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EFFECT OF FARMING SYSTEM ON ANT ASSEMBLAGES AND GROUND COVER FAUNA IN GREEK OLIVE GROVES

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ABSTRACT

Conventional pest control methods pose a damaging effect on farmland ecology, mainly by the long-term use of synthetic pesticides, which lead to the decrease of agrobiodiversity. Additionally, soil as a main habitat and natural resource on which flora and arthropod communities depend on, should be better managed to regulate agrobiodiversity loss. Agroecological and organic farming methods are proved to deliver a positive regenerative impact on ground-dwelling arthropods and groundcover flora. Specifically, ants play an important role in ecosystem functioning by maintaining or even restoring soil quality, as well as delivering pest control services. Similarly, groundcover flora while hosting beneficial insects, also contributes to soil structure maintenance, mitigating soil erosion in inclined terrains. In this case study, for assessing the impact of farming systems on vegetative groundcover and ant assemblages' abundance, an experiment was installed in two different olive groves (organic and conventional) at Messinia region in Peloponnese, a main olive production area of Greece. The survey took place during spring and autumn of 2023, in five replicated sampling procedures. The ant communities were taxonomized to a genera level and the groundcover flora density and abundance was assessed to species level. The monitoring results indicated that the highest abundance regarding both ant assemblages and groundcover flora were found in the organic olive grove during the whole duration of the sampling. Ant richness between genera was also significantly higher in the organic compared to the traditional olive grove. Consequently, the findings of the in-situ experimentation indicate the importance of integrating organic methods to soil management models for increasing soil health at farm level, especially with regards to agrobiodiversity.

Keywords: *Agrobiodiversity, Agroecology, Olive, Soil health, Sustainability.*

INTRODUCTION

Land desertification in the Mediterranean basin is becoming increasingly pronounced due to climate change and continuous pressures on agricultural and forest land (Yadav et al., 2016). Intensive agricultural production systems are severely affecting biodiversity, since such practices are heavily dependent on chemical fertilizers and large machinery use, creating ecologically artificial and genetically homogenous systems that often present a high vulnerability to pests. On the contrary, a rich biodiversity can contribute to more ecologically resilient agricultural ecosystem because of the complex biological interactions (Altieri, 1995).

Olive groves have been the main agricultural land use in Mediterranean for centuries. Though, its cultivation has changed significantly from the mid-20th Century onward, after the EU Common Agricultural Policy’s subsidies that prompted more intensified farming practices such as frequent mechanization and unrestrained chemical inputs (Martinez-Ballesta et al., 2008). Olive groves slowly tuned into a vast monoculture rather than the previous multifunctional, mosaic-like cultural landscape. This phenomenon has had several impacts on biodiversity and the ecological processes, generating significant environmental damage such as soil erosion and loss of natural habitat refuges (Coq-Huelva et al., 2012).

Meanwhile, nowadays soil conservation and organic farming are currently being fostered by the EU policies and organic olive farming is gaining increasing attention, subsequent to an increase in consumer demand for organic olive oil.

Additionally to the health benefits, organic farming could preserve a diverse ground cover flora that can enhance soil physical structure (Garcia-Díaz et al., 2018), elevating soil organic carbon and thus improving land productivity. Moreover, a diversified vegetative cover contributes to soil nutrient cycling by maintaining soil microbial diversity and enzyme activity (Saleem et al., 2020). Especially in inclined orchards, ground cover significantly reduces soil loss, runoff and thus nutrient loss (Garcia-Díaz et al., 2018). On top of their soil-improving functions, wild plants may play an important role in integrated pest management in olive orchards, influencing insect pest populations by providing critical food or habitat resources to their natural enemies (Bugg and Waddington, 1994).

Besides pest control, ground dwelling arthropod communities are beneficial to soil health contributing to various ecosystem functions, like the shredding of organic matter, mineralization of plant nutrients; stimulating bacteria and fungi, and burrowing. The burrowing by arthropods, particularly the subterranean network of tunnels and galleries that comprise ant nests, improves soil porosity to provide adequate aeration and water-holding capacity below ground, facilitate root penetration, and prevent surface crusting and erosion of topsoil. that improves water infiltration (Culliney, T. W., 2013; Caon and Vargas, 2017).

Composition and structure of the arthropod soil fauna within the olive groves can be rich and diverse, composed by arachnids, chilopods and insects (Gkisakis et al, 2016). Among other groups, some of ant species have been referred as having importance in the suppression of the olive fruit fly, especially in its pupal stage. In fact, ants as generalist predators can be more efficient in biological control of pests than specialist natural enemies (Stiling and Cornelissen, 2005). In a related research of Dinis et al. (2016), the main predators the olive fruit fly pupae in Mediterranean olive groves were ant species from the genera Aphaenogaster, Camponotus, Cardiocondyla, Crematogaster, Formica, Lasius, Plagiolepis, Tapinoma and Tetramorium.

Additionally, ants have been widely used as indicators for assessing the impacts of different soil management practices, considering their great biomass (Cotes et al., 2010).

In the present study, we explore the effects of different olive grove management practices on the functional diversity of ground cover vegetation and ant assemblages. This way we could conclude into a firm indicator of the agroecosystem's health, regarding both soil functionality and the overall agrobiodiversity.

MATERIALS AND METHODS

The study sites were located in south Greece, Messinia region, Peloponnese. The area is characterized by a continental Mediterranean climate, with a mean annual precipitation of approximately 700 mm and a mean annual temperature of 16 °C. We selected 2 olive groves in the study area considering two management regimes: (i) organic; applying soil management such as mowing and use organic fertilizers; and (ii) conventional, applying herbicides and synthetic fertilizers. To avoid other factors that might influence flora and ant diversity, in both the sampled olive groves was similarly aged trees of the Koroneiki variety with a planting pattern of 8 × 8 m. In addition, only rain-fed plots were selected, the most widespread condition in the study area. In each of the referred olive grove plots, five monitoring stations per hectare were selected for groundcover assessment and another three stations for ant assemblages, following a complete randomized design approach. Ant monitoring took place in each plot from within 5 weeks, from the end of April to the end of May 2023, with a sampling frequency once per week, to consider the weather variation and hibernation of some species. To measure the abundance of ant assemblages a pitfall trap was placed in each of the three monitoring stations per grove, where the ant individuals present in each trap was selected and collected in order to be later taxonomised up to morphospecies level. The individuals were identified by their collectors and the sample systematization was realized based on the morphospecies and grove of collection. Data from the three traps of each plot were pooled and genus richness was calculated as the total number of genera found per ha. The identification of main flora species was performed following the quadrat method, evaluating species richness, as well as the total abundance of the vegetative groundcover; defined as the total number of individual plants present. Additionally, the total groundcover percentage was assessed using quadrats while measuring the amount of covered to bare soil. Aboveground plant biomass was measured in three monitoring stations per olive grove during the period between April and May.

RESULTS AND DISCUSSION

Ant assemblages biodiversity

Families and genera found

A total number of 1081 individuals belonging to the family Formicinae were captured during 2023, divided into three subfamilies: Myrmicinae; Formicinae; and Dolihoderinae, including 10 different genera (Table 1). The genera present were the same in both systems, although the relative abundance showed significant differences. As the most abundant subfamily, it was found to be Myrmicinae (84.64 %), followed by Formicinae (11.1%) and Dolihoderinae (4.2 %). These results are similar to previous studies in terms of the most abundant Formicidae subfamilies in the olive agroecosystems (Campos et al., 2011; Hevia et al., 2019). In addition, Myrmicinae was the most diverse subfamily, where the most dominant genera by far was *Messor* which accounted for 88.34% of the total catches, followed by *Aphaenogaster* (10.78%). *Crematoghaster* was found to be the most abundant genera of the subfamily Formicinae and *Tapinoma spp.* was the only genus found of the subfamily Dolichoderinae.

Effect of management system on ant abundance and population dynamics

Regarding the diversity measures, the Shannon index indicated a higher diversity in organic rather than the conventional orchards, with significant differences between treatments (Table 1), (post-hoc Tukey's test; $P < 0.05$). A total of 949 individuals was recorded in the organic orchard and 132 individuals at the conventional one. This is probably attributed to the major effects of habitat disturbance of the conventional practices, influencing food supplies and nesting (Andersen et al., 2002).

The subfamilies present were the same in both systems, although the relative abundances were different. For example, the subfamily Myrmicinae had 15 times more captures in the organic than the conventional grove while the Dolichoderinae was threefold. On the contrary, Formicinae was more abundant in the conventional orchard.

The six genera of the subfamily Myrmicinae responded similarly to the different systems, with Plagiolepis being an exception. Specifically, captures of Messor and Pheidole, were grater in organic by 449 and 157 individuals, respectively, while those of the other three genera, Aphaenogaster, Tetramorium and Crematogaster were greater by 96, 74 and 33 individuals, respectively (Table 1).

Concerning the Formicinae subfamily, the two genera recorded in this study were favored by the conventional system and possibly by the removal of ground cover, as the number of the Cataglyphis individuals captured was 1.25 times more than in organic and of the Lepisiota eight times more (Figure 1). These results are complying with the ones that Campos et al., 2011, present in their research on the effect of ground cover on ant assemblages in olive orchards. Despite the fact that individuals of Campanotus were absent in the conventional orchard, it is difficult to determine the effect of the management system on Campanotus spp. as very few individuals were captured in general.

Tapinoma is the only genus from the subfamily Dolichoderinae represented and the number of individuals was higher in the conventional orchard, though without significant differences (P > 0.05) (Table 1).

Table 1. Ant assemblages' diversity shown by the genus relative abundance, along with total abundance, Shannon Index (S).

Subfamily	**Genus**	**System / zone**	
		Organic	Conventional
Dolichoderinae	*Tapinoma spp.*	36a	40 a
Formicinae	*Campanotus spp.*	3a	0 a
	Cataglyphis spp.	48a	60 a
	Lepisiota spp.	1a	8 a
Myrmicinae	*Pheidole spp.*	163a	5 b
	Messor spp.	468a	19 b
	Crematogaster spp.	34a	1 a
	Plagiolepis sp.	3a	6 a
	Tertamorium spp.	79 a	5 a
	Aphaenoghaster spp.	114 a	18 b
TOTAL ABUNDANCE		949 a	132 b
TOTAL RELATIVE ABUNDANCE		**862,73 a**	**110 b**

Statistically significant differences (P < 0. 05; Duncan test) are presented with different letters.

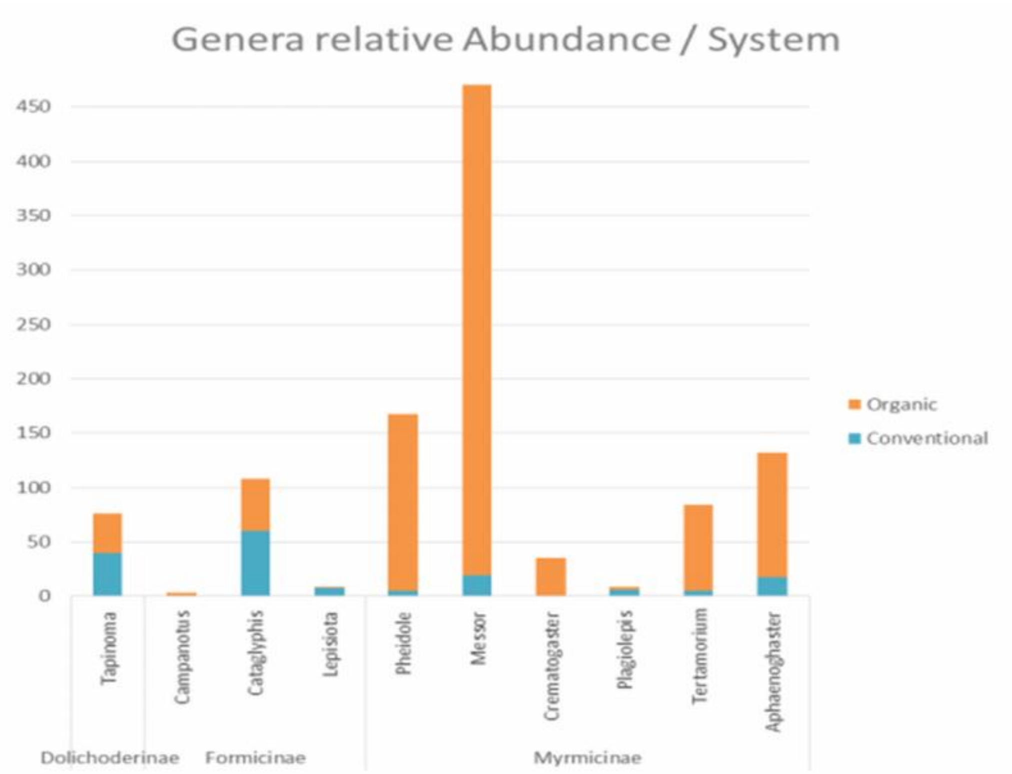

Figure 1. Ant genera relative abundance per management system (organic, conventional).

Groundcover vegetation biodiversity

Species richness and abundance

A total of 27 species belonging to 12 families occurred during indicative species sampling from the two groves (Table 2), 6 of which were Monocots and 21 Eudicots. Annual species were the most abundant, as expected considering the periodic disturbance by mowing, used as a routine management practice of the sampling orchards. Herbaceous biennial and perennial species were not present. In total eight of the species found belong to the family Asteraceae, six to Poaceae and three to Fabaceae. Most of the species had also a European distribution (European Mediterranean); those strictly linked to the Mediterranean environment (Steno-Mediterranean) accounted to 9 species (Table 2). The organic olive grove hosted a greater variety of species, since 44.4% of the total species were exclusively found there. The 33.3% of the total species found, were present in both orchards and 14.8% of them were found only in the conventional one. Nevertheless, there were not any statistical differences on the species richness between the two orchards.

Table 2. Indicative native flora species found in the organic (O) and conventional (C) olive orchards.

Family	**Species**	**System**
Poaceae	*Avena barbata*	*O /C*
	Briza maxima	*O*
	Lolium perenne	*O*
	Festuca lachenalii	*O*
	Bromus diandrus	*C*
	Hordeum murinum	*O / C*
Fabaceae	*Trifolium subterraneum L.*	*O*
	Trifolium hirtum	*O*
	Vicia villosa	*C*
Convulvulaceae	*Convolvulus arvensis*	*O / C*
Asteraceae	*Crepis sancta*	*O / C*
	Crepis foetida	*O / C*
	Tephroseris helenitis	*O / C*
	Pilosella caespitosa	*O*
	Galactites tomentosus	*O*
	Picris hieracioides	*O*
	Sonchus asper	*O / C*
	Pulicaria odora	*O*
Lythraceae	*Lythrum hyssopifolia*	*O*
Boranginaceae	*Echium vulgare*	*O*
	Echium arenarium	*O*
Amaranthaceae	*Atriplex laciniata*	*O*
Brassicaceae	*Diplotaxis muralis*	*O / C*
Apiaceae	*Aethusa cynapium*	*O / C*
Geraniaceae	*Geranium pusillum*	C
Urticaceae	*Urtica urens*	C
Malvaceae	*Malva nicaeensis*	C

The total abundance was found higher in the organic (55.4±2.6) than the conventional (36±3.1) olive grove, when covering 98.6±1% and 72±4.1% of the soil surface respectively (Table 3).

Table 3. Total abundance and mean cover percentage in May

System / zone	**Organic**	**Conventional**
Abundance (individuals/m2)	55.4±2.6 a	36±3.1 b
Mean Cover (%)	98.6±1 a	72±4.1 a

Statistically significant differences ($P < 0.05$; Duncan test) are presented with different letters.

Soil cover % and aboveground biomass production

Regarding the percentage of soil cover by the ground flora, it showed higher rates in the organic orchard almost in every month except August, where the conventional orchard indicated a higher soil cover percentage (Fig. 2).

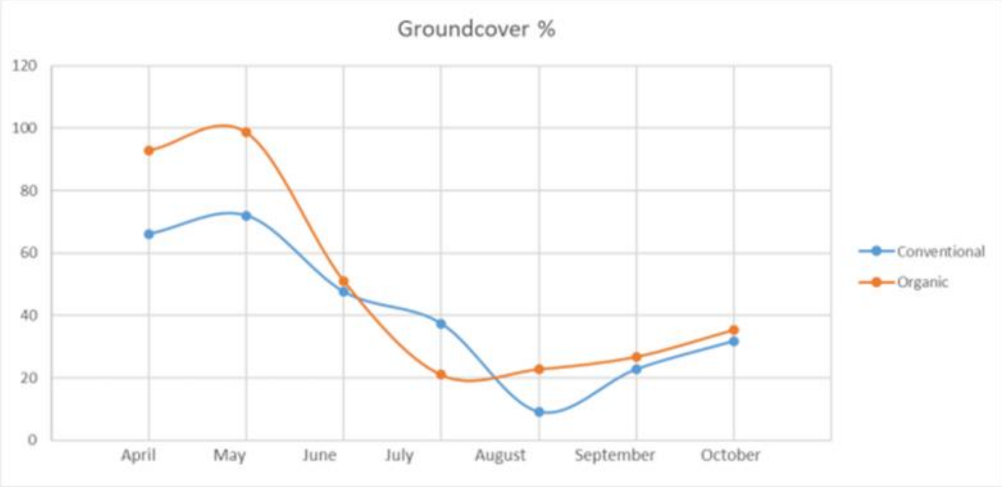

Figure 2. Soil cover percentage fluctuation from April to October within the two olive groves (conventional and organic).

The above-ground net primary production of the total biomass produced annually by the orchard floor, expressed on a dry weight basis (average of 3 replicates ± standard deviation), had higher means in the organic (0.15±0.008 kg m^{-2} $year^{-1}$) compared to the conventional (0.13±0.014 kg m^{-2} $year^{-1}$), though without any statistical differences (Fig. 3).

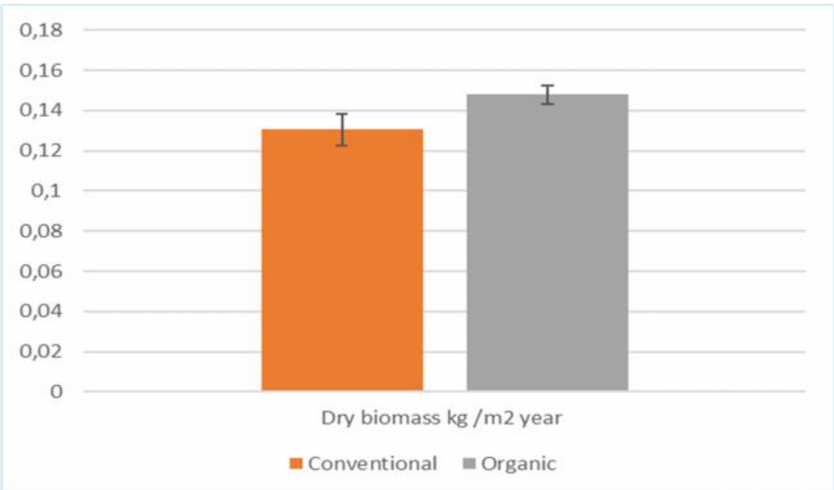

Figure 3. Net primary production of the groundcover biomass produced annually.

CONCLUSIONS

An assessment of two different management systems (organic and conventional) demonstrated diverse effects on ant assemblages and flora biodiversity, indicators used in the present study for comparing agrobiodiversity among olive groves. The differences in ant assemblages means confirmed an enhanced performance of the organic compared to the conventional grove, showing a positive effect on ant diversity. Wild flora richness and abundance has also been affected by the management system, where the organic grove resulted into a richer and denser groundcover. However, the effects on the overall flora species richness and soil cover percentage were not significant. Thus, further investigation is required to confirm the above results. Overall, an impact assessment of agricultural practices on plant and soil biodiversity in similar studies could help in designing sustainable olive-growing practice.

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