive orchard, with planting density of 100 trees ha^{-1}.

The experiment was consisted of six treatments which were:

i.natural vegetation

ii.bare soil (use of herbicides to eliminate vegetation)

iii.only oats (*Avena sativa*)

iv.only vicia (*Vicia sativa*)

v.a mixture of five legumes (*Vicia sativa*; *Pisum sativum* subsp. Arvense; *Trifolium alexandrinum*; *Vicia faba* var. minor and *Medicago sativa*)

vi.a mixture of five legumes with oats (*Vicia sativa*; *Pisum sativum* subsp. Arvense; *Trifolium alexandrinum*; *Vicia faba* var. minor; *Medicago sativa*, and *Avena sativa*).

These treatments were attributed to experimental units of 20 m^2, with three replications and arranged according to a completely randomized-block design. For seeding rates, the oat and hairy vetch treatments were seeded at rates of 300g/seed per plot. For both mixtures 60 g had been weighed from each individual species. The sowing was carried out manually on December of 2014. The seeds were incorporated in the soil by tractor with a rotary tiller pass.

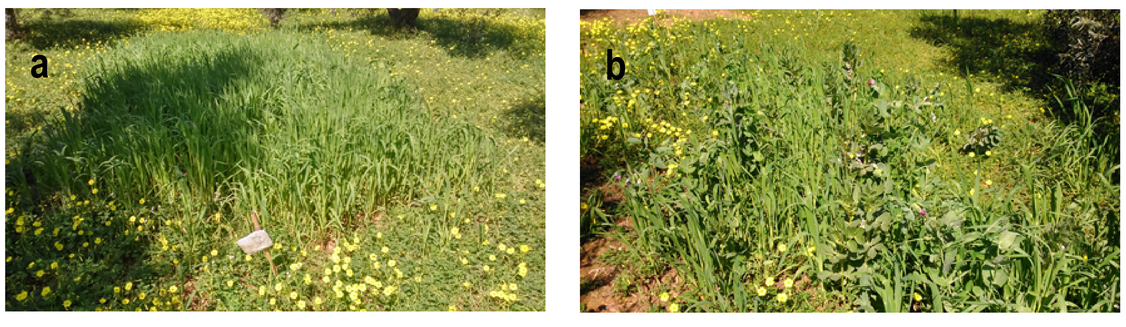

Figure 1. The photos illustrate two different treatments: a) only oats, and b) 6 mixed species

The soil nitrate and ammonium concentrations were determined every 15 days. The depth of the soil samplings was varying according to the growth rate of the cover plant roots. The soil depths were separated at 0-10, 10- 20 and 20-30cm. At the 0-10 cm soil depth, were conducted seven soil samplings, at 10-20cm four and at 20- 30 cm, one soil sampling. The samplings were started about one month after the sowing.

The soil microbial activity was estimated indirectly based on soil CO_2 emission produced from soil by inserting plastic rings, with 5.9 cm length and 10.35 cm diameter. The measurement was taken by a 6400-09 Soil CO_2 Flux Chamber, through the LI-6400XT device supplied by the LI-COR company. The measurement was carried out twice, on March and April.

Results

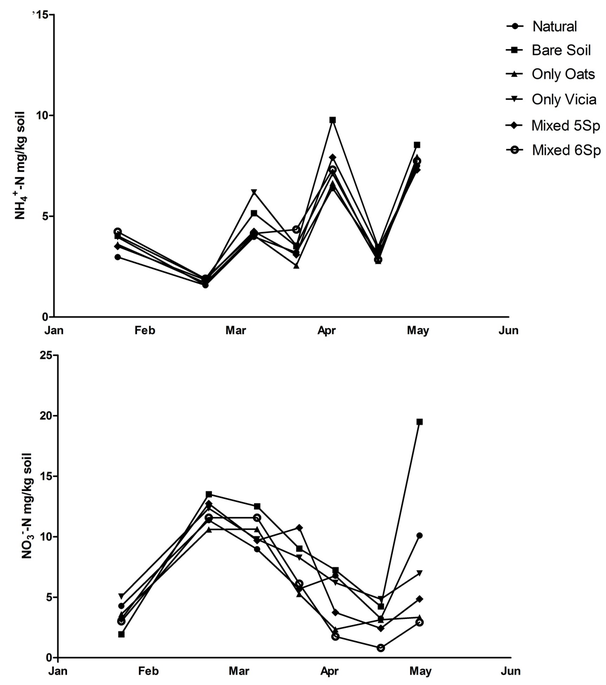

Figure 2. Variations of NH_4-N and NO_3-N at 0-10cm soil depth during the experimental period.

In all treatments, the first two samplings (at 0-10cm soil depth) revealed a reduction of NH_4-N concentration through time, and this can be explained by two main reasons: first, the initial slow mineralization of organic matter; and second, NH_4-N was nitrified to NO_3-N as quickly as it was mineralized which can be seen clearly from the sharp increase of the initial amount of NO_3-N in the same period.

The concentrations of NH_4-N and NO_3-N, at 10-20cm soil depth, followed the same trend as at 0-10cm depth, mainly due to the similar soil conditions.

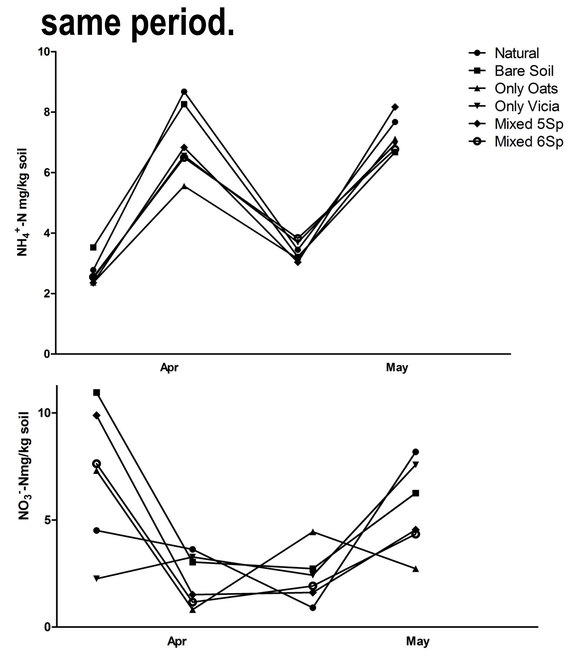

Figure 3. Variations of NH_4-N and NO_3-N at 10-20cm soil depth during the experimental period.

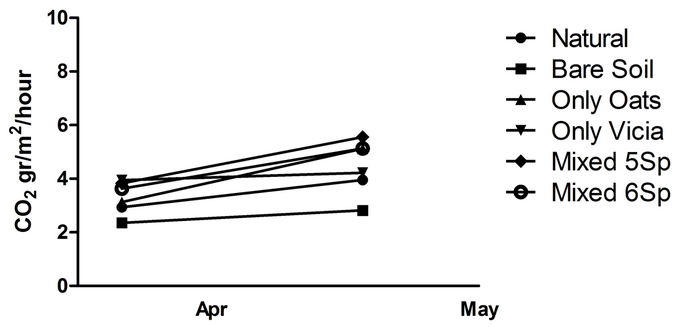

Figure 4. Changes of CO2 emissions expressed in g/m2/h for the six soil cover treatments

The results reveal that the main trend was an increment in CO_2 emissions combined with temperature increase. CO_2 was produced as a result of microbial activity for soil organic matter decomposition. Therefore, CO_2 emissions were influenced by all factors that stimulate soil organic matter decomposition or microbial activity, such as the temperature increase between March and April.

Conclusions

- Significant variations in soil NO_3-N and NH_4-N concentrations were observed during the studied experimental period.
- The inorganic nitrogen forms in soil will be transferred as organic matter in the plant tissues and will be released back slowly, as nutrients during decomposition.
- The amount of soil nitrogen which was not uptaken by olive trees, nitrates in particular, was uptaken by cover crops and a significant part of it was protected not to be lost from the soil due to different factors such as leaching or volatilization in gaseous forms.
- Consequently, cover crops could play an efficient role, as a sink for the inorganic forms of nitrogen.
- Soil CO_2 emissions increased with plant growth and air temperature raise, due to the increase of soil microbial activity.

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