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SHORT-TERM EFFECTS OF GREEN COVER ON SOIL QUALITY AND PLANT BIODIVERSITY OF MEDITERRANEAN ORGANIC OLIVE GROVES

SUMMARY

Environmental impacts, low yields and high production costs of conventional agriculture threaten the ancient olive groves which are an important Mediterranean benchmark. Implementation of low-impact and cost-effective agricultural practices and evaluation of their short-term effects under organic management are challenges for sustainable management. This work aimed to evaluate the short-term effects of green cover on soil quality and plant biodiversity, focusing on selecting sensitive indicators by comparing organic and conventional management systems. Two green covers - mixed cover crop species (ORG-MCCS) and natural cover (ORG-NATVEG) - were compared with conventional groves (CONV). Soil quality and plant biodiversity were evaluated before and after green cover application. The results showed that certain physical and chemical and most measured biological soil parameters differed significantly between treatments. Moreover, ORG-MCCS performed better than ORG-NATVEG. The parameters were selected to be sensitive indicators. In conclusion, the present work gives further information on the effects of management systems and green cover application on olive orchards. Impact assessment of agricultural practices on plant and soil biodiversity and testing of the selected indicators in similar studies could help in designing sustainable olive-growing practices.

Keywords: Grassing, organic olive groves, sustainability, indicators, biodiversity

INTRODUCTION

The environmental, socio-cultural and economic values are among the most perceived important values in the Mediterranean Region. Natural value, environmental quality and cultural heritage linked to extensive farming practices

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would allow characterizing them as "high natural-value farmlands" (Calabrese et al., 2015). These qualities positively or negatively are affected by agricultural practices depending on cropping systems and farm conditions. The Mediterranean ancient olive orchards (AOOs) play an important role for the Mediterranean basin to be one of the 34-biodiversity hot spots on Earth. Olive tree is one of the oldest known cultivated trees are a cultural and historical symbol of the basin (Kabourakis, 2012). Traditionally, olives were management with extensive agricultural practices and recognized as high ecological and cultural values (Calabrese et al., 2015). Environmental impacts, low yields and high production costs of conventional agriculture threaten the AOOs, which are an important Mediterranean benchmark. Intensification and implication of agricultural practices to reduce the cost of production has led to the widespread bare-soil practice. This can result in detrimental impacts on soil quality and plant biodiversity (Calabrese et al., 2015; CENT.OLI.MED, 2012). Implementing alternative farming practices, which are environmentally sound – conserve natural resources (Soil, water and biodiversity) and minimize the cost of production under organic management are promising. Application of cover crop using mixture of species is among the best alternative and beneficial practices (Clark 2007). Implementation of low-impact and cost-effective agricultural practices and evaluation of their short-term effects under organic management are challenges for sustainable management. This work hence aimed to evaluate the short-term effects of green cover on soil quality and plant biodiversity, focusing on selecting sensitive indicators by comparing organic and conventional management systems.

MATERIAL AND METHODS

The short-term effect of soil green cover practice –"grassing" on soil physical, chemical and plant biodiversity parameters on AOOS under organic management system during autumn 2011 to autumn 2012 was successfully investigated. The study was conducted in Torre Guaceto State Nature Reserve, Apulia Region (South Italy) (Fig.1A) with the aerial photo of the surveyed fields (Fig.1B).

This study quested alternative low-impact, cost-effective alternative to the environmentally detrimental practice of leaving the soil bare in monumental olive orchards. Two types of "Grassing" practices- mixed cover crop species (ORG-MCCS) and spontaneous natural cover (ORG-NATVEG) – under organic management were compared with conventional orchards (CONV).Several soil quality and plant biodiversity parameters were evaluated before (T0) and after (T1) green cover application during autumn 2011 and autumn 2012 (Table 1). Twenty six commercially mixed native species from seven different families mostly (80%) from the Fabaceae family (Table 2) were sown on ORG-MCCS_3a & 4a while ORG-NATVEG_3b & 4b were allowed to grow on (Fields 3b and 4b) at the same time the CONV orchards are managed as widespread practices that leaves the soil bare (Fig.1)

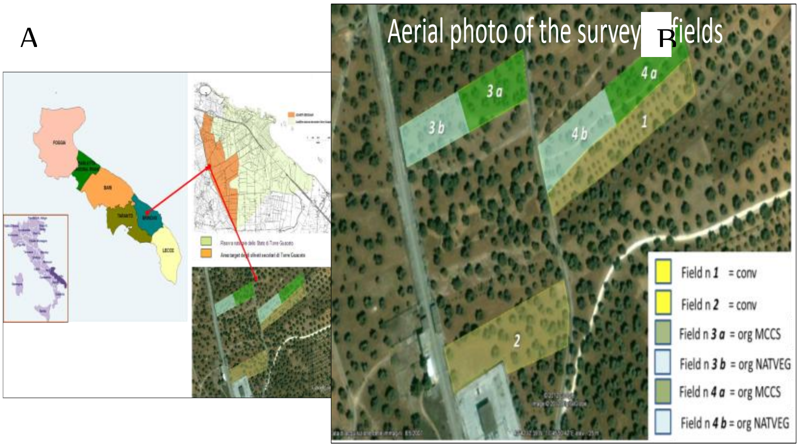

Figure 1 Torre Guaceto State Nature Reserve, Apulia Region (South Italy). In the box at the top on the right, Torre Guaceto State Nature Reserve is highlighted in green and AOOs in orange (A); Aerial photo the studied orchards (B) indicated as (fields) [Fields n1 and n2 –CONV_1 and CONV_2 and Fiends n 3a & n 4a - ORG-MCCS_3a & 4a and Fiends n 3b & n 4b–ORG-NATVEG_3b & 4b respectively]

Table 1 Potential indicators to evaluate soil quality and plant biodiversity

Sir.No.	Category	Indicator	Acronym	Unit
1		Soil Texture (Sand, Clay or Silt)	TXT	%
2		Bulky Density	BD	g cm^{-3}
3		Rock Fragments	RF	%
4		Field Capacity	FC	%
5		Erodibility	KE	t ha^{-1} MJ^{-1} mm^{-1}
6		Annual Soil Loss	ASL	t ha^{-1} yr^{-1}
7		pH (H_2O)	pH	-
8		Electrical conductivity	EC	mS cm^{-1}
9	Soil quality	Total Nitrogen	TN	g kg^{-1}
10		Available Phosphorus	PAS	mg kg^{-1}
11		Exchangeable Potassium	KX	mg kg^{-1}
12		Exchangeable Sodium	NaX	mg kg^{-1}
13		Exchangeable Calcium	CaX	mg kg^{-1}
14		Exchangeable Magnesium	MgX	mg kg^{-1}
15		Carbon –Nirogen Ratio	C/N	-
16		Cation exchange capacity	CEC	m e 100 g^{-1}
17		Soil Organic Matter	SOM	g kg^{-1}
18		Shannon diversity index	H’	-
19		Equitability	E	-
20	Plant biodiversity	Number of species	N	-
21		Richness index	RI	-

Table 2. Commercially mixed cover crop species sown on the org-mccs_3a & 4a fields with family names,% in the mix, and their common names

Sr. No.	Family names	%	Species Names	Common names
1	*Apiaceae*	1.00	*Calendula officinalis L.*	pot marigold
2		0.20	*Carum carvi L.*	caraway
3		0.05	*Anethum graveolens L.*	smelly dill
4		0.05	*Daucus carota L.*	wild carrot /queen Anne's lace
5		0.05	*Foeniculum vulgare Mill.*	sweet fennel
6		0.05	*Pastinaca sativa L*	wild parsnip
7		0.05	*Coriandrum sativum L.*	coriander
8		0.05	*Centaurea cyanus L.*	garden cornflower
9		0.04	*Cichorium endivia L.*	cultivated endive
10	*Boraginaceae*	0.05	*Borago officinalis L.*	common borage
11		6.00	*Raphanus sativus L.*	cultivated radish
12	*Caryophyllaceae*	0.16	*Agrostemma githago L*	common corn cockle
13	*Fabaceae*	20.00	*Vicia sativa L.*	garden vetch
14		12.00	*Onobrychis viciifolia Scop.*	sainfoin
15		8.00	*Trifolium incarnatum*	crimson clover / Italian clover
16		8.00	*Trifolium resupinatum L.*	persian clover
17		7.00	*Trifolium alexandrinum L.*	egyptian clover/berseem clover
18		7.00	*Melilotus officinalis (L.) Lam*	sweet clover
19		5.00	*Medicago lupulina*	black Medick
20		4.50	*Medicago sativa- Eugenia*	
21		4.50	*Medicago sativa L.*	alfalfa
22		2.00	*Trifolium hybridum*	alsike clover
23		1.00	*Ornithopus sativus Brot.*	common bird's-foot
24	*Hydrophyllaceae*	3.00	*Phacelia tanacetifolia Benth.*	lacy phacelia
25	*Malvaceae*	1.00	*Malva sylvestris L.*	high mallow
26	*Polygonaceae*	7.00	*Fagopyrum esculentum Moench*	buckwheat

According the weather data in area, most of the recorded rainfall of 2011-2012 was concentrated in december to march where it peaked in february 2012 (data not shown). The soil texture of the fields ranged from sandy clay loam, loam and clay loam. Parameters were compared in reference to the conv orchards at t0 and t1. Values were normalized to the condition of conv orchard before the application of the green cover (conv_ 1 (t0) =100). Results were then displayed using spider diagram. Additionally, a one-way analysise of variance (anova) of all collected data but soil biological parameters were run. Significant diffent paratemers at t0 and t1 were separated using tukey’s test (hsd) $p < 0.05$ using excel statistic software. Finally, significant variables were selected as sensitive minimum data set (mds) of indicators to evluate the short-term impacts of management and green cover practices of aoos.

RESULTS AND DISCUSSION

Effect of green cover on soil quality and plant biodiversity parameters

Any comparison of the impacts of organic and conventional farming systems on biodiversity (and soil biodiversity) is likely to be problematic, largely as a result of the complexity of, and interactions between, the range of farming practices that comprise the two systems (Hole et al., 2005). Results of the present study show that some soil physical, chemical, and almost all the plant biodiversity parameters showed already clear difference between management systems and grassing practices. Figure 2 shows the soil physical parameters at T0 and T1. It was very clear that the physical soil parameters change at difference times especially with most sensitive parameters such FC, which is very visible the moisture content of the soil, is extremely low regardless of management practices or cover to the soil. Another important an important soil physical property is the ASL significantly higher with CONV management but also with ORG-MCCS_4a probably influenced by the first tillage practices to sow the MCCS and adds to the higher the estimated ASL (Fig 2). Interestingly important soil physical parameters - FC and ASL had significantly better values with the ORG management systems and the grassing to slightly help in reducing ASL and hence soil erosion (Fig 2). Almost similar values of BD were observed. BD affects porosity and resistance to root penetration and gases and water exchange. It is therefore usual to use it as an index of soil compactness (USDA-NRCS 2008).

Like to the soil physical parameters, the soil chemical parameters were also variable between the systems at the two surveying times. Certainly, SOM, TN, MgX significantly improved with the ORG management and in ORG-MCCS practices (Fig.3). Practical experiences indicate maximal benefits of cover crop application cab be obtained by using mixtures grasses and legume species with rotates over time and space (Clark 2007). The plant biodiversity was noticeably improved with ORG-MCCS than ORG-MCCS during the 2011-2012 in terms of both diversity and resilience of plant biodiversity (Table 3). It was clear that H' and N subsequently the RI were improved under the ORG system and ORG-MCCS practices. Although the dynamics of plant species can be variable over time due to many biotic and abiotic factors especially in Mediterranean climate. However, during the following year (2012-2013) using few selected species did not improve the diversity and resilience in same area (Calabrese et al., 2015).

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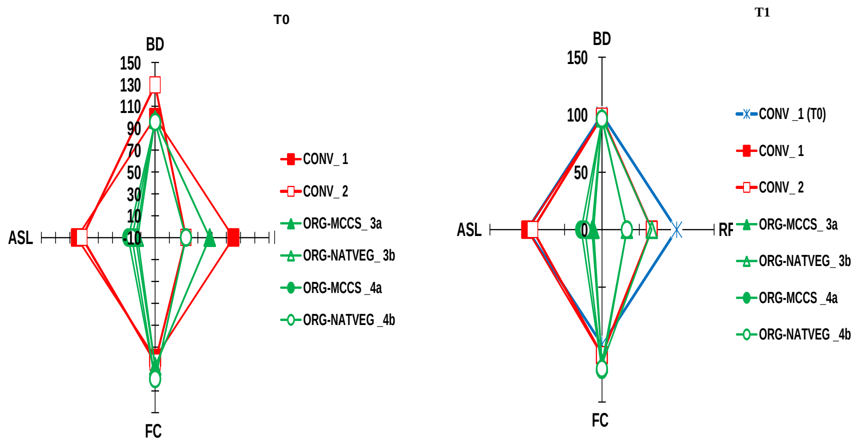

Figure 2 Soil physical parameters at T0 and T1, in reference to field 1 (CONV 1) at T0 (= 100); [Legend: BD= bulk density; RF = rock fragments; FC= field capacity; ASL = annual soil los

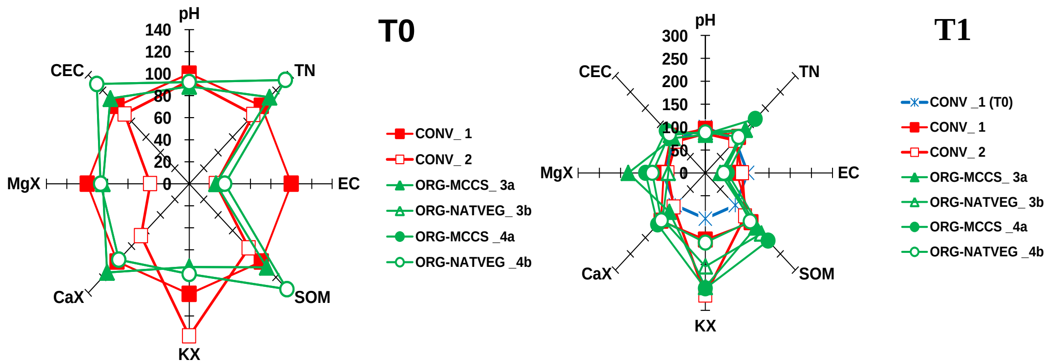

Figure 3 Chemical soil parameters compared before (T0) and after grassing (T1) with reference to (CONV_1 (T0) =100); [Legend: TN = total nitrogen; EC = electrical conductivity; SOM= soil organic matter; KX = exchangeable Potassium; CaX= exchangeable calcium; MgX = exchangeable magnesium; CEC – cation exchange capacity].

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Table 3. Plant biodiversity paratermeters measured before (T0) and aafter (T1) grassing application on AOOS (Autumn 2011 – Autunm 2012)

Management system/ practices	T0				T1			
	H'	E	N	RI	H'	E	N	RI
CONV _1 (T0)	-	-	-	-	100.00	100.00	100.00	100.00
CONV _1	100.00	100.00	100.00	100.00	147.37	108.86	44.44	78.87
CONV _2	91.39	57.59	66.67	82.40	0.00	0.00	0.00	0.00
ORG-MCCS _3a	156.94	80.19	107.41	82.40	190.43	88.61	125.93	110.57
ORG-NATVEG _3b	156.94	80.19	107.41	82.40	84.21	50.633	66.67	68.68
ORG-MCCS _4a	164.59	82.28	125.93	96.83	232.54	104.557	140.74	132.08
ORG-NATVEG_ 4b	164.59	82.28	125.93	96.83	244.98	111.39	133.33	173.58

[Legend: H'= Shannon diversity index; E =Equitability; N =number of species; RI= richness index]

This work provided early years effects of soil management practices on the aoos which are recognized high as ecological and cultural value crops especially in the south-eastern apulia region (Calabrese et al., 2015). The authors have been searching over the last three years for alternative low-impact, cost-effective agricultural practices to the widespread environmentally detrimental practice of leaving the soil bare in monumental olive orchards.

Table 4. Sensitive indicators selected as MDS to evaluate short-term impacts of management systems or grassing practices

Indicator category	Indicator	Management system		Green cover practices	
		ORG	CONV	MCCS	NATVEG
Soil quality	KE	0.28 a	0.20 b	0.27 a	0.25 b
	ASL	0.22 a	0.94 b	0.20 b	0.58 a
	pH	6.83 b	7.33 a	6.55 b	7.15 a
	TN	1.00 a	0.90 b	1.35 a	1.00 b
	MgX	215.67 a	149.00 b	295.50 a	162.38 b
	CEC	21.48 a	18.15 b	21.55 a	19.80 b
Plant biodiversity	H'	1.87 a	0.89 b	2.21 a	1.29 b
	N	15.75 a	7.13 b	18.00 a	10.86 b

CONCLUSIONS

In conclusion, the present work gives further information on the effects of management systems and green cover application on olive orchards. Some soil physical and chemical and plant biodiversity parameters showed differences between the two grassing types.Moreover, a positive effect of organic management was already observed from the first year survey. Impact assessment of agricultural practices on plant and soil biodiversity and testing of the selected indicators in similar studies could help in designing sustainable olive-growing practice.

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