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Original article

Effect of land-use types on edaphic properties and plant species diversity in Mediterranean agroecosystem

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ABSTRACT

Land-use intensification, contrary to sustainable land management, has an impact on the healthiness of the environmental agroecosystem. To assess the environmental implications in abandoned land, olive groves and maize crops, the most sensitive and reliable edaphic indicators were measured to estimate plant species diversity and potentially toxic elements in soil, among different types of land-use. Species diversity presents a decrease in maize crops and olive groves compared to abandoned land. The families with the greatest species diversity were *Poaceae*, *Asteraceae* and *Fabaceae* in each land-use. From the results of the canonical correspondence analysis among species, sampling sites and selected environmental variables, a clear separation between species and sampling sites belonging to different types of land-use was found, presenting strong correlation with specific edaphic parameters (pH, Soil Organic Matter, Silt, Electrical Conductivity, Total Nitrogen, NO_3^-, P, K, Zn and Cu). Species diversity was reduced in maize crops due to anthropogenic interventions such as the excessive use of nitrogen and phosphate fertilizers and herbicides. Despite the fact that the lowest richness of plant species was found in olive groves, non-removal of crop residue preserves soil organic matter. In 7.4% of soil samples in olive groves, Cu_{total} concentrations were over 100 mg kg^{-1} denoting polluted soils, while the potentially toxic concentrations of bioavailable copper fraction (Cu_{DTPA}) probably lead to a decrease of species diversity. Future researches should therefore focus on the accumulation of toxic elements in agricultural land to preserve species diversity and a healthy environment.

1. Introduction

A key issue in the debate on the contribution of agricultural land to an environmentally sustainable "green" growth model is whether management practices of cultivated land can preserve and protect our environment for future generations, considering the need to feed the growing population with the same land. In the Mediterranean basin the prevailing soil groups (Cambisols, Fluvisols, Luvisols, Leptosols) which exhibit high spatial variability of their properties, the ecological factors (vegetation, fauna, etc.) and the anthropogenic interventions such as tillage, fertilization, pesticide application, land-use intensification and the mismanagement of irrigation schemes, have an impact on agro environmental healthiness (Rodeghiero et al., 2011; Médail and Quézel, 1999; Cowling et al., 1996; Vasu et al., 2017; Gerakis and Kalburtji, 1998). In agriculture, diversity of naturally occurring plant species generally depends on factors acting in various spatial scales (Concepción et al., 2012), while locally it is also affected by the variability of landscape traits within the fields (Armengot et al., 2011). It is well documented that the agro-environment schemes (AES) applied in fields as well as the increased proportion of land under agro-environmental management in the surrounding landscape, enhance local diversity. (Gaba et al., 2010). Sustainable agriculture supports plant diversity, avoiding the accumulation of toxic elements, and preserving long-term soil fertility, aiming to achieve "green" agricultural growth and food security (Alston et al., 2009).

However, the long-lasting use of agrochemicals (fertilizers and pesticides) and land-use intensification (agricultural and livestock activities) have a negative impact on the dynamic parts of

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agroecosystems such as soil properties and plant species occurrence/abundance, causing uniformity of native flora across the European cultivated lands. Over the years the above interventions have overlapped the underlying natural patterns, have masked the contribution of parent material and have reduced floristic diversity (Alloway, 2013; Ferrero et al., 2017).

As it is already known, not only do plants respond to soil conditions but they also affect them, while changes in land-use affect input and output fluxes of nutrients and carbon in agro-soils (Dupouey et al., 2002). This can lead to changes of land quality and soil fertility, which in turn will affect crop productivity, plant species diversity and the decisions for management practices (Bakhshandeh et al., 2019; Ahmad et al., 2016; Benton et al., 2003). The effects of land-use on land quality may be either positive or negative mainly depending on the soils and climatic conditions of the area. Kosmas et al. (2000) report that soil properties and plant species diversity differ between abandoned and cultivated lands, estimating that the increase of organic matter (SOM) in topsoils of abandoned land is the most significant soil improvement factor. Allen et al. (2006) point out that 60% of interrelationships among plants and environmental variables in olive groves, could be explained through the interpretation of soil properties, slope gradient and slope aspect, and that the existing variation of plant species composition is the result of different management practices. However, sustainable practices in olive groves and no use of herbicides improve soil fertility (Vignozzi et al., 2019; Massaccesi et al., 2018; Bilalis et al., 2011). The use of fungicides on the other hand, generates secondary pollutants to the soil, which contribute to the increase of the concentration of heavy metals and therefore they should not be ignored (Ballabio et al., 2018). Triantafyllidis et al. (2020) have recently demonstrated that the wide use of Cu-fungicides in long term orchard cultivations causes important environmental implications. Tsiafouli et al. (2015) point out that land-use intensification in Greece and across Europe reduces soil biodiversity and may threaten the functioning of soil in agricultural production systems. Maize is a dominant and productive crop, both in local communities and the global food system. However, intensive tillage practices and weed chemical control in maize monocultures, reduce soil organic matter, which is a crucial for soil quality and species diversity (Ferrero et al., 2017; McDaniel et al., 2014). A crucial point related with plant species diversity in cultivated land with land-use intensification is whether anthropogenic interventions have led to the extinction of native species. Only a few studies look at the effect of land-use on the edaphic properties and plant species diversity, under particular soil and climatic conditions at a field level, which must always be taken into consideration in the selection of a suitable and sustainable land management (Buhk et al., 2017; Knudsen et al., 2017; Honnay et al., 2003). In the Mediterranean basin, Balzan et al., (2020) reported that agricultural intensification in arable systems was associated with the reduced of plant species and functional diversity. Plieninger et al. (2014) in a meta-analysis of the Mediterranean basin data, including Greece (Papanastasis 2007), mention that the responses of vascular plant richness were heterogeneous in different land-use types.

An attempt has been made in this study to evaluate the effect of land-use on edaphic parameters, the soil toxic element accumulation and the species diversity in fields under loamy soils near the city of Agrinio (Aitoloakarnania, Western Greece). Specifically, the aim of the present study is: (a) to evaluate the effect of three different land management practices on physicochemical soil characteristics and (b) to reveal which edaphic parameters are the most sensitive and reliable indicators of the correlation that exists among plant distribution, soil quality and land-use type under given soil and climatic conditions.

2. Materials and methods

2.1. Study area

The study area is located in the municipality of Agrinio in the prefecture of Aitoloakarnania in Western Greece (Fig. 1). Aitoloakarnania is the largest prefecture in Greece (38°37′N, 21°22′E) and it occupies an area of 5448 km^2, representing the 4% of the total area in Greece. The prefecture of Aitoloakarnania is one of the most agriculturally productive Greek areas, with tobacco being the main cultivated crop from 1883 until 2005. However, according to the Common Agriculture Policy (CAP) and the farm restructure in 2006, the majority of tobacco cultivated lands were abandoned and most of them were transformed into pasture land. According to recent data (Authority of Western Greece, Dept. of Agricultural Development, 2015), about half (13,020 ha) of the total cultivated land (28,910 ha) was abandoned or used as pastureland followed by olive trees (7114 ha) and corn (2072 ha). These three land- use types occupy the 76.8% of the total cultivated land in the municipality of Agrinio and that is the reason why they were chosen to be studied. Table 1 presents the usual management practices from each land-use type. The location of each of the eighty-one (81) fields which were selected to be studied is shown in Fig. 1. In this area, the dominant soil unit type is Calcaric Fluvisol (Yassoglou, 2004), while the land slope ranges from 0 to 3% (Directorate of Geospatial Information of the Ministry of Environment and Energy, 2019) reducing in this way the risk of soil erosion. The climate of Aitoloakarnania is suitable for many crops, due to the fact that the mean annual temperature is 17.5 °C and the mean annual rainfall ranges from 800 mm to 1000 mm. Nevertheless, the uneven seasonal distribution of rain makes irrigation an obvious and necessary option to increase and stabilize crop production. Olea europaea var. rotunda ‘Konservolia’ is usually cultivated in rainfed fields, and occupies the largest area compared to other cultivated olive varieties, in the municipality of Agrinio.

2.2. Data collection

Data collection took place during two successive years 2017 and 2018. The selected fields (81) were located in the agricultural area of Agrinio in Western Greece (Fig. 1). Twenty-seven (27) replications for each land-use (treatments) took place: (i) abandoned land, (ii) maize crop and (iii) olive groves were chosen based on the approximately same soil type (loamy soils), slope gradient (0–3%), and climatic conditions. Each of the selected fields had an area of approximately 1 ha; olive fields included approximately 200 trees, maize crops 80–88 thousand plants while abandoned fields of approximately the same size were chosen, in which no history of pesticide use has been recorded for the last 10 years. Short description of land-use, management practices and soil-climatic conditions of the study area are shown in Table 1.

2.2.1. Soil and plant species sampling

Soil sampling took place in the winter season for two years (2017–2018), when soils are inherently variable in their distribution of plant nutrients (Sabbe and Marx, 1987). A total number of 81 soil samples (27 from each land-use type, labeled through a GPS device) were collected (Fig. 1), according to a composite sample. In order to compose a soil sample from olive groves, one central sub-sample was collected and then four other sub-samples, within a distance of 2 m from the central sub-sample – all beneath tree canopy- were mixed, as proposed by LUCAS topsoil sampling methodology (Toth et al., 2013). Each of the samples which was

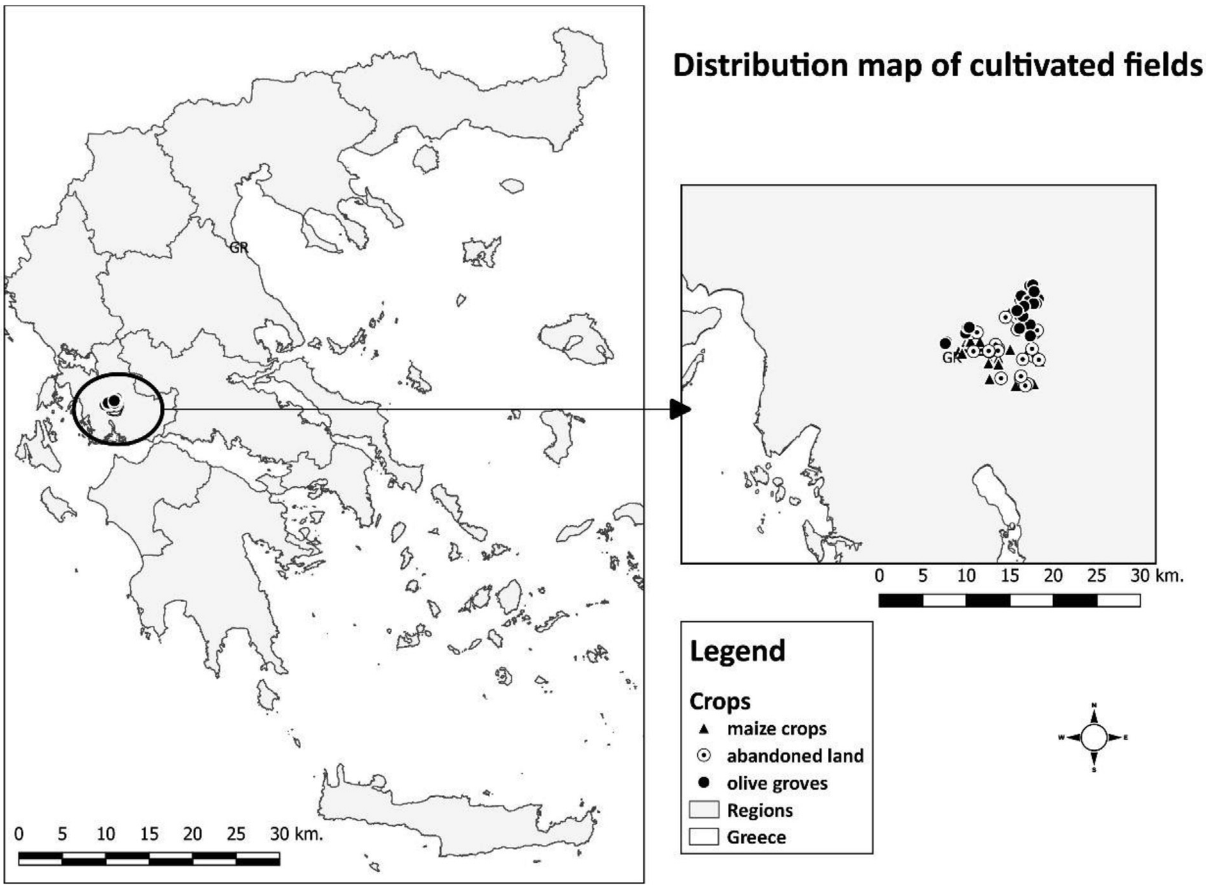

Fig. 1. Location of experimental fields from three different land use of Agrinion in Western Greece.

Table 1
Land use types and usually management practices of study area.*

	Abandoned land	Olive groves	Maize crops
Description	Abandoned farmland used for grazing. Previously, cultivated with tobacco (1883–2005)	Olea europaea var. rotunda 'Konservolia'. Mean yield: 50–70 Kg per tree. Cold tolerant	Zea mays L., mean maize yield: 10–12 tonnes ha^{-1}
Fertilization	No inorganic fertilizers Only sheep manure	February: 3 Kg/tree/NPK mineral fertilizers (11:15:15); April-May: 1 Kg/tree/simple-nitrogen (34.5:0:0)	Before sowing, early to mid-April: 700 Kg/ha/NPK mineral fertilizers (20:10:10); June-July: 400 Kg/ha/simple-nitrogen (34.5:0:0)
Plant protection	No pesticides	Herb: no herbicides were use, only grass shredder was used to control weeds. Fungi: Cu-fungicides from mid-September and late-February, approximately annual dose 3000–3500 gr Cu/ha. Insect: to control Bactrocera oleae: solution of ammonium salts mixed with insecticide (alpha-cypermethrin), applied either in McPhail traps or sprayed in olive foliage	Herb: (a) Before sowing: mechanical manipulation of soil. (b) After sowing: One herbicide spray per year was applied with mixed or simple a.i: nicosulfuron, rimsulfuron, dicamba at dose 50–60 g a.i. ha^{-1}, 10–15 g a.i. ha^{-1} and 240–280 g a.i. ha^{-1} respectively, took place approximately 30–35 days after sowing (DAS)
Tillage	No tillage	Planting density: Approximately 200 trees/ha (7 m × 7m). Age of groves: over 30 years old	Mouldboard ploughing at a depth of 20–25 cm on March, followed by one rotary hoeing before early to mid-April. Sowing dates were from early to mid-April for each year. Maize was planted at an approximate density of 80–88 thousand plants ha^{-1}
Irrigation	No irrigation	No irrigation	Gun sprinklers from early-June until early September, 6–8 times. Irrigation dose: 900–1200 m^3/ha/year
Residue treatment	Natural intervention, grazing	Grass shredder was used, the grass biomass is left in place to decompose and by using mulcher shredder for pruning-derived woody residues	Roots and part of straws buried in soil
Soil	Parent material: Holocene alluvium, Quaternary terraces; Dominannt STU (Soil Unit Type): Calcaric Fluvisol (FLca); Associated STU: Calcaric Cambisol, Haplic Calcisol, Rhodic Luvisol; Slope gradient: 0–3%		
Climate**	Mediterranean, characterized by hot dry summers and cold humid winters. Mean annual precipitation: 890 mm, with 70% falling over the period November to March, and mean annual temperature: 17.5 °C		

* Data is coming from the processing of questionnaires which completed by producers and agronomists of the study area.
** Meteorological data were obtained by a network of meteorological stations of our laboratory (PlantLab) in the study area. (http://150.140.205.52:8080/livedata/map.jsf).

received in maize fields and in abandoned lands, consisted of 10 cores, well mixed on site, and was collected from different points in the field with a zigzag soil sampling method (Sabbe and Marx, 1987). Sampling was conducted by using a Dutch auger to a depth of 0–30 cm for all soil samples. Undisturbed soil cores for each field were received from 0 to 30 cm depth using 100 cm^3-cylinders (5 cm height and 5.04 cm diameter) for the assessment of soil bulk density (BD) according to Lutz (1947).

During the sampling period (April to October 2017–2018) the native plant species that occur in the selected fields of the three different land-use types were also collected (Fig. 1). In particular, data concerning the plant species presence/absence were recorded in a total of 81 fields (27-olive groves, 27-maize crops and 27 fields of abandoned land).

2.3. Data analysis

Soil samples were air dried, then crushed and sieved through a 2-mm sieve. Particle size distribution was carried out using Bouyoucos's method (1962). Soil textural classes were determined based on the USDA particle-size classification (Soil Science Division Staff, 2017). Electrical conductivity (EC) and pH of saturated pastes were measured for each sample by using conductivity meters (HandyLab LF1) and pH meters (Crison GLP21) respectively (Rhoades, 1982; McLean, 1982). Total $CaCO_3$ equivalent was determined by using calcimeter (Bernard). Soil organic matter (SOM) was determined by the method Walkley–Black (Nelson and Sommers, 1982), while SOM concentrations were converted to SOC as follows: SOC = SOM $\times$ 0.58 (Mann, 1986). Available P (P_{Olsen}) was measured according to Olsen (1954). Exchangeable K, Na, Ca and Mg were extracted with 1 N (NH_4OAc at pH 7.0) ammonium acetate (Thomas, 1982). K and Na concentrations were determined using Jenway PFP7 flame photometer while those of Mg and Ca by an AAS analyzer. Exchangeable sodium percentage (ESP) was calculated as follows: $ESP = \left(\frac{Na_{exch}}{Ca_{exch}+Mg_{exch}+K_{exch}+Na_{exch}}\right) \times 100$. Also, analysis was carried out for aqua regia (ISO/DIS11466) and DTPA-extractable (Norvell and Lindsay, 1982) from Cu, Fe, Mn, and Zn. The relevant concentrations were calculated through flame atomic absorption spectrometry (AAS, model: Analyst 700 by Perkin Elmer). The determination of NO_3^- was performed in 1:10 water-extracts using Dionex-1500 Ionic (Kosma et al., 2009). The total nitrogen (Total N) was estimated by using the Kjeldahl method (Bremmer and Keeney, 1966) according to Velp Scientifica model UDK 130D. The presence of sufficient amounts of nitrogen was checked by the ratio of the total amount of carbon to the total amount of nitrogen (C/N) in each soil sample.

Plant specimens were identified mainly according to Tutin et al. (1968–80, 1993). Plant nomenclature follows Dimopoulos et al. (2013); (2016;).

2.3.1. Statistical analysis

In this study twenty three (23) soil physicochemical properties (pH, EC, SOC, *Total* $CaCO_3$, BD, Total N, NO_3^-, P_{Olsen}, K_{exch}, Mg_{exch}, Ca_{exch}, Na_{exch}, Fe_{DTPA}, Zn_{DTPA}, Cu_{DTPA}, Mn_{DTPA} and Cu_{total}, Zn_{total}, Cu_{total}, Mn_{total} and the texture indicators sand/silt/clay) were used in order to estimate the effect of land-use types on edaphic properties and plant species diversity in cultivated land. Descriptive statistics was used to quantify soil properties. Kruskal Wallis test (non-normal distributed sample) was used to identify significant differences among the different land-use types. Statistical analysis was carried out using SPSS statistical package version 20.

Principal component analysis (PCA) was used to assess how many and which of the above (23) mentioned parameters can be considered as representative edaphic indicators (Triantafyllidis et al., 2018) correlated both to native plant species presence/absence in arable land and the environmental changes arising from the chosen land management practices. Under each of the principal component (PC), only the variables with high factor loading were retained as selected environmental variables. Therefore, the PCs with eigenvalues >1 and those that explained at least 5% of the variation in the data were selected and subjected to varimax rotation to maximize the correlation between PCs and the measured attributes (Singh et al., 2014).

The sum of the data concerning the plant species and the selected environmental variables were input to CANOCO software version 4.5 (ter Braak and Šmilauer, 1998) in order to assess the effect of multivariate edaphic factors on plant species distribution pattern as well as on that of sampling fields where was recorded the presence/absence of them.

3. Results

3.1. Soil properties per land-use type

Topsoil properties resulting from the laboratory analysis are included in Table 2. In all land-use types, soil texture was loamy, and no statistically significant difference occurred among all treat-

Table 2
Least square means with Standard Deviation (SD), min – max values of soil physicochemical parameters among different types of land use, Agrinion plain – Western Greece. * *Number of analyzed soil samples for each land use (n = 27), ** Indicates significant differences at significance level P < 0.05 (Kruskal Wallis test) for each parameter ns: not significant.*

Soil properties	Land use									Totalsoil samples	Controlling factor
	Abandoned land			Olive groves			Maize crops*				Land use
	min	mean ± S.D.	max	min	mean ± S.D.	max	min	mean ± S.D.	max	mean ± S.D.	
pH	6.40	7.12 ± 0.47	7.80	6.50	7.51 ± 0.58	8.20	6.40	7,25 ± 0.54	7.90	7.29 ± 0.55	**
EC($dS\ m^{-1}$)	0.14	0.80 ± 0.32	1.22	0.30	0.86 ± 0.55	2.47	0.43	1.17 ± 0.58	2.73	0.94 ± 0.52	**
BD ($g\ cm^{-3}$)	1.23	1.42 ± 0.09	1.56	1.34	1.46 ± 0.09	1.55	1.23	1.47 ± 0.09	1.56	1.45 ± 0.08	ns
Clay (%)	16.0	28.3 ± 7.50	39.0	15.2	26.9 ± 6.56	38.4	17.9	30.1 ± 5.19	40.0	28.4 ± 6.54	ns
Silt (%)	21.6	32.0 ± 6.26	37.5	20.9	31.2 ± 6.44	37.5	24.0	33.2 ± 4.18	36.7	32.1 ± 5.71	ns
Sand (%)	23.5	39.6 ± 11.8	60.0	26.5	41.9 ± 8.95	60.0	25.3	36,8 ± 6.83	54.0	39.4 ± 9.29	ns
Total $CaCO_3$ (%)	0.00	4.39 ± 5.83	17.8	0.10	6.21 ± 6.42	20.2	0.00	5.51 ± 5.36	16.5	5.37 ± 5.86	ns
Soil Organic C ($g\ kg^{-1}$)	6.09	12.2 ± 2.92	20.4	9.51	13.5 ± 3.18	22.2	3.25	9.15 ± 2.63	13.7	11.6 ± 3.42	**
Total N ($g\ kg^{-1}$)	0.71	1.16 ± 0.34	2.00	0.78	1.26 ± 0.38	2.03	0.73	0.98 ± 0.18	1.26	1.13 ± 0.33	**
NO_3^- ($mg\ kg^{-1}$)	7.60	13.2 ± 3.40	20.3	4.90	11.2 ± 2.90	17.9	7.30	10.8 ± 2.36	19.2	11.7 ± 3.08	**
P_{Olsen} ($mg\ kg^{-1}$)	5.99	15.7 ± 5.78	28.8	9.6	18.1 ± 8.11	39.2	9.60	20.8 ± 6.67	42.8	18.2 ± 7.13	**
Ca_{exch} ($meq\ 100\ g^{-1}$)	7.10	18.7 ± 6.18	32.8	9.08	20.7 ± 5.34	31.6	5.79	19.8 ± 7.69	31.5	19.7 ± 6.45	ns
Mg_{exch} ($meq\ 100\ g^{-1}$)	0.74	1.45 ± 0,78	4.24	0.71	1.35 ± 0.68	3.54	0.69	1.21 ± 0.45	3.12	1.34 ± 0.65	ns
Na_{exch} ($meq\ 100\ g^{-1}$)	0.10	0.23 ± 0.11	0.48	0.10	0.24 ± 0.23	1.30	0.11	0.40 ± 0.37	1.69	0.29 ± 0.27	ns
K_{exch} ($meq\ 100\ g^{-1}$)	0.20	0.46 ± 0.21	0.87	0.26	0.51 ± 0.21	1.23	0.27	0.58 ± 0.27	1.41	0.52 ± 0.23	ns

ments. Slightly alkaline mean soil pH values were observed in olive groves and maize crops while neutral in abandoned land. The rich detectable amount of mean total $CaCO_3$ in olive groves was higher compared to maize crops while lower values were observed in abandoned land. Low mean soil EC values were observed in all studied samples, with significantly mean higher and mean lower EC values detected in those collected from maize crops and abandoned land, respectively (Table 2). In detail, the EC was moderate in 41% of soil samples collected in maize crops (maximum values up to 2.73 dS m^{-1}), and in 26% of soil samples taken from aban-

Table 3

Least square means with Standard Deviation (SD) of heavy metal fractions in agricultural soils. Significant differences of potentially toxic elements among different land-use types. * *Number of analyzed soil samples for each land cover (n = 27), ** Indicates significant differences at significance level P < 0.05 (Kruskal Wallis test) for each parameter ns: not significant.*

		Land use Abandoned land			Olive groves			Maize crops			Total soil samples mean ± S.D.	Controlling factor Land use
		min	mean ± S.D.	max	min	mean ± S.D.	max	min	mean ± S.D.	max		
Extractable (DTPA method)	Fe_{DTPA} (mg kg^{-1})	7.87	21.6 ± 20.4	77.6	4.97	19.9 ± 17.8	84.4	3.57	21.1 ± 17.0	74.5	20.9 ± 18.2	ns
	Cu_{DTPA} (mg kg^{-1})	0.84	2.44 ± 1.42	6.30	0.82	6. 36 ± 9.51	39.2	0.40	1.54 ± 0.84	3.50	3.45 ± 5.89	**
	Mn_{DTPA} (mg kg^{-1})	2.26	11.1 ± 8.99	38.5	3.16	12.3 ± 10.0	46.9	2.43	13.0 ± 8.20	38.8	12.2 ± 9.03	ns
	Zn_{DTPA} (mg kg^{-1})	0.49	1.43 ± 1.24	5.00	0.34	1.56 ± 1.26	4.80	0.31	0.83 ± 0.58	2.40	1.27 ± 1.11	**
Total (Aqua Regia method)	Zn_{total} (mg kg^{-1})	20.0	30.1 ± 8.53	52.8	21.7	29.9 ± 5.42	42.2	20.0	29.1 ± 6.21	43.9	29.7 ± 6.78	ns
	Cu_{total} (mg kg^{-1})	13.1	22.9 ± 8.69	46.5	15.6	33.8 ± 28.5	120	11.7	19.6 ± 4.94	29.6	25.4 ± 18.3	**
	Mn_{total} (g kg^{-1})	0.15	0.85 ± 0.75	2.87	0.15	0.81 ± 0.71	2.49	0.11	0.72 ± 0.58	1.99	0.79 ± 0.68	ns
	Fe_{total} (g kg^{-1})	0.18	0.32 ± 0.10	0.50	0.17	0.32 ± 0.11	0.51	0.17	0.30 ± 0.09	0.46	0.31 ± 0.10	ns

Table 4

Percentage distribution of heavy metal concentration in soil samples (total number of samples = 81) from fields of three different land use types (number of samples per land use type = 27). * a or A: Very low, b: Low, c: Sufficient, d: High, e: Very high.

Concentration mg kg^{-1} dry soil	Zn_{DTPA}					Cu_{DTPA}					Mn_{DTPA}					Fe_{DTPA}				
	<1 a*	1–3 b	3–5 c	5–8 d	>8.0 e	<0.3 A*	0.3–0.8 B	0.8–1.5 C	1.5–3 D	>3.0 E	<5 a	5–15 b	15–30 c	30–50 d	>50 e	<3 A	3–12 B	12–25 C	25–50 D	>50 E
Abandoned land (n = 27)	52%	37%	11%	–	–	–	–	25%	57%	23%	–	84%	8%	4%	4%	–	34%	36%	16%	14%
Olive Crops (n = 27)	44%	41%	15%	–	–	–	–	12%	47%	41%	–	75%	10%	15%	–	–	30%	52%	12%	4%
Maize crops (n = 27)	78%	22%	–	–	–	–	19%	47%	23%	11%	–	52%	22%	16%	10%	–	33%	56%	6%	5%
Total (n = 81)	58%	32%	10%	–	–	–	7%	20%	49%	25%		71%	12%	11%	6%	–	32%	48%	12%	8%

Table 5

Matrix of principal component analysis of normalized physicochemical properties and elemental concentrations of the selected agricultural soils in study area (significant loading factors are marked in bold).

Soil properties	Rotated component matrix					
	PC1	PC2	PC3	PC4	PC5	PC6
Soil Organic C	**0.820**	−0.005	0.207	0.266	0.062	−0.073
TotalN	**0.782**	0.075	0.293	0.265	0.039	−0.028
Zn_{DTPA}	**0.768**	0.064	0.111	0.170	0.119	−0.181
Zn_{total}	**0.755**	0.142	0.182	0.079	0.018	−0.057
BD	**−0.687**	0.082	0.015	0.252	0.159	−0.181
Mn_{total}	**0.684**	0.102	0.508	−0.001	0.001	0.197
Fe_{DTPA}	**0.653**	0.176	0.194	−0.083	−0.097	0.398
Mn_{DTPA}	**0.645**	0.071	0.472	−0.020	−0.025	0.427
EC	0.044	**0.877**	0.126	−0.031	0.134	0.304
Na_{exch}	−0.073	**0.853**	−0.117	−0.162	−0.149	0.054
NO_3^-	0.385	**0.740**	0.004	0.105	0.241	0.028
Clay	−0.169	**0.729**	0.250	0.179	0.302	0.066
Mg_{exch}	0.348	**0.696**	−0.023	0.070	0.042	−0.116
P_{Olsen}	0.086	0.033	**0.849**	−0.148	−0.103	−0.024
Total $CaCO_3$	−0.334	−0.104	**−0.810**	0.021	−0.090	0.141
pH	−0.494	−0.011	**−0.675**	0.103	−0.082	−0.264
Fe_{total}	0.573	0.049	0.591	0.123	0.038	0.327
Ca_{exch}	−0.398	0.320	−0.553	−0.117	−0.065	−0.476
Cu_{DTPA}	0.084	0.033	−0.087	**0.938**	−0.050	0.011
Cu_{total}	0.168	0.015	−0.069	**0.917**	−0.035	0.080
Silt	0.061	−0.002	−0.060	−0.098	**0.939**	0.049
Sand	0.040	−0.378	−0.082	−0.015	**−0.901**	−0.073
K_{exch}	−0.061	0.442	−0.004	0.125	0.181	**0.695**
Eigenvalue	5.426	3.599	3.295	2.130	2.007	1.489
% of Variance explained	23.590	15.646	14.326	9.262	8.726	6.472
Cumulative % variance	23.590	39.237	53.563	62.825	71.550	78.022

Table 6
Taxa collected in different cultivation fields (maize crops, olive groves and abandoned land) during April to October 2017 and 2018 (×) = presence and (–) = absence.

Species	Maize crops	Olive groves	Abandoned land
Abutilon theophrasti Medik	–	×	×
Agrostis stolonifera L.	–	–	×
Alopecurus myosuroides Hudson	–	–	×
Alopecurus rendlei Eig	–	–	×
Amaranthus deflexus L.	×	–	–
Amaranthus hybridus L.	×	×	–
Anagallis arvensis L.	×	×	×
Anthemis arvensis L.	–	×	×
Anthemis chia L.	×	–	×
Aster squamatus (Sprengel) Hieron.	×	–	×
Avena barbata Link	×	–	–
Avena sterilis L.	×	×	–
Briza minor L.	–	–	×
Bromus hordeaceus L.	–	–	×
Bromus madritensis L.	–	×	×
Calendula arvensis (Vaill.) L.	×	–	×
Capsella bursa-pastoris (L.) Medik	×	×	×
Carduus pycnocephalus L.	×	–	–
Carex distans L.	×	–	×
Carthamus lanatus L.	×	–	–
Cerastium glomeratum Thuill.	–	–	×
Chenopodium album L.	–	×	×
Cirsium arvense (L.) Scop.	×	×	×
Convolvulus arvensis L.	×	×	–
Conyza canadensis (L.) Cronquist.	×	–	×
Crepis foetida L.	–	–	×
Crepis sancta (L.) Bornm.	–	–	×
Cuscuta campestris Yunck.	–	–	×
Cynodon dactylon (L.) Pers.	×	×	×
Cynosurus echinatus L.	×	–	–
Cyperus longus L.	×	×	×
Cyperus rotundus L.	×	×	×
Dasypyrum villosum (L.) P. Candargy	×	–	×
Datura stramonium L.	–	×	–
Daucus carota L.	–	×	×
Digitaria sanguinalis (L.) Scop.	–	×	×
Dittrichia graveolens (L.) Greuter	×	–	–
Echinochloa crus-galli (L.) P. Beauv.	–	×	×
Echium plantagineum L.	×	×	×
Erodium chium (L.) Willd.	×	–	–
Erodium cicutarium (L.) L'Hér.	×	–	×
Erodium moschatum (L.) L'Hér.	×	–	×
Eryngium creticum Lam.	×	–	–
Euphorbia helioscopia L.	–	–	×
Fumaria officinalis L.	–	–	×
Galium aparine L.	–	–	×
Gaudinia fragilis (L.) P. Beauv.	×	–	–
Geranium dissectum L.	×	–	×
Geranium molle L.	×	–	×
Heliotropium halacsyi Riedl	×	–	×
Hirschfeldia incana (L.) Lagr.-Fossat	×	–	×
Hordeum murinum L.	×	×	×
Hypericum perforatum L.	–	–	×
Hypochaeris achyrophorus L.	×	–	×
Knautia integrifolia (L.) Bertol.	–	×	×
Lamium amplexicaule L.	–	–	×
Leontodon tuberosus L.	×	–	×
Lolium perenne L.	–	–	×
Lolium rigidum Gaudin	×	×	–
Lotus angustissimus L.	×	–	–
Lythrum hyssopifolia L.	×	–	×
Lythrum junceum Banks & Sol.	–	–	×
Malva sylvestris L.	–	–	×
Marrubium vulgare L.	×	–	–
Matricaria recutita L.	–	–	×
Medicago arabica (L.) Huds.	×	–	×
Medicago orbicularis (L.) Bartal.	×	–	×
Medicago polymorpha L.	×	–	×
Medicago sativa L.	–	–	×
Mentha longifolia (L.) Huds.	×	–	–
Mentha pulegium L.	×	×	×
Mentha spicata L.	×	–	–
Myosotis arvensis (L.) Hill	–	–	×
Myosotis ramosissima Rochel	–	–	×

(*continued on next page*)

Table 6 (*continued*)

Species	Maize crops	Olive groves	Abandoned land
Neslia sp.	×	–	–
Ononis pubescens L.	–	–	×
Oxalis pes-caprae L.	–	×	–
Parentucellia latifolia (L.) Caruel	×	–	–
Paspalum distichum L.	×	–	×
Phalaris sp.	–	×	–
Phleum subulatum (Savi) Asch. & Graebner	–	–	×
Picris echioides L.	×	–	×
Piptatherum miliaceum (L.) Coss.	–	–	×
Plantago afra L.	–	–	×
Plantago lanceolata L.	–	–	×
Poa annua L.	×	–	×
Poa trivialis L.	×	–	×
Polygonum arenarium Waldst. & Kit.	–	–	×
Polygonum aviculare L.	–	×	×
Polygonum lapathifolium L.	–	–	×
Portulaca oleracea L. s. str	×	×	×
Ranunculus sardous Crantz	×	–	×
Rumex conglomeratus Murray	×	–	×
Rumex palustris Sm.	–	–	×
Rumex pulcher L.	×	–	–
Scolymus hispanicus L.	×	–	×
Senecio vernalis Waldst. & Kit.	–	–	×
Setaria sp.	–	×	–
Silene colorata Poiret	×	–	×
Silene gallica L.	×	–	×
Silybum marianum (L.) Gaertner	×	×	–
Sinapis arvensis L.	–	×	–
Sisymbrium officinale (L.) Scop.	×	–	–
Solanum elaeagnifolium Cav.	–	–	×
Solanum nigrum L.	–	×	×
Sonchus arvensis L.	–	×	–
Sonchus asper (L.) Hill	×	–	×
Sonchus oleraceus L.	×	×	–
Sorghum halepense (L.) Pers.	×	×	×
Stellaria media (L.) Vill.	–	–	×
Tordylium apulum L.	×	–	×
Trifolium campestre Schreb.	×	×	×
Trifolium pratense L.	–	–	×
Trifolium repens L.	×	–	–
Trifolium resupinatum L.	×	–	×
Trifolium scabrum L.	–	–	×
Trigonella corniculata (L.) L.	–	–	×
Verbascum sinuatum L.	×	–	×
Verbena officinalis L.	–	–	×
Veronica arvensis L.	–	–	×
Vicia lathyroides L.	×	–	–
Vicia lutea L.	–	×	×
Vulpia muralis (Kunth) Nees	×	–	–
Xanthium spinosum L.	×	–	×
Xanthium strumarium L.	×	×	×
Total	**71**	**36**	**94**

doned fields, (maximum values not higher than 1.22 dS m^{-1}). Thus, an increasing trend of soil EC values in maize cultivations versus those of abandoned land is observed. In addition, the results of exchangeable sodium percentage (ESP) showed that the mean value with S.D. in all study area was 1.32% ± 0.83 with min and max values, 0.38% and 4.89%, respectively. Among land-use types, significantly higher mean values were observed in maize crops (1. 76% ± 1.09) while, lower in abandoned land (1.04% ± 0.44).

Significantly higher mean P_{Olsen} soil concentration was observed in annual crops and olive groves compared to abandoned land. K_{exch} values show similar tendency without however any significant difference among the land-use types under study (Table 2). The average values of soil organic C (SOC) were generally moderate but varied significantly among the land-use types, since the olive groves and the abandoned lands exhibit higher values than that recorded in maize fields (Table 2). Concentration of total nitrogen shows a similar trend since in the 85% of the collected soil samples it ranges at low levels (<1.5 g Kg^{-1}). The C/N calculated ratio showed statistically significant differences among land-use types. Specifically, in maize crops C/N was lower (9.59 ± 1.02) while the highest ratio (11.1 ± 1.65) was found in olive groves. The average soil NO_3^- content, was also significantly different among land-use types, with the lowest mean values recorded in maize crops.

The detected concentrations of heavy metals are shown in Table 3. Zinc mean concentration extractable with DTPA method (Zn_{DTPA}) in olive groves was significantly higher than that of the other two land-use types, possibly due to Zn fertilizers and/or organometallic fungicides that may have been used in the past. The percentage distribution of soil heavy metals concentration (Table 4), shows that very high and very low plant-available fractions of analyzed metals, particularly of Cu and Zn, were detected. Except for Cu, the other total or pseudo-total (aqua regia) metals studied, did not present an abnormal content. Cu mean concentrations obtained either with DTPA method (Cu_{DTPA}) or with aqua regia extraction (Cu_{total}) were significantly higher in the topsoil of olive groves in relation to the topsoil of the other two land-use types. Especially in olive groves, the detected Cu_{DTPA} concentrations ranged from 0.82 to 39.2 mg Kg^{-1} and as for Cu_{total}, it ranged from 15.6 to 120 mg Kg^{-1}, while the Cu_{total} concentrations in the other two types ranged from 11.7 to 29.6 mg Kg^{-1} and from 13.1 to

Table 7
Summary table of families and number of species per family in the different cultivation fields.

	Abandoned land		Olive groves		Maize crops	
Families	No of species	% presence of species	No of species	% presence of species	No of species	% presence of species
Amaranthaceae	1	1.06	1	2.78	2	2.82
Apiaceae	2	2.13	1	2.78	2	2.82
Asteraceae	17	18.09	6	16.67	17	23.94
Boraginaceae	4	4.26	1	2.78	2	2.82
Brassicaceae	2	2.13	2	5.56	4	5.63
Caryophyllaceae	4	4.26	0	0.00	2	2.82
Chenopodiaceae	1	1.06	1	2.78	0	0.00
Convolvulaceae	1	1.06	1	2.78	1	1.41
Cyperaceae	3	3.19	2	5.56	3	4.23
Dipsacaceae	1	1.06	1	2.78	0	0.00
Euphorbiaceae	1	1.06	0	0.00	0	0.00
Fabaceae	11	11.70	2	5.56	8	11.27
Geraniaceae	4	4.26	0	0.00	5	7.04
Hypericaceae	1	1.06	0	0.00	0	0.00
Lamiaceae	2	2.13	1	2.78	4	5.63
Lythraceae	2	2.13	0	0.00	1	1.41
Malvaceae	2	2.13	1	2.78	0	0.00
Oxalidaceae	0	0.00	1	2.78	0	0.00
Papaveraceae	1	1.06	0	0.00	0	0.00
Plantaginaceae	2	2.13	0	0.00	0	0.00
Poaceae	18	19.15	10	27.78	13	18.31
Polygonaceae	5	5.32	1	2.78	2	2.82
Portulacaceae	1	1.06	1	2.78	1	1.41
Primulaceae	1	1.06	1	2.78	1	1.41
Ranunculaceae	1	1.06	0	0.00	1	1.41
Rubiaceae	1	1.06	0	0.00	0	0.00
Scrophulariaceae	2	2.13	0	0.00	2	2.82
Solanaceae	2	2.13	2	5.56	0	0.00
Verbenaceae	1	1.06	0	0.00	0	0.00

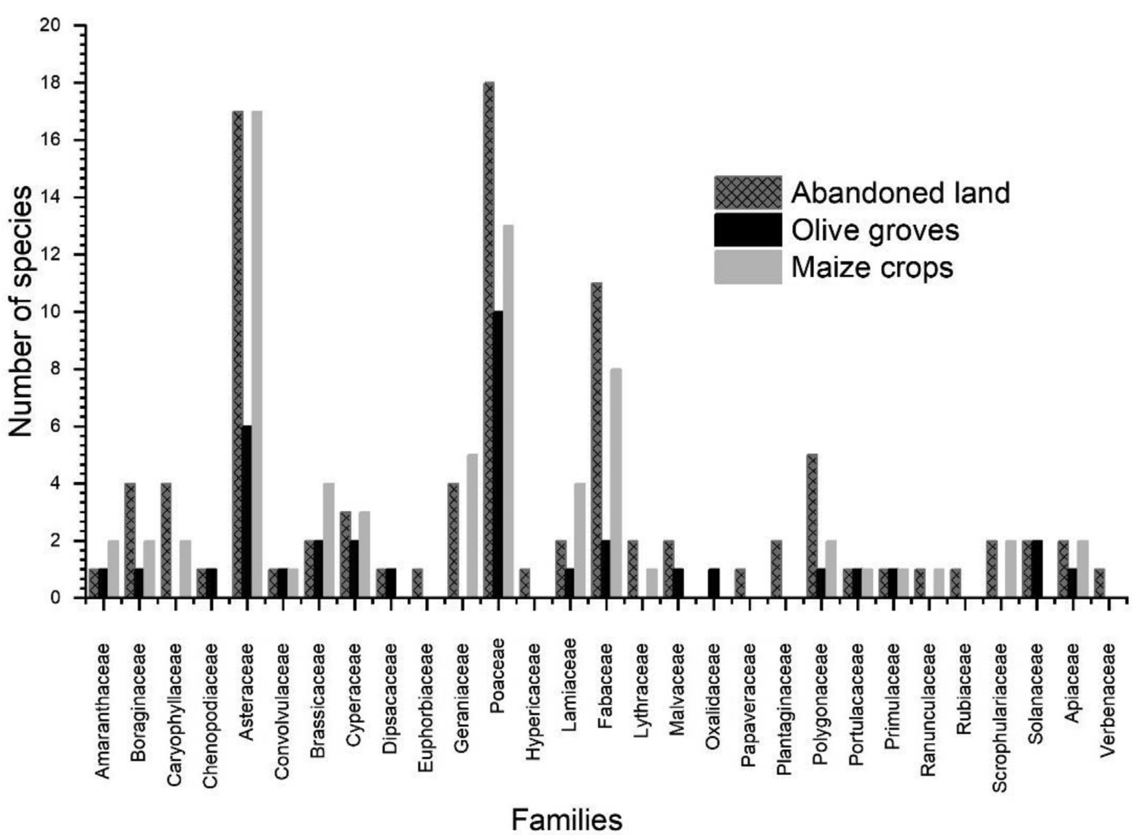

Fig. 2. Numbers of species from each family which were collected in cultivation fields of three different land use types.

46.5 mg Kg^{-1} for the maize crops and the abandoned fields, respectively (Table 3).

From the data presented in Tables 2 and 3, it is obvious that in the three different land-use types (maize crops – olive groves – abandoned land), in 9 out of 23 edaphic parameters (pH, EC, SOC, Total N, NO_3^-, P_{Olsen} and Cu_{DTPA}, Zn_{DTPA} and Cu_{total}) statistically significant differences were observed.

3.2. Edaphic indicators assessment in the selected land-use types

Principal component analysis (PCA) was used to assess how many and which of the above (23) mentioned parameters can be considered as representative edaphic indicators correlated both to native plant species presence/absence in arable land and the environmental changes arising from the chosen land management practices. After applying varimax rotation factor analysis six principal components were revealed (PC1, PC2, PC3, PC4, PC5, PC6, Eigenvalue >1). Those components represent 78,022% of cumulative variance (Table 5). PC1 is defined by soil fertility, PC2 by soil electrical conductivity, PC3 is defined by soil reaction and PC4 by the use of agrochemicals, that are mainly based on Cu. PC5 is defined by soil texture, while PC6 is attributed to nutrients "pseudocorrelation" and its effect on K_{exch}.

Table 8
Sørensen similarity index between different type of land use.

Land use	Sorensen similarity index
Abandoned land/maize crops	0.3529
Olive groves/abandoned land	0.2696
Olive groves/maize crops	0.2621

3.3. Comparison of species richness in different land-use

During the field work 126 taxa that belong to 29 families were recorded in total. The number of taxa per land-use type is given in Table 6, while in Table 7 the families and number of taxa per family, are presented Fig. 2. From a floristic point of view, the abandoned land is the richest land-use type since it includes 94 taxa, while the olive groves with only 36 recorded taxa represent the poorest category. Twenty taxa were recorded only in maize crops, thirty-eight only in abandoned land and six only in olive crops. In

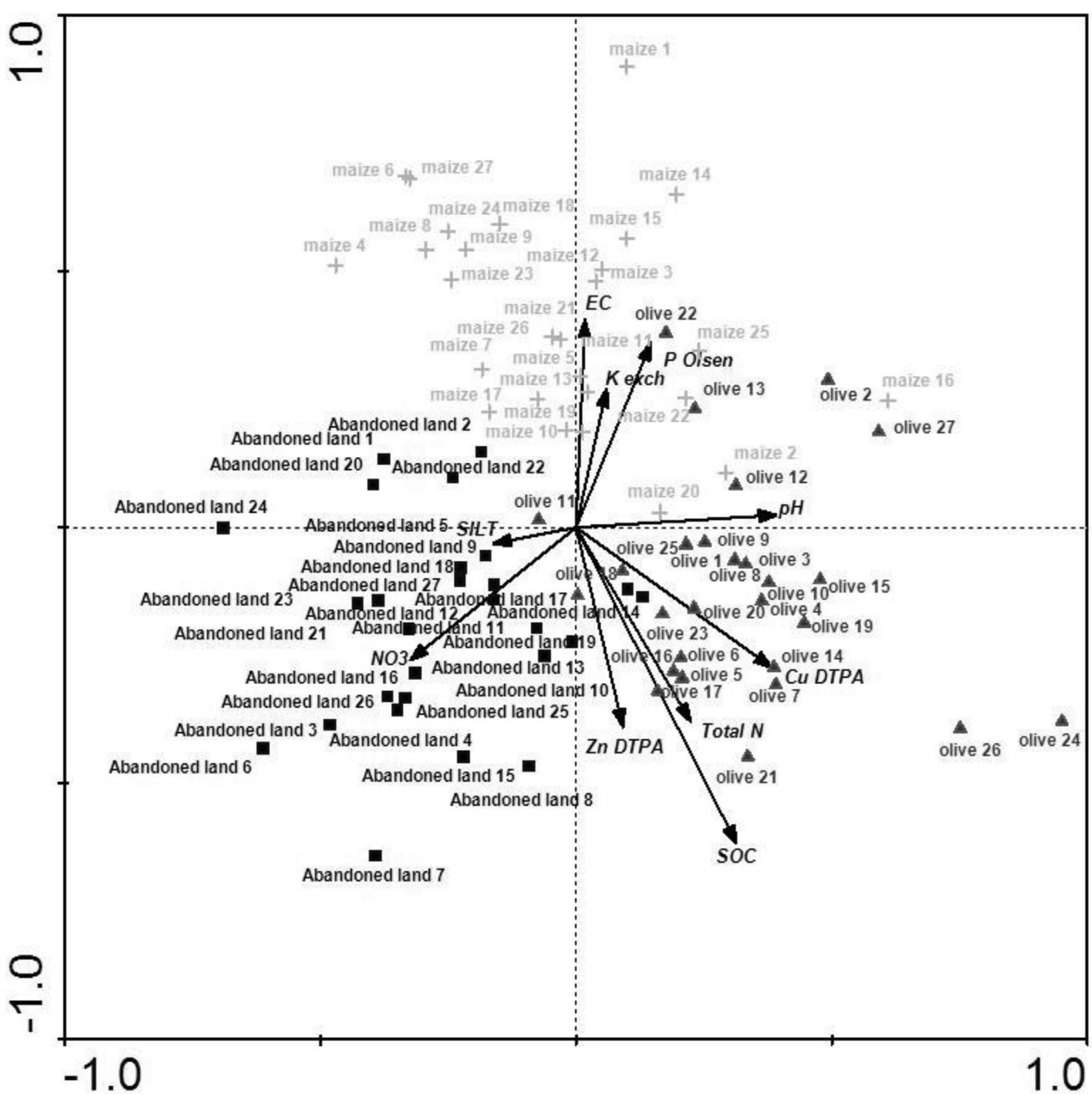

Fig. 3. CCA biplot ordination diagram of the first two canonical axes 1,2 with cultivation fields (+) in maize crops, (■) in abandoned land, and (▲) in olive groves and environmental variables (arrows).

addition, 13 taxa are common to all 3 different types of land-use. The Sørensen similarity index was used in order to find the floristic similarity between the fields of different cultivation use. This particular index was selected due to the fact that it gives greater weight to taxa that are common in all three investigated cultivation types rather than to taxa found in only one lan-use category (Bobo et al., 2006). The greatest similarity was found between abandoned land/maize crops followed by olive groves/abandoned land. The least similarity was found between olive groves/maize crops (Table 8).

3.4. Ordination

In the selected cultivation types the interrelation between floristic composition and environmental parameters was also studied. The results of the Canonical Correspondence Analysis between taxa, sampling fields and environmental variables are shown in two CCA biplot graphs (Figs. 3, 4). CCA analysis of experimental fields, plant species and environmental variables based on the first two axis, explains the 14.1% of the variance (inertia) of data concerning taxa, and the 72.7 (%) of the variance in the weighed averages of taxa in relation to the environmental variables (Table 9).

The environmental variables on the biplots diagrams are represented by arrows (Figs. 3 and 4). The arrow for each environmental variable points to the direction of the maximum change of that environmental variable across the diagram and its length is proportional to the rate of change in this direction (ter Braak, 1987). Among the examined environmental variables, the soil organic carbon, pH, EC, Total N, Cu_{DTPA} and Zn_{DTPA} (axis 1: pH and Cu_{DTPA}, axis 2: SOC, electrical conductivity, Total N andZn_{DTPA}) are represented by the longest arrows. These environmental variables with long arrows are mostly correlated both to ordination axes and the variation patterns of species or sampling fields shown in the ordination diagrams (Fig. 3).

Along axis 1, the 31% and the 30% of species composition are explained by the pH and Cu_{DTPA} respectively, whilst along axis 2,

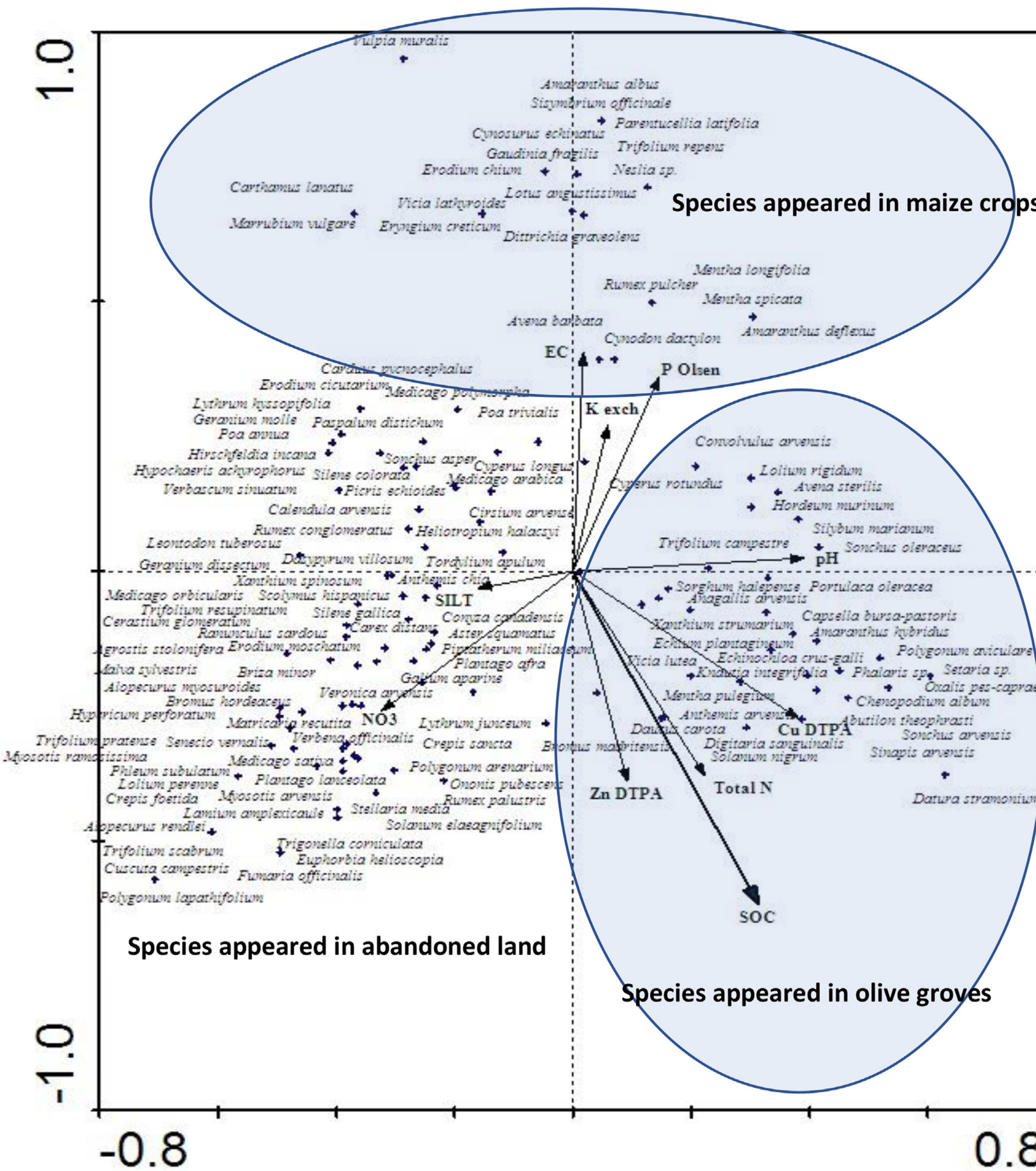

Fig. 4. CCA biplot ordination diagram of the first two canonical axes 1, 2 with plant species and environmental variables (arrows) in cultivation fields of three different land use types.

Table 9
Correlations of environmental factors (pH, electrical conductivity (EC), silt, soil organic carbon (SOC), Total N, NO_3^-, P_{Olsen}, K_{exch}, Cu_{DTPA}, Zn_{DTPA}) with the first two CCA axes, Eigenvalues of the ordination axes and sum of all unconstrained Eigenvalues (total inertia) for CCA analysis.

Environmental variables		Axis 1	Axis 2
pH		0.31	0.02
EC		0.01	0.33
Silt		−0.13	−0.03
SOC		0.25	−0.50
Total N		0.18	−0.31
NO_3^-		−0.25	−0.21
P_{Olsen}		0.11	0.29
K_{exch}		0.04	0.22
Cu_{DTPA}		0.30	−0.22
Zn_{DTPA}		0.07	−0.31
Species-environment correlation		0.79	0.82
Cumulative percentage variance:			
(i) of species data		8.4	14.1
(ii) of species-environment relation		43.5	72.7
Total inertia:	0.72		
Sum of all eigenvalues:	3.73		

species composition could be attributed to the soil organic carbon, electrical conductivity, Total N and Zn_{DTPA} in percentages 50%, 33%, 31% and 31% respectively (Table 9).

According to the CCA biplots ordination diagrams it is evident that the sampling fields deriving from different land-use are well segregated. Plots with medium to high positive score on Axis 1 are strongly correlated with the Cu_{DTPA}, and are those from the olive groves. The plots from maize crops show medium to high score in Axis 2 and have a strong correlation with EC, P_{Olsen} and K_{exch}. The rest sample plots which took place at abandoned land are grouped on the negative side of Axis 1 and Axis 2 in the lower left part of the diagram and are strongly correlated with nitrate (NO_3^-).

From the second CCA biplots ordination diagrams that concern plants and environmental variables a clear distinction between the taxa which were found in the three different land-use types (Fig. 4) was observed. Taxa which were found in abandoned land were grouped on the lower left part of the diagram and their occurrence is strongly correlated with NO_3^-. A much smaller number of taxa is dispersed in the upper and lower right part of the ordination diagram, including mainly those recorded in maize crops and olive groves. The first group on the upper right side presents strong correlation with P_{Olsen}, K_{exch} and electrical conductivity (EC) while the second one with Cu_{DTPA}, Total N, Zn_{DTPA} and soil organic carbon (SOC). Both groups present a positive correlation with pH.

4. Discussion

In the Mediterranean countries, intensive agriculture and the wide use of agrochemicals are usually associated with the decrease of soil content in organic substances, the presence of potentially toxic elements such as heavy metals, and the reduction of species richness in the agricultural land. This degradation and soil pollution, in connection with the depletion of species diversity, causes many environmental problems (Newbold et al., 2015; Tilman et al., 2011). The results of the present study are in agreement with previous literature data (Lange et al., 2015; Manzoni et al., 2012) as they show clearly that the management practices applicable to different types of land-use such as tillage, irrigation, treatment of residue and the using of fertilizers/pesticides, affect plant species diversity and soil properties of cultivated fields. However, the applied agricultural practices should not deteriorate the quality of soils, deplete the stocks of organic matter, erode the upper fertile layer of soil and diminish species diversity leading to the uniformity of flora in cultivated land. For this reason, in the present study selected soil properties were measured in abandoned fields, olive groves and maize crops of the study area in order to identify the most sensitive and reliable soil indicators for the evaluation of land-use impact on soil quality and species diversity.

A holistic dataset of soil health indicators should include physical, chemical and biological properties (Doran and Zeiss, 2000; Dick, 1994). However, Takoutsing et al. (2016) focused on chemical properties because they were considered as the most important factors that have been reported to be affected by land management and also, they have a great impact on crop productivity. Triantafyllidis et al., (2018) used sixteen soil physicochemical parameters as a dataset of soil health indicators, to develop different soil quality indexes, as a tool to support cost-effective soil management practices in the area of Aitoloakarnania (Greece). In this study twenty-three (23) soil physicochemical properties were used to estimate the effect of land-use types on edaphic properties and plant species diversity in cultivated land. Also, in the fields of the three different cultivation types (Table 1) which however, are under the same climatic conditions and have similar slope (0–3%), SUT (FLca) and soil type (Loamy soils), only the 39% (9/23) of edaphic properties (mean values) presented statistical differences (Tables 2 and 3). This probably reveals that mostly the geogenic enrichment and less the anthropogenic activities affect most of the soil properties. However, in agricultural soils their physicochemical properties mainly exhibit to a mixed source both by natural and anthropogenic sources (Kelepertzis, 2014). After the analysis of our data, it is obvious that ten out of twenty-three (10/23) are the most sensitive and reliable environmental variables (pH, EC, silt, SOC, Total N, NO_3^-, P_{Olsen}, K_{exch}, Cu_{DTPA}, Zn_{DTPA}).

Soil pH variability observed among different land-use types (Table 2), is correlated to a corresponding increase of $CaCO_3$. As a consequence, significantly different values could be attributed to a combination of causes such as spatial variation of geogenic $CaCO_3$ (Yassoglou, 2004), different land management practices (Table 1) and probably prior application of liming or acidifying materials. Our results are in accordance with what is suggested by Goulding (2016), who reports that soil pH is affected by the type of plant cultivation and the use of fertilizers. Significant differences among different land-use types (olive/corn/wheat/pastures/forest) are also reported from Lesvos island (Tsadila et al., 2012). Furthermore, our results show that soil pH is an environmental variable which is correlated with species diversity (Table 9). According to Ahmad et al. (2016) deviations from soil pH values are possibly related to seed germination and plant growth, consequently influencing species composition in fields.

The variability of pH values could influence P_{Olsen} concentration in alkaline or acidic soil conditions. This is a good explanation for the rapid insolubilization of P_20_5 in alkaline pH values while the reduction of pH can accelerate calcium phosphate solubility and increase P bioavailability (Moore et al., 2014). In our case the moderate mean P_{Olsen} concentration that was observed in the abandoned land could be attributed to a such reduction of pH mean values (Table 2). Nevertheless, in the other two land-use types significantly higher mean P_{Olsen} concentrations were observed due to the long-lasting use of N-P-K fertilizers that reduces species richness and potentially affect their diversity (Ceulemans et al., 2014). Similar results were observed by Chen et al. (2011) among orchards, vegetable fields and croplands, in which different management practices were applied. Yan et al. (2013) report that the intensive and consecutive applying of fertilizers can alter soil pH, organic matter, and some properties of soil biology, which affect both the absorption and the desorption of Phosphorus (P) in soils. Other studies report that soil P fractions are influenced by the vegetation and its nutrient demands in phospates (Yang et al., 2019).

It is obvious that the type of land-use significantly affects the soil *EC values*, with higher values being observed in maize crops (Table 2), a result that is in accordance with previous studies (Tsadila et al., 2012; Willy et al., 2019). This variation of EC values within the selected land-use types could be mostly attributed to input fluxes of nutrients in agro-soils and less to the quality of irrigation water (low concentration of Na^+) which leads to permanent high soil EC changes (Bünemann et al., 2018). As shown in Table 5, soil EC is mainly related to the nitrate content of soil, the clay content, and the exchangeable Mg and Na and less with the K_{exch} concentrations, results that are in line with those reported by Patriquin et al. (1993).

The crop nutrient requirement varies among different crops due to their leaf morphology, photosynthesis and different growing conditions (Lambers and Poorter, 1992). However, nitrogen inputs (inorganic fertilizers, animal manure, sludge and composts, cover crops, etc.) mainly affects soil nitrogen content (Nazaryuk et al., 2002; Colombo et al., 2015). Our results show significantly higher concentrations in the abandoned lands and olive groves possibly due to different management practices and/or crop nutrient requirements (Table 1). Even though during cultivate period of maize, approximately 270–280 units of nitrogen were added (Table 1), the NO_3^- concentration which was detected in soil samplings of February was moderate (10–20 mg Kg^{-1}) or low (<10). This is probably due to the high degree of nitrogen uptake by maize plants (Weih et al., 2018) and to seasonal variation of NO_3^- in soil, as a result of high rainfall height (800–1000 mm per year) which was recorded in the study area, leading to leaching and/or runoff of nitrates. However, crop yield specifically in maize is closely associated with N application, where other inputs and management practices are optimal (Bedoussac et al., 2015). These practices seem to affect significantly soil organic matter and total N, which are both important sources of soil nitrates (Table 2). However, the extensive use of fertilizers, the management practice related to N enrichment and the consequent disturbance of soil quality influence the species richness in the maize crops in comparison with olive groves (Table 6). Similar results were observed in previous studies (Van den Berg et al., 2005; Horswill et al., 2008; Maskell et al., 2010), reporting that N enrichment influences species diversity. Moreover, previous studies (Noitsakis et al., 1992; Karatassiou, 1999) demonstrated that vegetation succession in the Mediterranean fields is affected by the ability of each species to withstand summer drought. In this study, irrigation water was used only in maize crops (Table 1) and not in the abandoned land or in the rainfed olive groves.

Soil organic carbon in the study areas was also affected by the type of land-use, with the lowest values detected in maize crops (Table 2). Crews and Rumsey (2017) report that in intensive maize monocultures SOC concentration decreases, although in agricultural land it takes years to decades to change the diminished SOC stock (Poeplau et al., 2011). According to Lange et al. (2015) SOC enrichment in cultivation lands is probably correlated to species richness. This assumption could possibly explain the organic carbon concentrations measured in abandoned lands of study area (Fig. 4). Although the number of species per family is lower in the olive groves in comparison with the relative numbers of the other two cultivation types (Table 7), SOC content remains in high levels. We suppose that this is mainly due to the different residue treatment as it is given in Table 1. Therefore, according to Vignozzi et al. (2019), sustainable management practices such as integration of pruning residues in olive groves, seem to contribute in preserving soil organic matter (Vignozzi et al., 2019).

The significant differences of *total N* topsoil concentration that are observed among the types of land-use (Table 2), could be correlated to the different amount of total inorganic nitrogen supplied to soil, depending on weed management, pruning residues integration, the animal manure and the use of inorganic fertilizers (Table 1). Our results indicate that the ratio C/N calculated, ranged from 7.85 to 14.3 in 81 fields, a rate within the normal range, which is observed in common agricultural topsoil (Analogidis, 2000; Fazhu et al., 2015; Bui and Henderson, 2013). Moreover, in the study area the ratio C/N in loamy soils seems to be significantly affected by land-use. The lowest ratio was measured in maize crops due to tillage practices and species richness, an assumption which is in line with the data reported by Fazhu et al. (2015) and Zhong et al. (2013).

The potential toxic element accumulation in cultivation lands, due to long-term application of unsustainable management practices, has a significant impact on soil healthiness and on the functionality of agroecosystems (Triantafyllidis et al., 2020). Although fertilizers are essential in order to provide adequate nutrients and ensure successful harvest, they contribute to the increment of some toxic heavy metals content in agricultural soils (Kabata-Pendias and Mukherjee, 2007). Rezapour et al. (2020) report that the successive anthropogenic interventions such as the wide use of agrochemicals (synthetic chemical fertilizers, fungicides, insecticides, herbicides) can overlap the parent material's contribution to the soil agro-environment. In the study area and specifically in olive groves the successive inputs of Cu amount up to 3500 gr ha^{-1} each year, due to the broad use of Cu-fungicides. On the other hand, "hidden" impurities of Cu- that are integrated in inorganic fertilizers were approximately 8.2 gr ha^{-1} Cu. This percentage was indirectly assessed by multiplying the inputs of inorganic fertilizers applied recently in the olive groves of the study area (Table 1), taking into consideration their Cu-impurity content, as it is described in Milinovic et al. (2015) and Gimeno-García et al. (1996). From the above it is evident that the land-use and the usual management practices play an important role in the healthiness and the sustainability of agroecosystem environment.

However, for the evaluation of the agrochemical effect on crucial environmental properties, the total fraction of heavy metals and DTPA-extractable in agricultural soil, was determined. The interpretation of the results showed that only Cu concentration is a threat of contamination of agro environment, according to the threshold and guideline values for metals in soils (Ministry of the Environment—MEF, Finland, 2007). The threshold Cu_{total} (100 mg kg^{-1}) is the lowest possible value for further assessment in the area, while a value over 150 mg kg^{-1} in an area, is considered to be an ecological or health risk (Tóth et al., 2016). Although in the European Union, there is no common agreement on copper threshold values for the definition of risk, Adrees et al. (2015) proposed 5–30 mg kg^{-1} as the optimal range in croplands, since lower Cu concentration leads to plant deficiency, while higher values may lead to a toxic effect. Our results showed that in 7.4% of analyzed soil samples, more than 100 mg kg^{-1} of Cu_{total}concentration was detected. All these soil samples with high Cu accumulation were observed in olive groves. The max Cu_{total} concentration in olive groves was 120 mg kg^{-1}, while in the other two land-uses, abandoned land and maize crops, was 46.5 and 29.6 mg kg^{-1}, respectively. According to the optimal range of Cu in croplands, proposed by Adrees et al. (2015), the interpretation of our results showed that abnormal Cu_{total} concentration (>30 mg kg^{-1}) was observed in 26% of olive grove soils. Furthermore, in cropland the mobility and availability of Cu depend on complex interactions between parent material, on soil characteristics (organic carbon content, texture, pH) and possible exogenous inputs (Cu-fungicides, "hidden" Cu-impurities of fertilizers), while the bioavailability of these elements may lead to toxic effects on soil organisms and susceptible plants (Rezapour et al., 2020). For instance, copper availability decreases with high pH, high soil organic carbon and high clay content (Baker and Senft, 1995).Our findings showed that Cu_{DTPA} concentration ($Cu_{bioavailable}$) was increased in olive groves compared to other land-use types (Tables 3 and 4), despite the simultaneous increase in soil organic carbon (Table 2). The same pattern between SOC and Cu bioavailability, was observed in vineyard soil (Kelepertzis et al., 2018) which is indicative of Cu-humic complexes as a result of the long-term use of Cu-containing compounds and the processes of humification. Therefore, this approximately tripling of the bioavailable fraction of Cu in olive groves (Table 3) is obvious due to the management practices as it is described in Table 1. Moreover, high significant Spearman's correlation (0.693 for $P \leq 0.01$) was observed between Cu_{total} and Cu_{DTPA} (data not shown) while the interpretation of results showed good linear relationships (R^2 = 0.8295) which are described by the following equation: $Cu_{DTPA} = 0.2937Cu_{total} - 4.0235$. From the above it is evident that a continuous interaction is observed between Cu fractions in soil environment. This continuous interaction proves the major role of copper exogenous inputs. These Cu inputs increase the bioavailable copper fraction and can lead to a decrease of species diversity due to the potentially toxic concentrations (Table 5) which are in accordance with Poschenrieder et al. (2001). In addition, previous studies (Soons et al., 2017; Suding et al., 2005; Clark et al., 2007; De Schrijver et al., 2011) demonstrate that the anthropogenic N, P enrichment and other management practices, have negative effects on species diversity, reducing the richness of plant species which is in accordance with our results in olive groves and maize crops in comparison with abandoned land. Therefore, different relationships were observed in olive, maize and abandoned land indicating that the land-use affects the above interaction (Tables 3, 4 and 6). Consequently, limiting the application of Cu-fungicides to reduce the contamination risk in specific land-use, will have beneficial effects on environmental health (e.g. in soil organisms and susceptible plants and thus, on the functions that they support). Taking all the above into consideration, we are led to the following interpretation: different agronomic practices influence soil nutrient content, soil salt content and the accumulation of heavy metals (Cu), which are likely to affect species diversity and the environmental implications among different land uses.

5. Conclusion

Different land use types affect soil edaphic properties and plant species diversity. From the twenty three (23) edaphic parameters which were studied, significant differences were observed in six (6) physicochemical parameters (pH, EC, SOC, total N total, NO_3^-, P_{Olsen}) among different land uses. Moreover, among the potential toxic elements, differences were observed for Cu_{total}, Cu_{DTPA} and Zn_{DTPA}. The anthropogenic activities such as land-use intensification, fertilization and pesticide application have negative effects on species diversity reducing the richness of plant species in olive groves and maize crops in comparison with abandoned land. Notably in permanent crops "olive groves" higher Cu accumulation was observed in comparison with arable crops "maize" and abandoned land, due to long-term application of Cu-fungicides. This environmental variable (Cu) was found to deviate from normal limits having probably a crucial impact on plant species diversity in olive groves. However, a further research should be done with the aim to estimate the Cu toxicity in species diversity. In addition, among the examined environmental variables which were taken into account in the present study the SOC, total N, NO_3^-, P_{Olsen} and K_{exch} seem to play a particularly important role in the maintenance of the ecological balance in agroecosystems.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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