

Using innovative legume-based mixtures as cover crops in a multi-functional olive system

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Abstract

The main objective of this experiment is to provide useful indications on sustainable management of multi-functional olive systems under Mediterranean rainfed conditions by analysing the effects of different soil management on olive trees. Two field trials were established in 2022 in Italy and Lebanon, using a randomised block design and comparing four treatments: (1) cover crop with innovative mixture (IM); (2) cover crop with commercial mixture (CM); (3) natural cover + fertilization (NC); (4) traditional soil tillage + fertilization (ST). The preliminary results referred to the first year showed a better establishment of NC compared to both mixtures, regardless of whether it is below or outside the tree canopy. The higher grass-based biomass produced by NC below the tree canopy may have influenced the competition for available soil water between the sward and tree components. Regarding the water potential of olive trees, during the period of greatest water deficit, ST showed lower levels of water potential and NC showed a significantly lower photochemical efficiency. Moreover, NC promotes a smaller fruit size while no significant differences emerged between the other treatments.

Keywords: cover crop, soil management, olive grove, Mediterranean environment

Introduction

Among different soil management techniques with a low environmental impact, an important role is given to cover crops, not only for production purposes but also to ensure soil fertility year after year (Mercenaro *et al.*, 2014). Temporary or permanent cover crops can improve rhizosphere conditions and tree mineral nutrition, increase soil bearing capacity, reduce soil erosion and N-leaching, etc. (Arias-Giraldo *et al.*, 2021). However, cover cropping may cause a reduction in water availability for trees, with potential negative effects on yields, particularly under dry conditions in Mediterranean environments. On the other hand, cover cropping can provide additional forage production for sheep or horse grazing. The main objective of this experiment is to provide useful indications for the sustainable management of multi-functional olive systems under Mediterranean rainfall conditions by analysing the effects of cover crops on olive groves.

Materials and methods

Two field trials were established in January 2022 in Sardinia (Italy) and Lebanon, using a randomised block experimental design with three replications and plot of 1000 m². Four treatments were compared: (1) cover crop with sowing of innovative forage legume-based mixture (IM) (*Medicago polymorpha*, *Trifolium brachycalycinum*, *T. yanninicum*, *Lolium rigidum*); (2) cover crop with sowing of commercial complex forage mixture (CM) (*Dactylis glomerata*, *Festuca rubra*, *L. multiflorum*, *L. perenne*, *M. polymorpha*, *Ornithopus sativus*, *T. incarnatum*, *T. michelianum*, *T. resupinatum*, *T. subterraneum*, *T. yanninicum*); (3) natural cover + fertilization (NC); (4) traditional soil tillage + fertilization (ST), as reference treatment. Before sowing, we carried out a minimum soil tillage followed by fertilization (30 kg P ha⁻¹). The data

collection conducted on the grassland sward, below and outside the tree canopy, considered the following parameters: soil cover percentage and seedling establishment in the first year (sampling area 25×25 cm), dry matter yield (DMY) and its botanical composition (sampling area 100×50 cm). Only one cutting date was applied at a height of 5 cm, at the end of May 2022. The effects on physiological response of olive trees were determined by monitoring: (1) water status as stem water potential (SWP), monitored through the Pressure bomb; (2) photosynthesis efficiency (Fv/Fm ratio); (3) olive production. One-way ANOVA and Tukey's test were applied to test differences between treatments for each variable (P -value <0.05). In this contribution only the results of the trial conducted in Sardinia are presented and discussed.

Results and discussion

Concerning the sward component, a higher percentage of soil cover and a higher presence of legume below the tree canopy than outside, during the establishment phase, were observed in CM (15 vs 10% and 5 vs 1%, respectively). Furthermore, IM showed a higher DMY below than outside the tree canopy (0.64 vs 0.41 Mg ha⁻¹, respectively). These results can be explained by the higher soil moisture conditions below the tree canopy. Outside the tree canopy, NC showed better establishment than both mixtures, with a higher number of seedlings m⁻² and greater soil cover; furthermore, in NC we observed a significantly higher presence of grasses and other non-legume species (Table 1A). In both mixtures we observed a significantly greater presence of legume species. Below the tree canopy, NC showed similar performance; however, IM showed a higher presence of legume and lower presence of grasses than CM. Regarding DMY, in the NC plots outside the tree canopy we observed a lower biomass moisture compared to both mixtures and a higher contribution of grasses compared to CM (Table 1B). Below the tree canopy, NC showed higher DMY than the other two cover crops, with lower biomass moisture, higher contribution of grasses and lower contribution of other non-legume species.

Table 1. Comparison of the establishment parameters (A) and comparison of the dry matter yield (DMY) (B) between the three cover crop treatments in the first year of the experiment.¹

A					
Treatment	Soil cover (%)	N. seedlings m ⁻²	Grass (%)	Legume (%)	Other species (%)
Outside the tree canopy					
Innovative mix	17 ^b	720 ^b	25 ^b	74 ^a	1 ^b
Commercial mix	10 ^b	652 ^b	32 ^b	67 ^a	1 ^b
Natural cover	86 ^a	2,305 ^a	86 ^a	3 ^b	11 ^a
Below the tree canopy					
Innovative mix	14 ^b	334 ^b	22 ^c	74 ^a	5
Commercial mix	15 ^b	496 ^b	43 ^b	53 ^b	5
Natural cover	84 ^a	2,443 ^a	78 ^a	0 ^c	22
B					
Treatment	Yield (Mg DM ha ⁻¹)	Moisture (%)	Grass (%)	Legume (%)	Other species (%)
Outside the tree canopy					
Innovative mix	0.41	25 ^b	36 ^{ab}	36	28
Commercial mix	0.45	25 ^b	5 ^b	51	44
Natural cover	1.09	41 ^a	91 ^a	0	9
Below the tree canopy					
Innovative mix	0.64 ^b	27 ^b	6 ^b	22	71 ^a
Commercial mix	0.38 ^b	25 ^b	14 ^b	26	60 ^a
Natural cover	1.07 ^a	40 ^a	81 ^a	0	19 ^b

¹ Different letters indicate significantly different means in different treatments (P <0.05).

With regard to the eco-physiological response of olive plants, SWP showed a similar trend among the four treatments under observation (Figure 1A). From June to the first decade of September, olive trees showed a gradual increase in SWP, in response to reduction in soil water content. Only in August and until the rainy event in late September, the SWP of ST showed statistically lower values than the other cover crop treatments. Moreover, Fv/Fm ratios in all treatments dropped below 0.70, suggesting significant photo-inhibition (Figure 1B), also conceivable by leaves showed occasionally high temperature values in the season (data not shown). During the driest and hottest period of the season, the olive plants subjected to ST showed the highest photosynthetic efficiencies. Even if only at one sampling date, NC promoted a greater decrease in photosynthetic efficiency. With regard to yield, the average weight of the olive in NC was statistically lower than IM, CM and ST (1.68 g, 1.97 g, 2.01 g and 2.18 g, respectively).

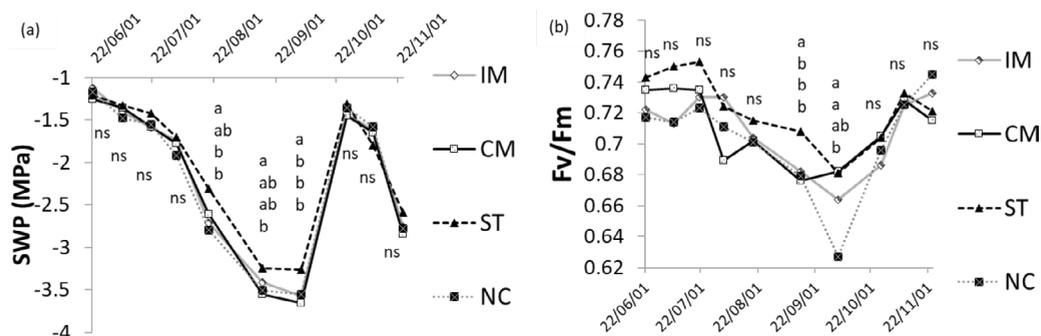


Figure 1. Stem Water Potential (SWP, megapascal = MPa) (A) and photosynthetic efficiency (Fv/Fm) (B) under four different soil management treatments (IM = innovative mixture; CM = commercial mixture; ST = soil tillage; NC = natural cover) during the study period (10 sampling dates). Different letters indicate significantly different means; ns = no significant difference ($P < 0.05$).

Conclusions

The preliminary results of our study showed a better establishment of the natural cover compared to both mixtures, regardless of whether it is below or outside the tree canopy. The higher DMY produced by NC may have influenced the competition for available soil water between the sward and tree components. At least as far as yield aspects are concerned, the use of natural cover is not recommended in Mediterranean environments where irrigation cannot be used. It will be very important to monitor the long-term effects on competition for water, nitrogen and at the same time the provision of ecosystem services.

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References

- Arias-Giraldo L.F., Guzmán G., Montes-Borrego M., Gramaje D., Gómez J.A. and Landa B.B. (2021) Going beyond soil conservation with the use of cover crops in Mediterranean sloping olive orchards. *Agronomy* 11 (7), 1387.
- Mercenaro L., Nieddu G., Pulina P. and Porqueddu C. (2014) Sustainable management of an intercropped Mediterranean vineyard. *Agriculture, Ecosystems and Environment* 192, 95-104.