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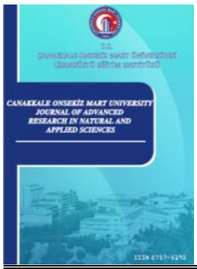

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The Effect of the Increasing Doses of Vermicompost Applications to Soil on Some Nutrient Concentrations in Olive (*Olea europaea* L.) Leaves

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Research Article

Abstract − This research was conducted on young olive (*Olea europaea* L.) trees in a private cultivation land located in Bozkoy closed to Geyikli District of Çanakkale Province, Türkiye in the year 2018. The study aimed to investigate the effects of different doses of vermicompost [(control) 0, 2, 4, 6 kg tree^{-1}] on macro and micro nutrient elements of olive trees. Randomized complete block design was established applying four doses with 5 replications. Vermicompost was applied to the soil in a depth of 15-20cm under the crown projection area. During the fruit maturity stage, the leaf samples were collected from annual shoot tip leaves. Macro nutrient element concentrations namely nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) stayed inside the limit values upon applications of increasing doses of vermicompost. While the changes were statistically non-significant. Even though, this research was an annual study comprised on a single year, where N was in an increasing trend and 2 kg tree^{-1} was found to be the most effective dose of vermicompost on N values (17.13 g kg^{-1}). Among the leaf micro nutrient elements, statistically significant increases were obtained by 2 kg tree^{-1} on copper (Cu) (31.32 mg kg^{-1}), on manganese (Mn) (50.77 mg kg^{-1}), and 6 kg tree^{-1}, on zinc (Zn) (21 mg kg^{-1}); while a decrease was observed on iron (Fe) concentration by 6 kg tree^{-1} (100.88 mg kg^{-1}). Micro nutrient elements remained under the limit of toxic effect upon all the applications. The dose 2 kg tree^{-1} was determined to be the most suitable one in terms of both macro and micro element concentrations under such trial circumstances.

Keywords − *Leaf element concentration, olive tree, organic fertilization, plant nutrient, vermicompost*

1. Introduction

Natural needs of human beings such as feeding, sheltering, healthy life, dressing and heating have been increased in parallel with the increasing world's population and ecological conditions. Agriculture, which is crucial for the nutrient supply to maintain human life also forms the basis of economy. While the unconscious use of chemical fertilizers and pesticides threaten the human and environmental health, improper agricultural practices may contaminate the soil, cause environmental problems as well as the consumption of natural sources.

Since enlarging the agricultural lands in Türkiye is not possible, preservation of the current agricultural land is crucial. "Organic and sustainable" terms evolved in the process for the search of appropriate and modern practices to preserve the natural balance (Acikgoz, 2009). The main element in the sustainable soil efficiency is the soil organic matter. Addition of organic matters to meet the low organic matter in the soil of Türkiye is obligatory. Animal manure, plant residues, mulching, farmyard manures and compost are among the leading practices to enhance the number of soil organic matters. Along with the above-mentioned practices, the organic matter can also be increased by the conscious and trained farmers who comprehend the situation by which the organic matter content is low in 79% of the soils in Türkiye (Eyüpoğlu, Kurucu, & Talaz, 1999). Organic matter loss due to some reasons is still higher than the addition of them to the soils. Therefore, educating the farmers about the different methods of soil cultivation and not performing scouting, and leading them to good

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agricultural practices will help the conservation and then preservation of the current soil organic matter and the efforts to increase them.

There is a delicate balance on earth so that every single living organism has a vital role and benefit to the nature. Use of organic fertilizers and microorganisms in agriculture is on the table according to the researches. As a result, vermicompost which is known for its positive effects among the organic materials has become important. Vermicompost is the process of conversion of natural wastes to fertilizer by decomposing by earthworms. These fertilizers are called "vermicompost" or "vermicast". Manure of the earthworms (vermicompost) which are called as "ecosystem engineers" include live nitrogen fixing fungi (Demir, Sönmez, & Polat, 2010). Beneficial microorganisms, plant nutrient elements, rhizobium bacteria, coelom liquid and enzymes enhance the structure of soil. Earthworms affect the soil fertility and plant production, and can also enhance the balance of soil, increase soil permeability and porosity as well as mix organic matter (OM), lime and fertilizers with soil. Different studies revealed that the vermicompost enhanced plant height, fresh weight and root development (Sönmez, Çıtak, Koçak, & Yaşin, 2011). The reason why vermicompost is important for agriculture and soil is that besides containing soluble and available forms of macro and micro nutrients. It also includes organic compounds and microorganisms that enhance plant growth. Nutrients in the organic wastes passing through the worms' gut can be easily uptake by the plants without any loss since they are thrown out after naturally chelated and are in colloidal form. Earthworms are known to inhibit the soil erosions with the help of the galleries they open via which they decrease the surface water in inclined lands and inhibit the water flow (Edwards & Arancon 2022).

In this study, olive (*Olea europaea* L.) trees, which are one of the most important crop in Mediterranean countries and also an important source of income of the farmers in Geyikli District of Çanakkale Türkiye, were selected as research material. Olive trees were about 14-15 years old and Ayvalık oil type. Vermicompost was produced from farmyard manure and organic wastes. The aim of this research is to investigate the effect of increasing rates of vermicompost applications on olive tree leaf nutrient concentrations.

2. Materials and Methods

The study to investigate the effect of different doses of vermicompost on the nutrients of olive trees was conducted on Ayvalık oil type olive (*Olea europaea* L.) trees of 14-15 years old situated in a private production land located in Ezine/Geyikli District of Çanakkale Province located on 39° 50' 12" N, 26° 12' 4" E. The vermicompost used in the study was produced as a result of composting fermented farmyard manure and organic wastes produced by the earthworms reared in Çanakkale Onsekiz Mart University, Faculty of Agriculture in the years 2017 and 2018. An amount of vermicompost was obtained and dried in the incubator for 48 hours at 60-80 °C of temperature (Kacar & İnal, 2010). After the drying process, the vermicompost was grinded with a stain knifed grinder. Macro and micro nutrients were determined with ICP-OES after proper extraction (Müftüoğlu, Türkmen, & Çıkılı, 2014). The results of fertilizer analysis are given in Table 1.

Table 1.

Nutrient content of the applied vermicompost (VC)

	pH	EC (dS m^{-1})	Organic-C (%)	C/N	OM (%)	N (g kg^{-1})	P (g kg^{-1})	K (g kg^{-1})	Ca (g kg^{-1})	Mg (g kg^{-1})	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
VC	6.10	2.38	30.12	13.51	51.93	22.25	9.43	16.92	20.75	5.58	2455.2	160.9	38.1	87

The experiment was conducted on 20 trees according to randomized complete block design with five replications and four different doses. Soils have been sampled in February from the crown projection area (0-30 cm) of the trees in research plots. Results are given in Table 2. Basic fertilization is arranged (Irget, Anaç, Kılıç, Tepecik, & Özer, 2010). Each plot received 10 kg da^{-1} K_2SO_4, 10 kg da^{-1} MAP in November and 20 kg da^{-1} $(NH_4)_2SO_4$ in April. The vermicompost doses were determined as 0 (control), 2, 4 and 6 kg $tree^{-1}$ upon the dry weight, except the control treatment. The determined amount of vermicompost was applied as burying to 15-20 cm depth to the tree crown projection area on the date of 18.02.2018. Additionally, each tree received 100 liters of water after vermicompost application.

Table 2.
Properties and nutrient contents of the soil of the study area

Fundamental Analyses		Macro Nutrients		Micro Nutrients	
pH (Richards, 1954)	7.51	Total N (%) (Bremner & Mulvaney 1982)	0.03	Available Fe (ppm) (Lindsay & Norvell, 1978)	7.12
EC (%) (U.S. Salinity Lab. Staff, 1954)	0.06	Available P (ppm) (Olsen & Sommers, 1982)	5.62	Available Mn (ppm) (Lindsay & Norvell, 1978)	8.49
Organic Matter (%) (Nelson & Sommers, 1996)	0.69	Available K (ppm) (Jackson, 1985)	180.71	Available Cu (ppm) (Lindsay & Norvell, 1978)	1.35
Soil Texture (Bouyoucos, 1951)	Loam	Available Ca (ppm) (Jackson, 1985)	3637.54	Available Zn (ppm) (Lindsay & Norvell, 1978)	0.12
$CaCO_3$ (%) (Loeppert & Suarez, 1996)	8.05	Available Mg (ppm) (Jackson, 1985)	59.87		
		Available Na (ppm) (Jackson, 1985)	13.01		

Usanmaz, Canözer, & Özahçı (1988) reported that the olive trees grew well on the range of pH between 6.0-8.0, and the soil was appropriate for olive cultivation. According to the results, the soil was mildly alkaline without any saltiness risk. Llamas (1984) indicated that the olive soils should have organic matter of ≥1%. The soil in this study was determined to be very poor in terms of organic matter. The lime in the loamy soil was found to be high. Uyanık & Ekinci (2017) and Kacar & Katkat (2022) indicated that the loamy soil was appropriate for olive cultivation as long as homogeneity was maintained. Among the macro elements, the soil N was very low, P and K was deficient. Genç, Moltay, Soyergin, Fidan, & Sütçü (1991) indicated that the soil in Marmara region olive soils should have Mg amount of 66-930 mg kg^{-1}. The concentrations of Ca, and Na in the soil of this study were sufficient. The Zn concentration, among the micro nutrients, was deficient while Cu, Fe, and Mn concentrations were sufficient.

The fruit ripening time when the proper leaf sampling time for olive trees started (30.11.2018 for this study) Bozkaya, 2009; Kutlu & Şen, 2011), the couple of leaves on the middle of the tip of annual shoot were taken for the purpose of sampling. Around 180 leaves were obtained from each tree and got ready for analysis in the laboratory. All samples were washed to remove any adhering soil particles and rinsed with distilled water. The plant samples were dried at 65-70 °C for 48 h and then grinded and made ready for analysis. Leaf samples were used for total nitrogen determination with Kjeldahl method which is a wet decomposition method (Nelson & Sommers, 1980). Plant extracts were obtained with dry decomposition to determine the macro and micro nutrient elements except N, using ICP-OES (Perkin Elmer OPTIMA-5300 DV) device.

Analysis of variance of the data was carried out with *F* test, multiple comparison of the means were done with Duncan Multiple Comparison ($\alpha < 0.05$).

3. Results and Discussion

3.1. Effect of Vermicompost on N Concentration of Leaf

The results of the N concentration in olive leaves upon applications of increasing rates of vermicompost (0, 2, 4 and 6 kg $tree^{-1}$) are given in Figure 1.

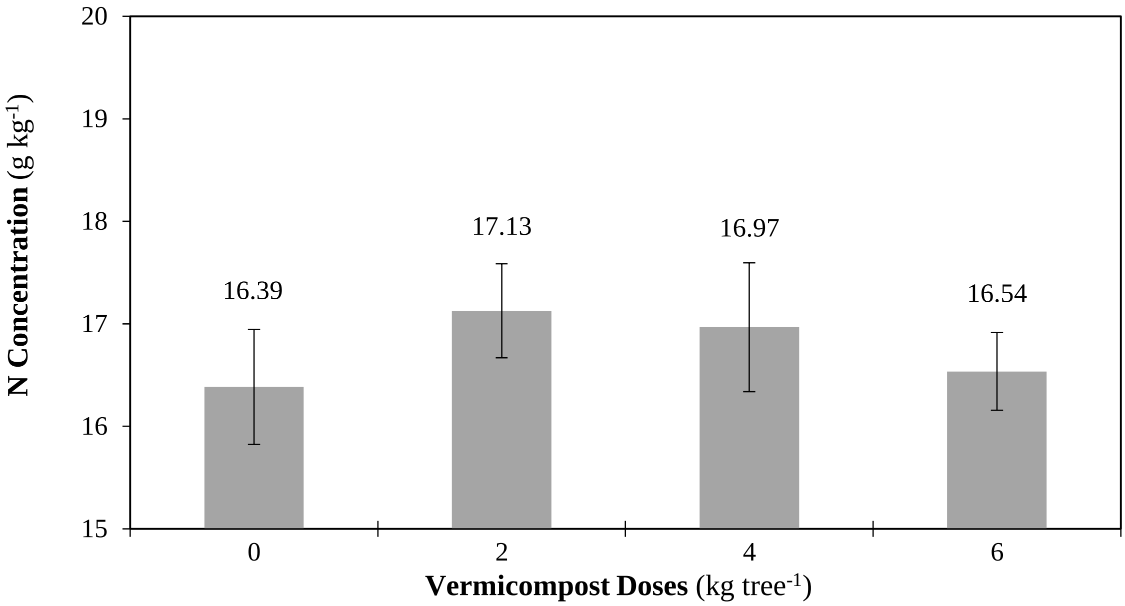

Figure 1. The effect of vermicompost applied to soil at increasing rates on olive tree leaf total N concentration

Compared to (16.39 g kg^{-1}), the N concentration of olive leaves were found to be 17.13, 16.97 and 16.54 g kg^{-1} upon increasing rates of vermicompost (2, 4 and 6 kg tree^{-1}) shown in Figure 1. The N concentrations increased by 4.51%, 3.53% and 0.91% upon 2, 4 and 6 kg tree^{-1}, respectively as compared to the control treatment. Although, there are increases in N concentrations and they were non-significant statistically. The highest N concentration was obtained by the application of 2 kg tree^{-1} vermicompost (Figure 1).

The N concentrations of olive tree was inside the limit values in all applications including the control treatment (Jones, Wolf, & Mills, 1991; Haspolat, 2006) and the levels were sufficient. Zincirlioğlu (2010) conducted research with Ayvalık oil type olives in Ayvalık region and reported that the N concentrations in the leaves were recorded between 0.74-1.33% in traditional gardens, while they were observed between 0.90-1.48% in organic gardens. The N concentrations in all the applications including the control, were 1.67% in average and sufficient according to Reuter & Robinson (1986). Şahin (2013) determined that the organic fertilizer application of different doses (0-0.5-1 and 1.5 kg tree^{-1}) did not affect the leaf N content significantly on his study of two years. These results were compatible with those of our study. The results of the same study showed that the N content of the leaves in the first year were noted as 1.12% upon 0.5 kg tree^{-1}, 1.07% upon1 kg tree^{-1}, and 1.24% upon 1.5 kg tree^{-1} applications, while they were 0.91% upon 0.5 kg tree^{-1}, 0.90% upon 1 kg tree^{-1} and 0.95% upon 1.5 kg tree^{-1} applications in the second year of the study where the N contents were lower than that of the first year of the study.

3.2. Effect of Vermicompost on P Concentration of Leaf

The results of the P concentration in olive leaves upon applications of increasing rates of vermicompost (0, 2, 4 and 6 kg tree^{-1}) are given in Figure 2.

Compared to control (0.97 g kg^{-1}) the P concentrations in olive plant were 0.90, 1.00 and 0.91 g kg^{-1} with increasing rates of vermicompost (2, 4, and 6 kg tree^{-1}) shown in Figure 2. 2 and 6 kg tree^{-1} vermicompost applications decreased the P concentration of the tree while 4 kg tree^{-1} increased it compared to the control treatment. Although, there were increases and decreases, and they were non-significant statistically (Figure 2).

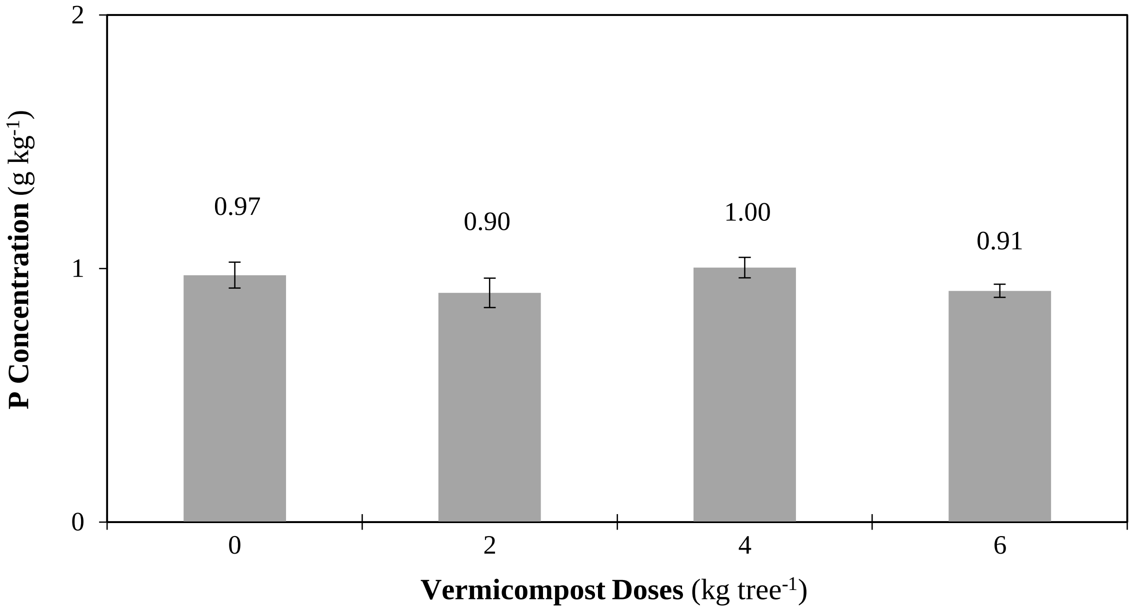

Figure 2. The effect of vermicompost applied to soil at increasing rates on olive tree leaf P concentration

The P concentrations of olive leaves were on the lowest value (>1.0 g kg^{-1}) of the limit values described by Jones et al. (1991). Llamas (1984) reported P_2O_5 should be ≥50 mg kg^{-1} for olive cultivation. Frantzeskakis, Vassouglou, & Androulakis (1977) reported that the available phosphorus should be ≥20 mg kg^{-1} and that the response of olive to phosphorus to be low (Zincirlioğlu, 2010). In our study, the vermicompost applications were not effective on P concentrations in olive leaves can be explained by lower mineralization rate in soil although vermicompost contains higher P than that of the farmyard manure (Çıtak, 2011).

3.3. Effect of Vermicompost on K Concentration of Leaf

The results of K concentration in olive leaves upon applications of increasing rates of vermicompost (0, 2, 4 and 6 kg tree^{-1}) are given in Figure 3.

As compared to control treatment (11.95 g kg^{-1}), the K concentrations of olive leaves were recorded as 11.04, 11.31 and 11.65 g kg^{-1} upon increasing rate of vermicompost (2, 4 and 6 kg tree^{-1}) applications shown in Figure 3. The decreases according to control with 2, 4, and 6 kg tree^{-1} applications were observed as 7.62%, 5.36% and 2.51%, respectively. Variations in K concentrations were statistically non-significant. The reason for the non-significant change in leaf K can be available K in soil being in sufficient amount.

Zincirlioğlu (2010) reported that the K concentration in olive is between 0.9-1.4% in the first year of study, 0.5-1.2% in the second year in traditional gardening, while it was noted as between 0.6-1.2% in the first year and between the 0.5-1.1% in the second year in organic gardening.

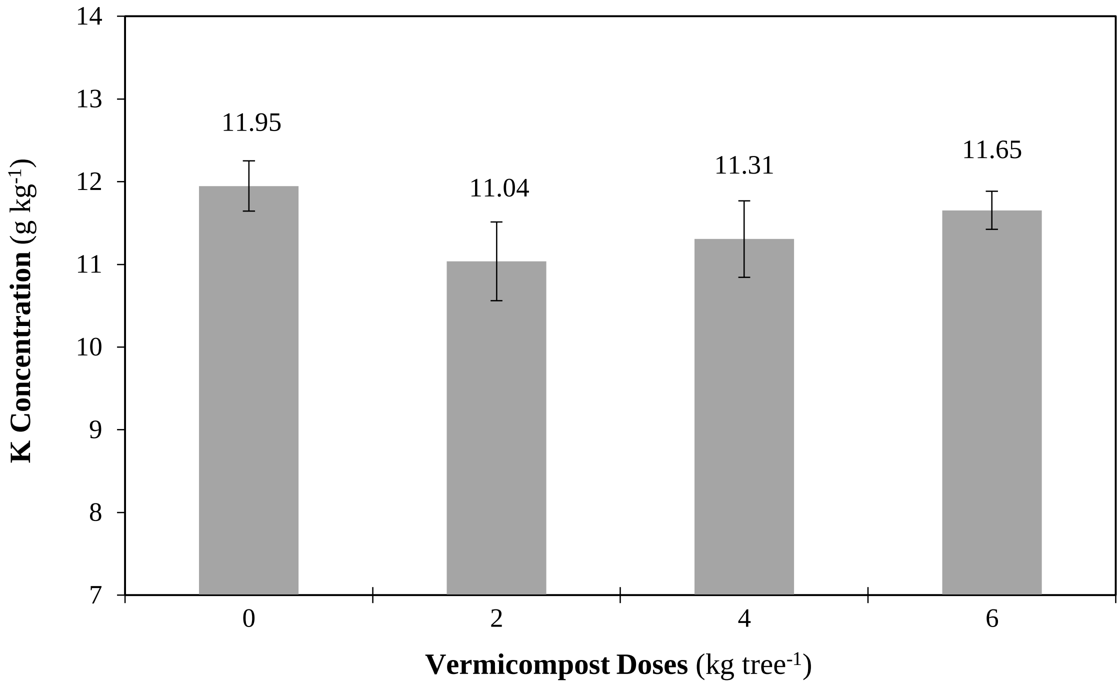

Figure 3. The effect of vermicompost applied to soil at increasing rates on olive tree leaf K concentration

Şahin (2013) determined in two-year study that the vermicompost did not have significant effect on olive leaf K concentrations, however, the interaction of year x dose was significant. K values (0.09-0.13%) were insufficient in both years according to Reuter & Robinson (1986).

K concentrations were found into the limit values (Haspolat, 2006; Reuter & Robinson, 1986) and in sufficient limits different doses of vermicompost application. The available K in soil was sufficient (Table 2) and this might be the reason why there were no significant change in olive leaves in terms of K concentrations.

3.4. Effect of Vermicompost on Ca Concentration of Leaf

The results of Ca concentration in olive leaves upon applications of increasing rates of vermicompost (0, 2, 4 and 6 kg tree^{-1}) are given in Figure 4.

As compared to control treatment (16.18 g kg^{-1}), Ca concentrations of olive tree upon increasing vermicompost applications (2, 4, and 6 kg tree^{-1}) were recorded as 16.78%, 15.78% and 16.57%, respectively shown in Figure 4. While 2 and 6 kg tree^{-1} increased Ca concentration of olive, 4 kg tree^{-1} decreased when that compared with the control treatment. Although there are increases and decreases as compared to control treatment, are not found to be statistically significant (Figure 4).

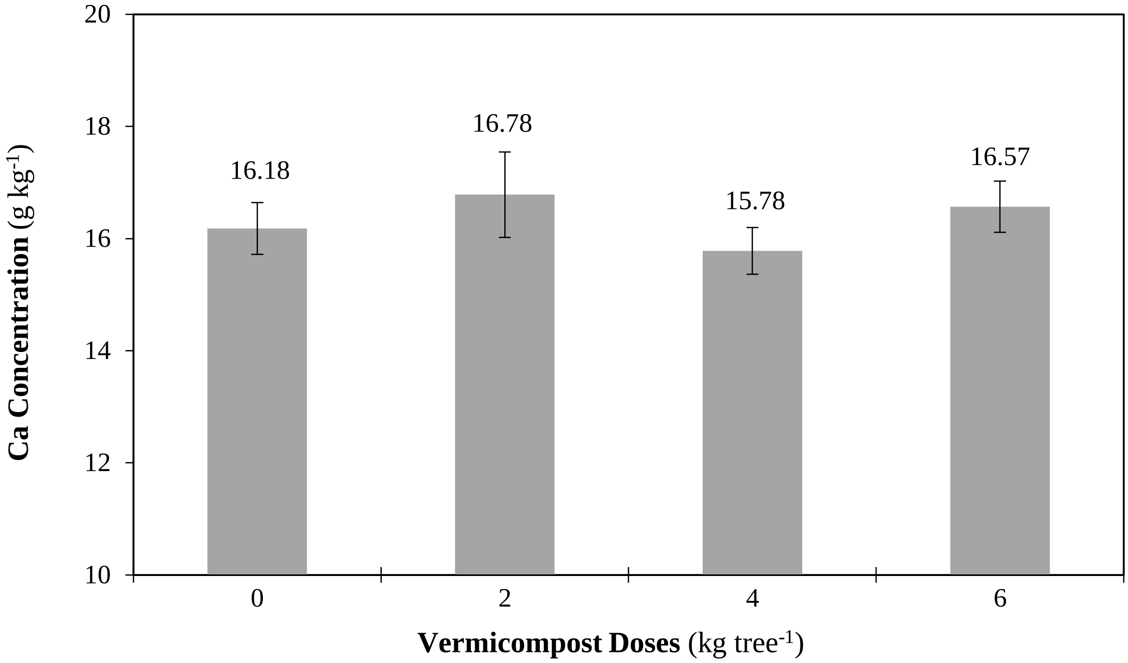

Figure 4. The effect of vermicompost applied to soil at increasing rates on olive tree leaf Ca concentration

Reuter & Robinson (1986) indicated that the available Ca should be between 1.4-2.4% for the good development for olive cultivation. The effect of vermicompost on olive Ca was between 1.5-1.6% in our study, and it was compatible with the previous study literatures. Ca concentrations of olive leaves upon different doses of vermicompost were found into the limit values (Jones et al., 1991; Haspolat, 2006), and they were all sufficient. Eryüce (1980) reported that the Ca in leaves of Ayvalık type trees as recorded as 0.88-2.14%. Our results are similar to the previous study literatures. Şahin (2013) reported that the Ca concentrations in olive leaves were the highest upon vermicompost application (0.136%) in the first year of study where the doses were applied between 0- 0.5- 1 and 1.5 kg tree^{-1}. In the second year of study, there was an increase upon vermicompost application, however, the concentration was not sufficient according to Reuter & Robinson (1986). Macro plant nutritional elements (N, P, K, Ca and Mg) were found to be different in Tepecik et al., (2022).

3.5. Effect of Vermicompost on Mg Concentration of Leaf

The results of Mg concentration in olive leaves upon applications of increasing rates of vermicompost (0, 2, 4 and 6 kg tree^{-1}) are given in Figure 5.

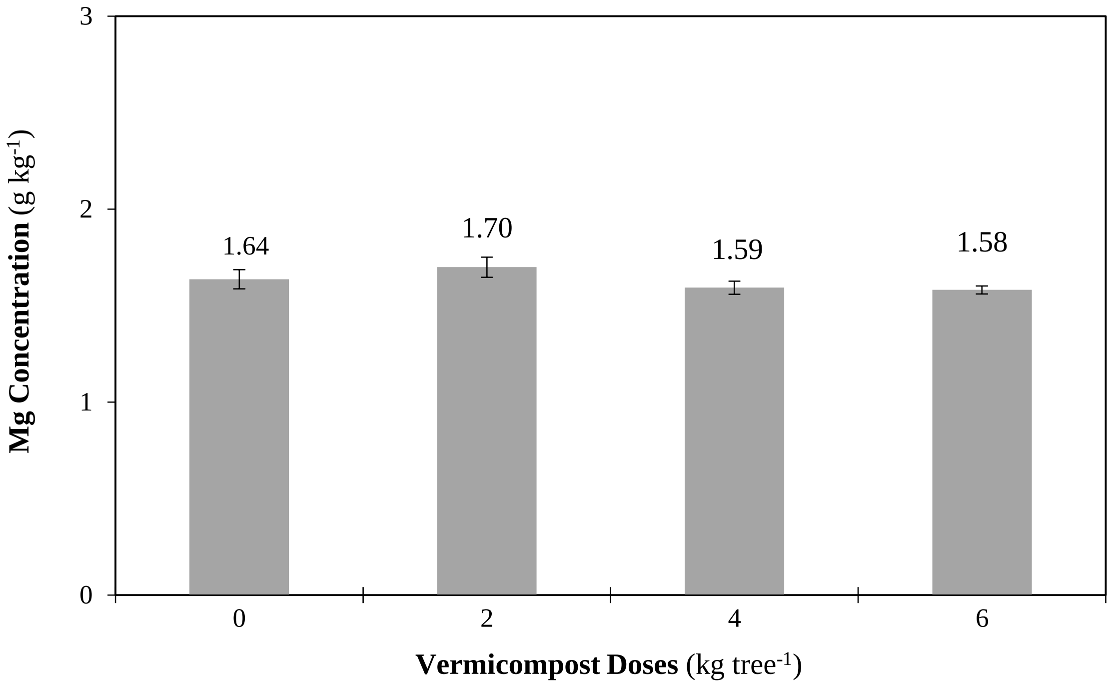

Figure 5. The effect of vermicompost applied to soil at increasing rates on olive tree leaf Mg concentration

As compared to the control treatment (1.64 g kg^{-1}), the Mg concentrations with increasing rates of vermicompost applications (2, 4, and 6 kg tree^{-1}) were found to be 1.70, 1.59 and 1.58 g kg^{-1} shown in Figure 5. There was an increase in Mg concentration of olive upon 2 kg tree^{-1} vermicompost dose as compared to control treatment, but there were decreased with 4 and 6 kg tree^{-1} vermicompost doses. Although, there are increases and decreases, and were not statistically significant (Figure 5).

Eryüksel (2016) observed the changes on onion, garlic, parsley and purslane by vermicompost application in 2 kg pots. The results of the study were similar to ours as there was increase up to 2 kg tree^{-1} dose and later there were decreases. Mg concentrations were low in all applications including control treatment according to Jones et al. (1991). In our research, none of the applications significantly affected plant Mg concentration. As described in Table 2, the deficiency of soil for Mg can be the reason of Mg concentrations being below the limit values. Eryüce (1980) revealed the Mg levels in Ayvalık type as recorded as 0.12-0.37%, while Seferoğlu (1996) observed it as 0.15-0.31%. The results of our study were similar to the above-mentioned ones.

3.6. Effect of Vermicompost on Fe Concentration of Leaf

Results regarding the Fe concentration in olive leaves upon applications of increasing rates of vermicompost (0, 2, 4 and 6 kg tree^{-1}) are given in Figure 6 and they are significantly importance at p<0.05 level. When compared to the control treatment (127.62 mg kg^{-1}), increasing rates of vermicompost (2, 4, and 6 kg tree^{-1}) the Fe concentrations in olive leaves were found to be 117.63, 121.95 and 100.88 mg kg^{-1}, respectively given in Figure 6. There were decreases in Fe concentrations upon 2, 4, and 6 kg tree^{-1} vermicompost applications when compared with the control treatment, and such decreases were as 7.83%, 4.44% and 20.95%. Variation in Fe concentration in leaves were found non-significant in control treatment, 2 and 4 kg tree^{-1} doses, but the decrease upon 6 kg tree^{-1} application was found significantly importance (Figure 6).

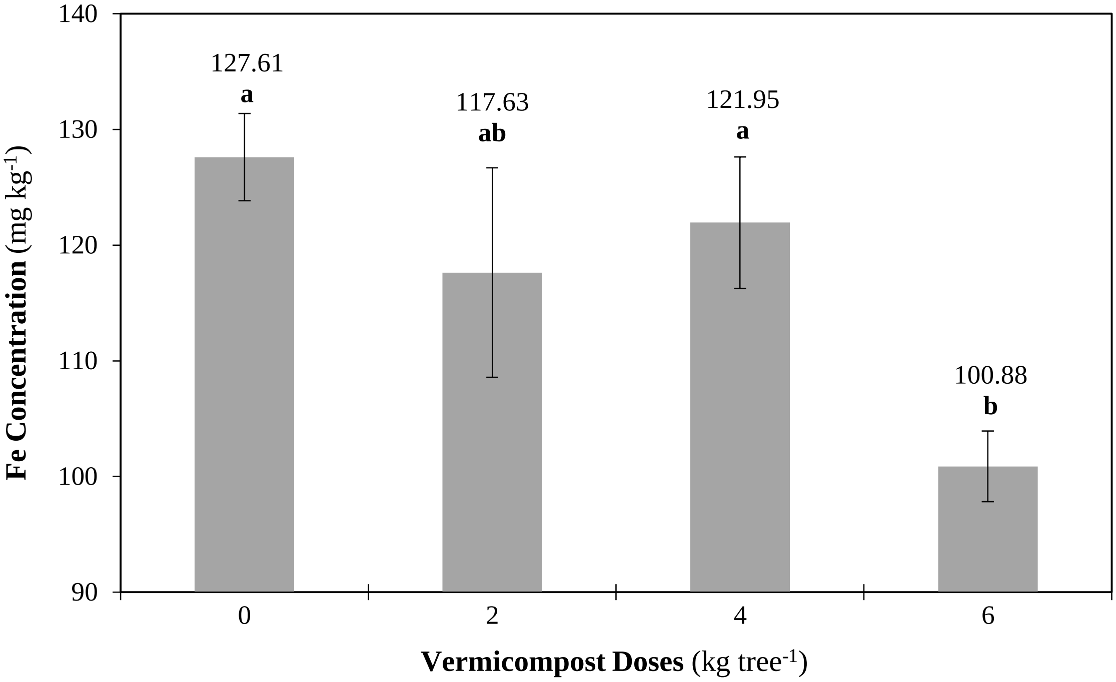

Figure 6. The effect of vermicompost applied to soil at increasing rates on olive tree leaf Fe concentration

Adiloğlu, Eryılmaz, Adiloğlu & Solmaz (2016) described that the vermicompost applications (200, 400 and 800 kg da^{-1}) decreased the Fe concentrations as compared to control treatment, and the rates changed between 18.81 and 49.82 mg kg^{-1} in case of sunflower. When we evaluated the Fe concentrations of olive as 100.88-127.62 mg kg^{-1} upon different vermicompost doses, and then they are very high in all of the applications according to Haspolat (2006). The Fe concentrations in control treatment and all other vermicompost applications were lower than the toxic effect limit (>460 ppm). Eryüksel (2016) conducted a pot experiment in 2kg of pots contained onion, garlic, parsley and purslane where different doses of vermicompost (0.5%, 25%, 50%, 75% and 100%) were applied. Fe was observed to increase with the increasing rate of vermicompost in garlic and purslane. In our study, there was a significant decrease upon the highest vermicompost application shown in Figure 6. Alpaslan & Taban (1996) reported that Fe decreased Zn uptake in plants, and Zn negatively affected the uptake of Fe, when Fe x Zn interaction was analyzed. As seen in Figure 9, the highest Zn concentration was observed in 6 kg tree^{-1} dose. Increased Zn might have decreased the Fe concentration based on the above-mentioned interaction. Güneş, Alpaslan, & İnal (2002) obtained different results and reported that the fertilizer application increased the Fe concentration of plant as compared to control treatment.

3.7. Effect of Vermicompost on Mn Concentration of Leaf

Results regarding to the concentration of Mn presence in the leaves of olive upon applications of increasing rates of vermicompost (0, 2, 4 and 6 kg tree^{-1}) are given in Figure 7, and they are significantly importance at p<0.05. As compared with the control treatment (42.87 mg kg^{-1}), the Mn concentrations in olive tree with increasing vermicompost doses (2, 4, and 6 kg tree^{-1}) were determined as 50.77, 39.69 and 47.96 mg kg^{-1}, respectively shown in Figure 7. A significant increase (18.43%) in Mn concentration upon 2 kg tree^{-1} vermicompost was observed as compared to the control treatment. There was non-significant difference in applications of 4 and 6 kg tree^{-1} vermicompost. 2 kg tree^{-1} vermicompost application was determined to be the application with the highest concentration of Mn recorded as 50.77 mg kg^{-1} (Figure 7).

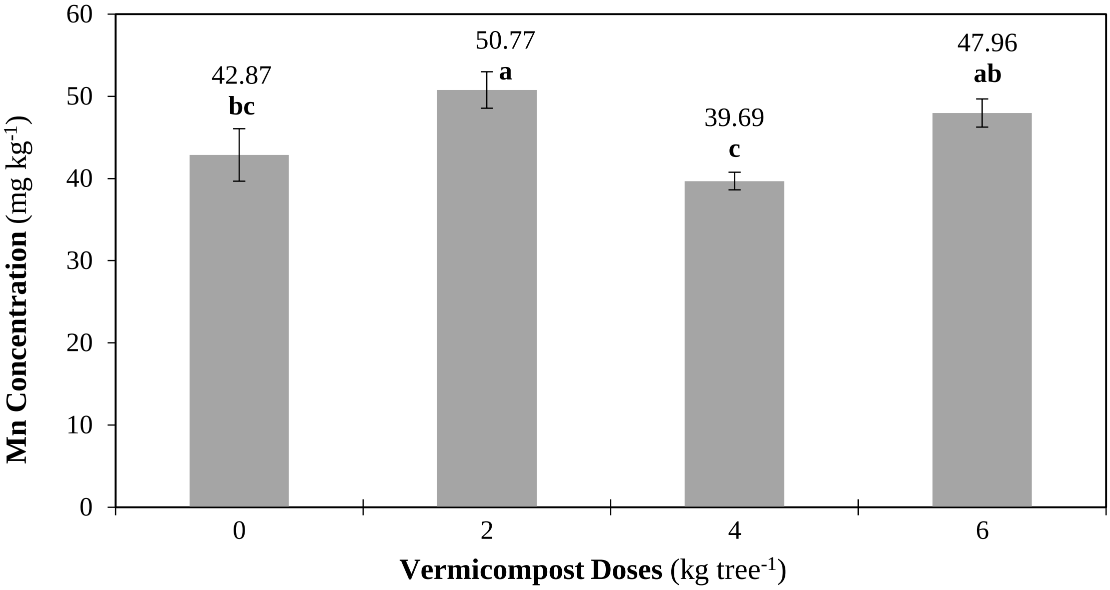

Figure 7. The effect of vermicompost applied to soil at increasing rates on olive tree leaf Mn concentration

When different doses of vermicompost were applied to olive tree, the concentrations of Mn were found to be into the limit values (Jones et al., 1991; Haspolat, 2006) and the values of Mn were all sufficient including the control treatment. The concentration of Mn in leaves were lower than the toxic effect level (>164 ppm) in all of the applications including the control treatment (Figure 7). Şahin (2013) reported that the concentrations of Mn in leaves were recorded as 50.37-57.75 and 52.37 ppm upon applications of 0.5-1 and 1.5 kg tree^{-1}, respectively, in the first year of study, while they were 41.00-60.12 and 68.87 ppm in the second year. The results of the above-mentioned study are compatible with those of our study.

3.8. Effect of Vermicompost on Cu Concentration of Leaf

Results regarding to Cu concentration in olive leaves upon applications of increasing rates of vermicompost (0, 2, 4 and 6 kg tree^{-1}) are given in Figure 8, and they found significantly important at p<0.001. The Cu contents of olive were found to be 31.32, 14.72, and 22.37 mg kg^{-1} with increasing rates of vermicompost (2, 4, and 6 tree^{-1}) when compared to control treatment (24.79 mg kg^{-1}) shown in Figure 8. The results showed that when compared to control treatment, the Cu content in olive significantly increased 26.34% with 2 kg tree^{-1} vermicompost (p<0.001) while a significant decrease upon 4 kg tree^{-1}, and no significant change with 6 kg tree^{-1}. The highest ratio of Cu in olive tree was observed by 2 kg tree^{-1} vermicompost application (Figure 8).

According to Haspolat (2006), the Cu concentration on 4 kg tree^{-1} was sufficient, high upon 6 kg tree^{-1} and in control treatment, and very high upon 6 kg tree^{-1} application. The concentration of Cu in control treatment and the other vermicompost applications were all lower than the toxic effect level (>78 ppm) given in Figure 8. Şahin (2013) conducted a study for two years with organic fertilizer application using different doses (0-0.5-1, and 1.5 kg tree^{-1}) and showed that they significantly affected the Cu contents. In the first year of study, the lowest concentration was obtained from cattle manure and the highest in case of vermicompost. While in the second year of study, there was a decrease in all applications of fertilizer, except the control treatment. The Cu content increased with increasing fertilizer application in the first year of study. The Cu content was found to be 47.500 ppm upon 1.5 kg tree^{-1}. In our study, the highest Cu concentration was found as 31.32 mg kg^{-1} with 2 kg tree^{-1} vermicompost application (Figure 8).

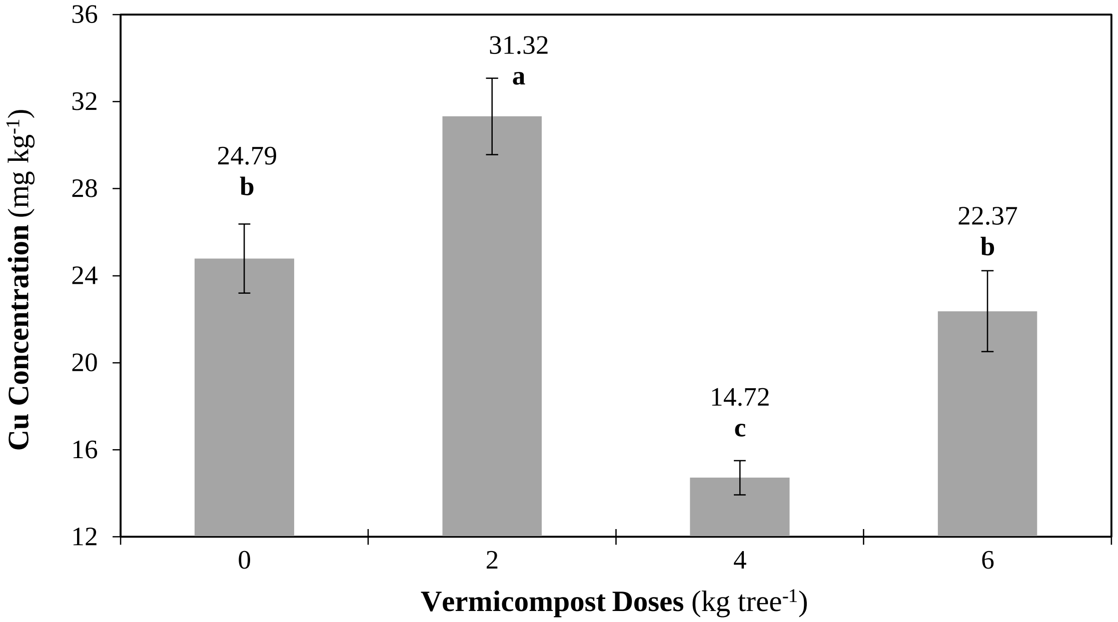

Figure 8. The effect of vermicompost applied to soil at increasing rates on olive tree leaf Cu concentration

3.9. Effect of Vermicompost on Zn Concentration of Leaf

The effect of increasing rates of vermicompost applications (0, 2, 4 and 6 kg tree^{-1}) on Zn concentration of olive tree are significantly importance at p<0.05 as shown in Figure 9.

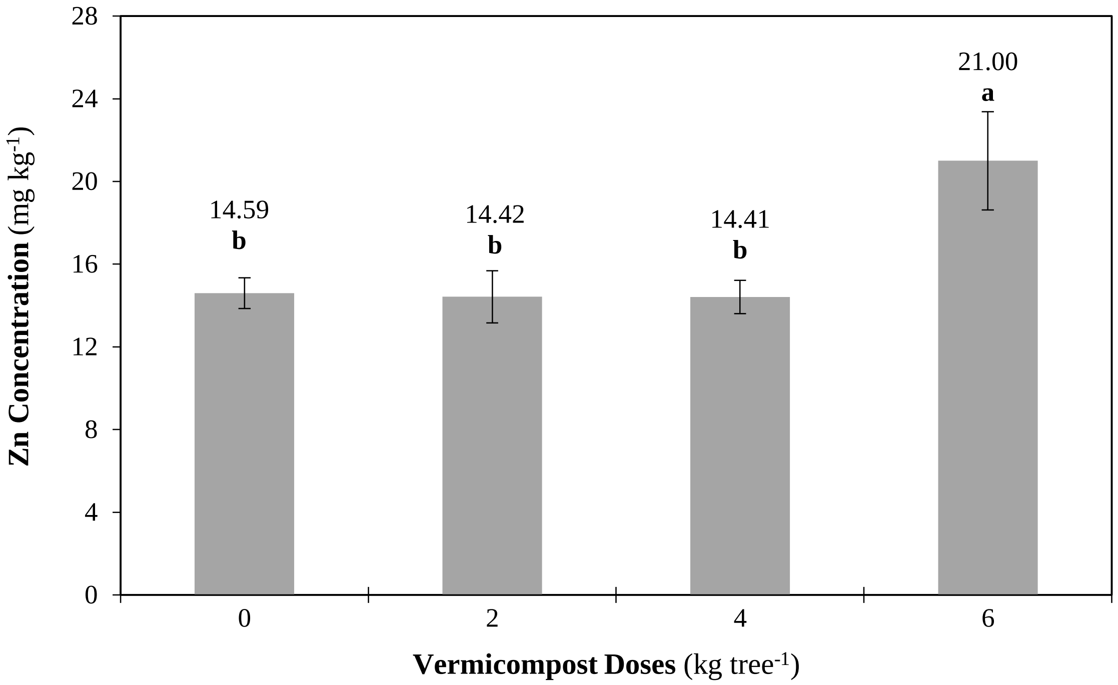

Figure 9. The effect of vermicompost applied to soil at increasing rates on olive tree leaf Zn concentration

As compared with control treatment (14.59 mg kg^{-1}), the concentrations of Zn in olive upon increasing rates of vermicompost (2, 4 and 6 kg tree^{-1}) were determined as 14.42, 14.41 and 21.00 mg kg^{-1}, respectively (Figure 9). There was non-significant variation upon 2 and 4 kg tree^{-1} vermicompost applications when compared to control treatment, but there was a significant increase upon 6 kg tree^{-1} application at p<0.05 (Figure 9). Zn concentration results were low in control treatment, 2 and 4 tree^{-1} but increased sufficiently upon 6 kg tree^{-1}

application (Haspolat, 2006). Eryüksel (2016) observed the changes in onion, garlic, parsley and purslane using different doses of vermicompost (0.5%, 25%, 50%, 75% and 100%) in 2kg pots. The results showed that the Zn element increased as vermicompost dose increased in all the plants. According to Sharma & Deb (1988), soil organic matter increased the diffusion rate of Zn as well as the uptake of plants. The Zn occurring as a result of microbial activity and forming chelate is uptake more by plants. Srivastava & Sethi (1981) reported that organic fertilizer given to the alkaline soil poor in organic matter increase the solubility and availability of Zn. The highest Zn concentration of leaf upon the highest vermicompost (6 kg tree^{-1}) can be explained by the mentioned study.

4. Conclusion

Organic fertilizers have been applied together with a dense application of fertilizers in Türkiye similar to developed countries. Vermicompost is one of the frequently used organic fertilizers. Besides the ameliorating effects on the physical and biological structure of soil, clean content without negative effects on human beings and environmental health are the positive aspects of vermicompost. Another importance of vermicompost for soil and agriculture is the macro and micro nutrient elements being dissolved and available for plants. According to Bellitürk (2018), research regarding to economic analyses on single use of vermicompost or its combination with chemical fertilizers are limited. Principally, this study planned by considering the need to carry out studies on olive, which is important for the agriculture sector of Türkiye. And it is thought to assist other research in the future.

This study carried out on olive trees of Ayvalık oil type (age of 14-15) under field conditions in Geyikli district of Çanakkale Province. The effects of different doses of vermicompost [0 (control), 2, 4 and 6 kg tree^{-1}] on macro and micro nutrient element uptake by olive leaves were investigated.

The concentrations of macro nutrients upon different doses of vermicompost applications remained to the limit values in all treatments including the control and there was non-significant difference between different doses. The values of N started to increase even though it was a single year study, and the dose of 2 kg tree^{-1} was observed to increase the concentration of N which was the highest. No chance in concentrations of leaf P, Ca, K and Mg was observed. The low concentration of leaf Mg can be related to the deficiency of soil for Mg, therefore, fertilization containing Mg besides vermicompost is suggested for this region. The satisfactory results for Cu and Mn in olive leaves were observed upon 2 kg tree^{-1} and best result for Zn was observed upon 6 kg tree^{-1} dose. The values of all the micro nutrients were below the toxic effect limit values. The dose of 2 kg tree^{-1} was seen to the suggested dose of vermicompost for olive trees. Besides the vermicompost, Zn and Fe can be suggested to be applied to soil in chelated form or as leaf fertilization. Addition of organic matters are crucial for the soil due to the nonsufficient organic matter in the soil of Türkiye. Since olive is a perennial tree, a study of at least 3 years, including 2 existence years, is suggested and more satisfactory results are projected to be obtained upon different methods of application, applied doses, and variations during the application processes.

Author Contributions

Ali Sümer: Conducted the research and wrote the article.

Ayşe Nur Coşkun: Made soil and plant analysis and statistical analysis.

This article is based on a master's thesis from “Ayşe Nur Coşkun”

Conflicts of Interest

The authors declare no conflict of interest.

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