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The Effect of Vermicompost Application on Yield and Nutrient Concentration of Oily Rose[#]

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ABSTRACT

In the study, the impact of employing vermicompost to boost oil rose (*Rosa damascena* Mill.), a native of Isparta province, to improve yield and nutrient content, was explored. Four different doses (V0: 0 kg ha^{-1}, V1: 1000 kg ha^{-1}, V2: 2000 kg ha$^{-1,}$ and V3: 3000 kg ha^{-1}) of vermicompost were tested in the field conditions at 3 replicates. Vermicompost was applied to the canopy projection area and incorporated into the soil. Flower harvest was started on April 30, 2018, and throughout 20 days, the blooming flowers were collected and weighed daily basis. Following the harvest, leaf samples were collected from the plants, and the concentrations of certain macro and micronutrients were assessed.The study's findings demonstrated that applying vermicompost boosted the yield of oily rose blooms. The greatest yield value was determined to be 5850 kg ha^{-1} at a vermicompost dose of 2000 kg ha^{-1}, which was 660 kg ha^{-1} greater than the control application. It was observed that vermicompost treatments had no significant influence on plant nutrient concentrations. This condition is assumed to be related to the removal of minerals from the plant during harvest. The findings indicate that the usage of vermicompost can contribute in the production of oil roses, and a dose of 2000 kg ha^{-1} can be suggested. This research establishes the feasibility of employing vermicompost in oil rose cultivation and sets the framework for future research.

Türk Tarım – Gıda Bilim ve Teknoloji Dergisi, ?(?): ???-???, ????

Solucan Gübresi Uygulamasının Yağ Gülünün Verimine ve Besin Elementi Konsantrasyonuna Etkisi

MAKALE BİLGİSİ

Araştırma Makalesi

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Rosa damascena
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Gül çiçeği
Yağlı gül verimi

ÖZ

Araştırmada, Isparta iline özgü yağlık gülün (Rosa damascena Mill.) verim ve besin elementi konsantrasyonunu artırmak için solucan gübresi kullanımının etkisi incelenmiştir. Tarla denemesi olarak yürütülen araştırmada 4 farklı dozda (V0: 0 kg ha-1, V1: 1000 kg ha-1, V2: 2000 kg ha-1 ve V3: 3000 kg ha-1) solucan gübresi uygulaması 3 tekerrürlü olarak yapılmıştır. Uygulamalar bitkinin taç iz düşümüne yapılmış ve toprağa karıştırılmıştır. Çiçek hasadı 30.04.2018 tarihinde başlamış ve 20 gün boyunca günlük olarak açan çiçekler toplanarak tartılmıştır. Hasat tamamlandıktan sonra bitkilerden yaprak örnekleri alınmış ve bazı makro ve mikro besin elementlerinin konsantrasyonları belirlenmiştir. Çalışmadan elde edilen sonuçlar solucan gübresi uygulamasının gül çiçeği verimini artırdığını göstermiştir. En yüksek verim değeri, kontrol uygulamasından 660 kg ha-1 daha yüksek olarak, 5850 kg ha-1 ile 2000 kg ha-1 solucan gübresi uygulamasında belirlenmiştir. Solucan gübresi uygulamalarının bitkinin besin elementi konsantrasyonları üzerinde ise belirgin bir etkisi olmadığı görülmüştür. Bu durumun alınan elementlerin hasat ile bitkiden uzaklaşması ile ilişkili olabileceği düşünülmektedir. Sonuçlar, solucan gübresi kullanımının yağlık gül tarımına katkı sağlayabileceğini ve 2000 kg ha-1 dozunun önerilebileceğini göstermektedir. Bu çalışma, yağlık gül yetiştiriciliğinde solucan gübresinin kullanımının potansiyelini ortaya koymaktadır ve gelecekteki araştırmalar için temel teşkil etmektedir.

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Introduction

Most of the oily rose production in Türkiye is realized in the area called Lakes Region, where Isparta province is located in this area. Rose planting areas are smaller and more fragmented than other cultivated plants (Baydar and Kazaz, 2013). Thus, small increases in yield have great importance for local farmers. The geographical features of the region have made the region the most important rose production center not only in Türkiye but also in the whole world (Ates and Dogutas, 2020). According to Turkish Statistical Institute data, the 5-year mean yield of the oil rose plant produced in Isparta is 4550 kg ha^{-1} and the average of Türkiye is 4300 kg ha^{-1}. The national oily rose production quantity of Türkiye is 16 185 000 kg whereas the 13 585 000 kg realizes in Isparta province (TUIK, 2022). The main concerns of rose farmers include diseases, pests, marketing, harvest, lack of soil and plant analysis, fertilization, pruning, and irrigation (Gokdogan and Demir, 2011). The rose plant is a key ingredient in many cosmetic products; therefore, a sizeable portion is exported and has a high added value. Thus, research mainly focused on the improvement of fresh leaf weight, regardless of the impact of applications on the oil content. On the other hand, it has been reported that some applications increase the oil content along with the yield (Arin et al., 2018).

The soils in Türkiye have insufficient organic matter content (Ozcelik and Sengonul, 2014). Organic fertilizers from diverse sources are used to improve soil organic matter content and vermicompost is one of the alternative substrates (Taban et al., 2013). Eyupoglu (1999) reported that the reason for the low productivity in agricultural production in Türkiye is the low organic matter content of agricultural soils. Tejada et al. (2008) stated that applications such as animal manure, green manure, compost, and vermicompost (worm manure) should be made to increase the organic matter ratio in the soil. Vermicompost, which is obtained by composting organic materials through the digestive system of worms, has no harm to human health and the ecosystem. Compared to traditional compost, vermicompost provides better results in terms of plant growth (Edwards and Bohlen, 1996; Fritz et al., 2012). Studies reported that vermicompost increases the yield of pepper (Alaboz et al., 2017), tomato (Durukan and Demirbas, 2019), maize (Durukan et al., 2020), and basil (Senyigit et al., 2021). Moreover, vermicompost increases plant nutrient concentration (Kus, 2019) as well as plant water consumption (Senyigit et al., 2021). The source of positive effects is associated with the ingredients of vermicompost such as various organic substances secreted by worms and especially microorganisms (Mohd Din et al., 2017). Vermicompost provides a delayed transition of nutrients to the environment, thus nutrients become available for a longer period (Buchanan et al., 1988). It has been stated that vermicompost improves soil fertility and biological productivity by increasing the microbial activity in the soil via forming various substances (Singh et al., 2008; Tavali et al., 2014; Köksal et al., 2017; Ceritoglu, 2019). It has been reported that vermicompost can be used to protect against pests and diseases, apart from the use of plant nutrition and soil regulation (Wang et al., 2014). One of the differences between conventional compost and vermicompost is the amino acids and enzymes transmitted from the worm's digestive system (Coskan and Yilmaz, 2015). Another difference is that the movements of worms change raw materials' chemical properties while breaking down organic matter (Dominguez, et al., 2010). Vermicompost also have amelioration stress factors in the soil leading to better plant development in stress condition (Makkar et al., 2022; Alamer et al., 2022).

In this study, the effects of vermicompost application were investigated to increase the yield in the production of oil roses, which is a product with high added value. The study aims to investigate the effects of different doses of vermicompost on rose plant nutrition and yield. The researchers believe that the findings of this study could contribute to local development in the rose production industry.

Materials and Methods

The field experiment was conducted in the Isparta region, which has a transitional climate regime between the West Mediterranean and Coastal climate. The soil used for the experiment had a sandy clay loam texture, with 2.14% organic matter content and 33% $CaCO_3$. The pH of the soil was determined as 7.87, and the electrical conductivity (EC) was 0.42 mmhos cm^{-1}. Vermicompost, with properties listed in Table 1, was obtained from a local compost producer. The test plant used in the experiment was oily rose (*Rosa damascena* Mill.).

Table 1. Some properties of vermicompost used in the experiment

Properties	Value
Organic matter (%)	40
pH (1:10)	7.7
EC (dS cm^{-1})	13.5
N (%)	1.28
Moisture (%)	20

The experiment was conducted as a field trial at 0.2 ha, 7 years old oily rose planted field, using randomized block design. The total area of Vermicompost doses of 0, 1000, 2000, and 3000 kg ha^{-1} were applied by incorporating them into the canopy projection area, in addition to conventional fertilization. Harvesting of rose petals started on 30.04.2018 and lasted for 20 days, ending on 19.05.2018. Rose petals collected daily during the harvest were weighed and recorded. Matured fourth to fifth petals from the shoot tip were collected for nutritional analysis.

Total nitrogen was determined using to the method of Kjeldahl (Bremner, 1965) while available phosphorus was determined using the methods defined by Barton (1948) for soil and Olsen (1954) for plants. For microelement analysis, 0.5 g of plant sample was placed in a Teflon tube, 8 ml of concentrated nitric acid + 2 ml of concentrated perchloric acid was added. Samples were wet digested using a microwave oven at 180 °C and the concentrations of Fe, Mn, Zn, Cu, K, and Ca were analyzed using an Atomic Absorption Spectrophotometer (Kacar and Inal, 2010). The results obtained from the experiment were analyzed using analysis of variance (ANOVA) with the Minitab program. Means were compared using the Tukey test to identify significant differences among treatment groups.

Results

Yield

Figure 1 presents the effect of increasing vermicompost doses on the yield of the oil rose plant, while Figure 2 shows the daily yield values recorded during the harvest period.

The application of vermicompost significantly increased flower yield ($P<0.05$), with the lowest yield observed in the control group. Yield values consistently increased with vermicompost doses of 1000 and 2000 kg ha^{-1} (Figure 1). Although not statistically significant, a decrease in yield was observed at the 3000 kg ha^{-1} dose compared to the highest vermicompost dose of the 2000 kg ha^{-1}. Similar result reported by Senyigit et al. (2021) which overdose vermicompost application slightly reduced basil yield. The average yield increase from vermicompost application was calculated as 10.7%, with increasing values of 7.7%, 12.9%, and 11.4% for doses of 1000, 2000, and 3000 kg ha^{-1}, respectively. Considering the additional cost of vermicompost and the decrease in the yield at the 3000 kg ha^{-1} dose, it was concluded that a dose of 2000 kg ha^{-1}, which provided the highest increase of 12.9%, should be recommended. The daily flower yield (Figure 2) was found to be consistent with the total yield (Figure 1), and with more flowers were collected almost every harvest day from the 2000 kg ha^{-1} vermicompost dose, where the highest yield was obtained.

The lowest daily rose flower harvest was obtained with 99 kg ha^{-1} from the control application on 12.05.2018, and the highest harvest with 417 kg ha^{-1} was obtained from the 2000 kg ha^{-1} vermicompost dose on 10.05.2018. From the beginning of the rose harvest on 30.04.2018 to the last harvest date of 19.05.2018, the great fluctuation was determined in the amount of daily collected flowers. Since only the blooming flowers are collected in the rose harvest, it does not bloom equally every day due to the climate. Air temperature and humidity are the most effective factors in flowering time. Moreover, flowering is influenced by the factors such as the distance from water reservoirs, landforms, and cloudiness resulting in considerable variation in daily yield.

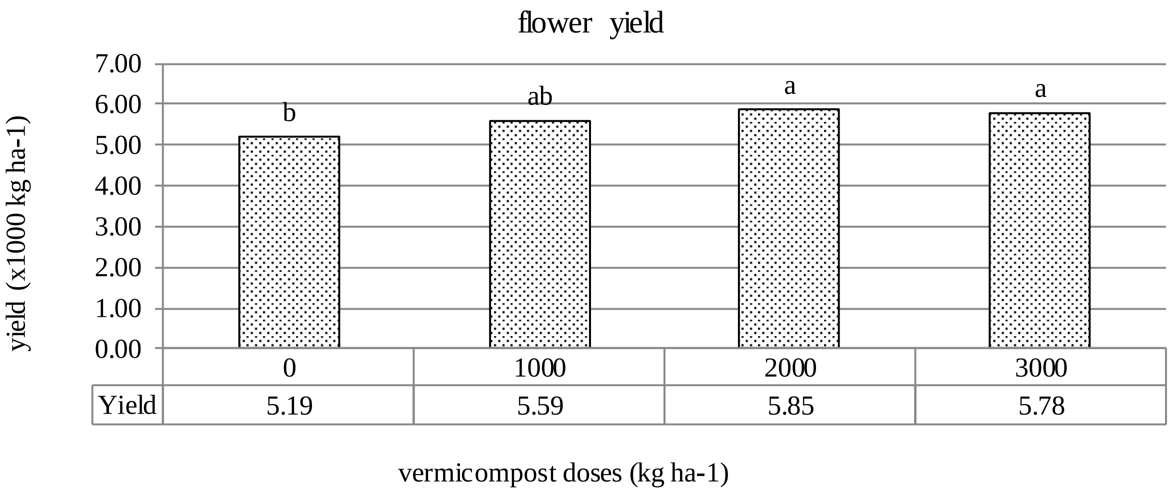

Figure 1. Effects of vermicompost doses on yield

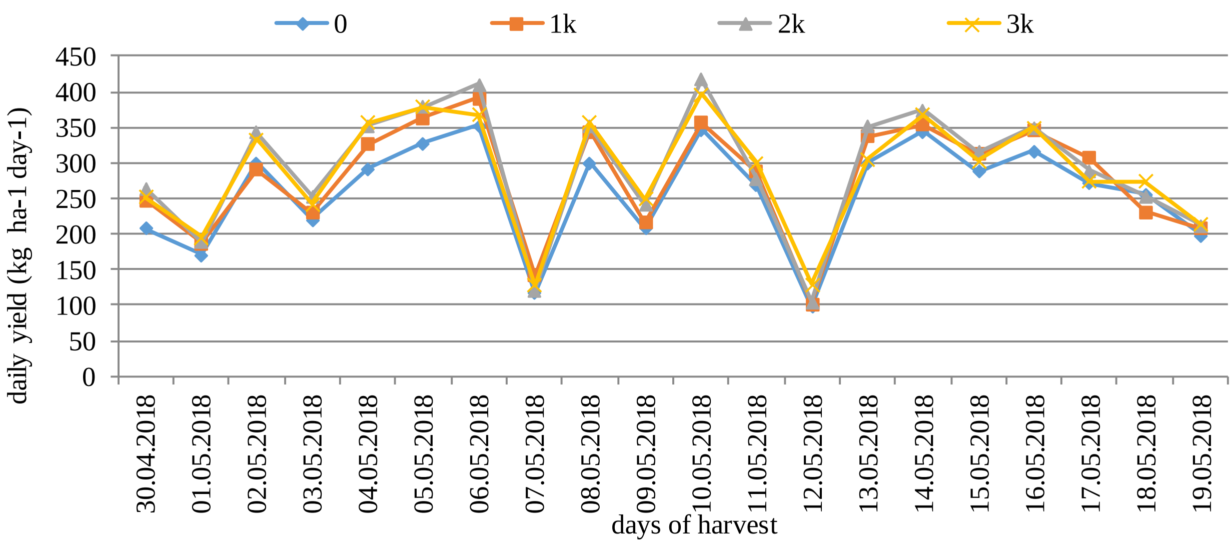

Figure 2. Recorded daily flower yield

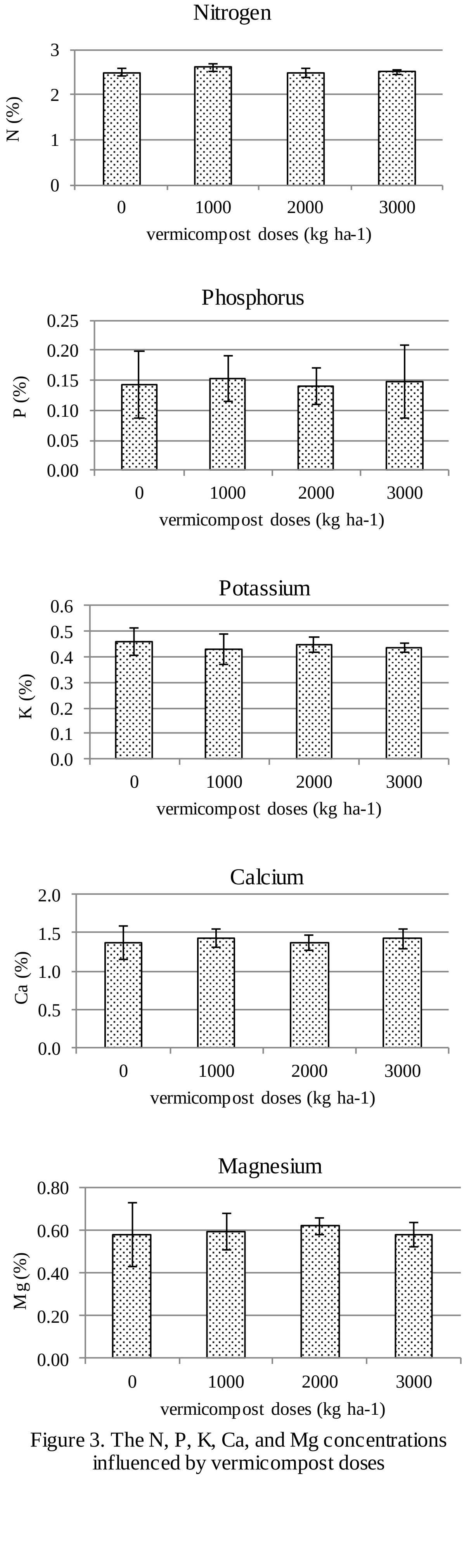

Figure 3. The N, P, K, Ca, and Mg concentrations influenced by vermicompost doses

Selected macro element concentrations

The N, P, K, Ca, and Mg concentrations determined in the leaf samples taken at the end of the harvest time are presented in Figure 3. None of the determined macro elements were statistically affected by vermicompost applications (P>0.05). This situation was associated with the sampling time, it was thought that the possible positive effects occurred in the vegetative period of the plants, and the elements removed by the plant may have been removed with the harvested rose flowers. The concentration of nitrogen (N) in the plants was influenced by the vermicompost dose, with the highest concentration of 2.61% observed in the application of 1000 kg ha^{-1}, and the lowest concentration of 2.49% observed in the control and 2000 kg ha^{-1} dose (Figure 3). The difference between the determined highest value and the lowest value was 0.12%. Phosphorus (P) concentrations showed slight differences, but these differences were not statistically significant. It was evaluated that this situation was caused by the high variation observed between replications as reported by Zhang et al. (2019) and Wang et al. (2020). The highest phosphorus concentration of 0.153% was observed in the 1000 kg ha^{-1} vermicompost dose, while the lowest values of 0.141% and 0.142% were observed in the control and 2000 kg ha^{-1} applications. Potassium (K) concentrations did not show any clear trend with increasing vermicompost doses, and no statistically significant differences were observed. Lower potassium concentrations were observed in vermicompost doses compared to the control treatment, and a slight increase in potassium concentration was observed at 2000 kg ha^{-1} vermicompost dose.

The difference between the highest and lowest values in terms of potassium concentration was 0.027%. Calcium (Ca) concentrations showed some variability, with the highest value of 1.434% observed in the application of 1000 kg ha^{-1}, and the lowest values of 1.371% and 1.370% observed in the 2000 kg ha^{-1} dose and control treatment. No clear trend was observed in calcium concentration with increasing vermicompost doses, as calcium concentration increased at 1000 kg ha^{-1}, decreased at 2000 kg ha^{-1}, and increased again at 3000 kg ha^{-1} (Figure 3). However, these changes were not statistically significant. In the calcium concentration, the difference between the highest value and the lowest value was calculated as 0.063%. In general vermicompost can be use to improve Ca concentration as Naseem et al. (2017) reported significant calcium uptake by vermicompost application. Moreover, Sharma et al. (2016) showed that vermicompost application increased the calcium content in maize plants by 30% compared to control plants. Among the determined magnesium concentrations (Figure 3), a steadily increasing trend was observed up to 2000 kg ha^{-1} dose of vermicompost, which was not statistically significant (P>0.05). Magnesium concentration in the control application was 0.579%, and it increased to 0.593% at the dose of 1000 kg ha^{-1} and 0.617% at the dose of 2000 kg ha^{-1}. However, at the dose of 3000 kg ha^{-1}, the magnesium concentration decreased to the same level as the control application.

Selected microelement concentrations

The selected microelements as Fe, Zn, Mn, and Cu were analyzed in the leaf samples taken at the end of the flowering stages and obtained results presented in Figure 4. None of the determined microelement concentrations were statistically influenced by increasing vermicompost doses (P>0.05).

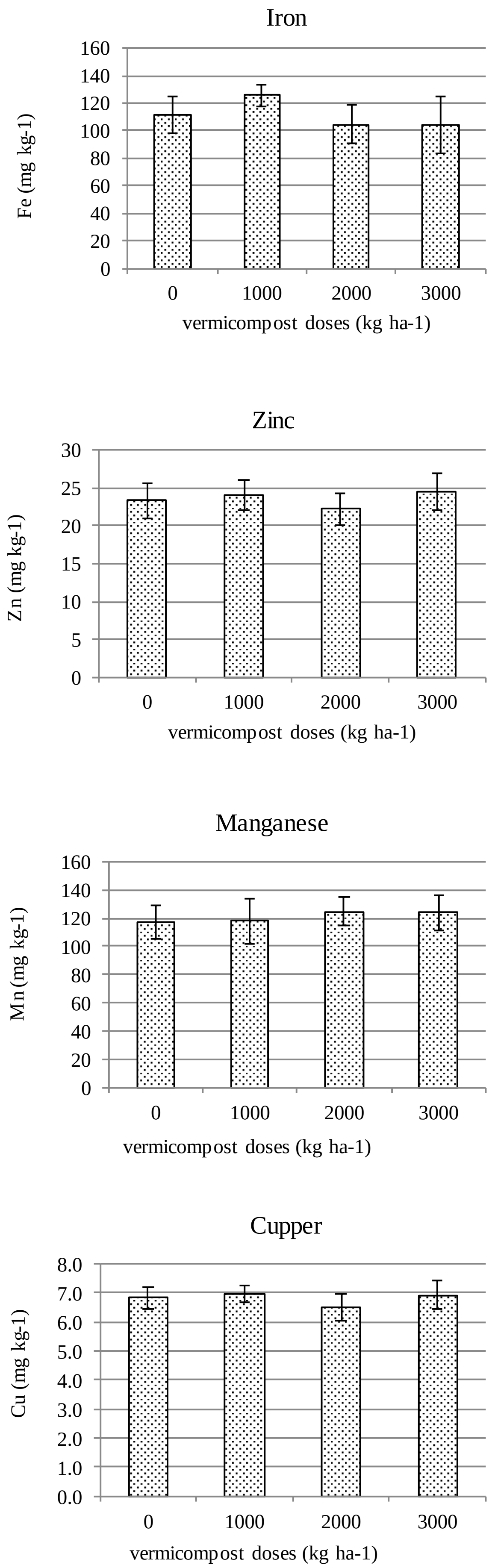

Figure 4. The Fe, Zn, Mn, and Cu concentrations influenced by vermicompost doses

The iron concentration (Figure 4) was the most affected microelement from vermicompost applications whereas the difference between the highest value and the lowest value was determined as 21 mg kg^{-1}. However, these differences were not statistically significant due to the high variation observed between replications. When the iron values were examined, it was seen that 1000 kg ha^{-1} vermicompost application increased the iron content of the plant up to 125 mg kg^{-1}, and the iron concentration was even below the control application at 2000 and 3000 kg ha^{-1} doses. Several studies have reported higher iron uptake by vermicompost application, for instance, Das et al. (2018) reported 20% higher iron content compared to control plants. The difference between the zinc concentrations (Figure 4) was only 2 mg kg^{-1}, and the effect of the applications on zinc was found to be insignificant. The highest value was 24 mg kg^{-1} in both 1000 and 300 kg ha^{-1} vermicompost applications, while the lowest value was obtained from 2000 kg ha^{-1} as 22 mg kg^{-1}. Contrariliy to findings by Nkongho et al. (2018), in which 30% higher manganese uptake, manganese concentrations determined in this study were affected by vermicompost applications at a very low level. The highest manganese concentration was obtained from the application of 2000 kg ha^{-1} vermicompost dose as 125 mg kg^{-1}, while the lowest value was obtained from the control application with 117 mg/kg. While the lowest value in copper concentrations was obtained as 6.50 mg kg^{-1} at 2000 kg ha^{-1} vermicompost dose. The highest values were obtained from 1000 and 3000 kg ha^{-1} vermicompost doses as 6.95 and 6.93 mg kg^{-1}, respectively.

Economic analyses

The base price of oily rose flower announced by Gulbirlik Rose, Rose Oil, and Oil Seeds Agricultural Sales Cooperatives Association which dominate the market for the year 2022 is 22 Turkish Lira (TL) for 1 kg of fresh rose flower. While the income from the control application which 5190 kg ha^{-1} yield obtained is 114 180 TL, the income from 2000 kg ha^{-1} vermicompost dose is 128 700 TL by 5850 kg ha^{-1} yield. Thus, the economic equivalent of 660 kg rose flower obtained by the dose of 2000 kg ha-1 is 14 520 TL. The local vermicompost manufacturers in Isparta sell their products for 4 to 5 TL kg^{-1}. If the average sales price of vermicompost is considered as 4.5 TL kg^{-1}, the additional cost of 2000 kg ha^{-1} is 9 000 TL. In light of these data, it was determined that 5520 TL more income per hectare could be obtained by vermicompost application. The calculations are made for the dose which the highest profitability provided; the calculations for other doses are given in Table 2.

Conclusion

The overall results demonstrated that the vermicompost application contributed to the cultivation of oil roses. However, considering the low application dose of vermicompost, the organic matter did not seem to be responsible for the observed yield improvement. Because 1k, 2k and 3k kg ha^{-1} doses are corresponding to only %0.038, %0.077, and %0.015 organic matter added to the soil. Thus, other properties of vermicompost are hypothesized to be responsible for higher yield.

Table 2. Possible additional income from vermicompost doses

Vermicompost doses (kg ha^{-1})	Yield (kg ha^{-1})	Yield increase (kg ha^{-1})	Additional income (TL)	Cost of vermicompost (TL)	Net income (TL)
0	5190	-	-	-	-
100	5590	400	8800	4500	4300
200	5850	660	14520	9000	5520
300	5780	590	12980	13500	-520

On the other hand, several nutrients are added to the soil with vermicompost. When nitrogen addition via vermicompost is considered, the given nitrogen to the soil is about 2.5 kg with a dose of 2000 kg ha^{-1}. Since the experimental area was fertilized with all the required nitrogen, this addition is also far to explain the yield obtained. The increase obtained may be due to the trace elements in the vermicompost, which are not typically applied to the soil as fertilizer. Moreover, other organic substances like amino acids and hormones, may play crucial role in the yield increase obtained in this experiment. Apart from the features mentioned above, the fact that the vermicompost contains a high concentration of microorganisms that promotes plant growth, which those microorganisms may also be the key factor to improve yield. The observed improvement in yield is not in accordance with plant nutrient concentration. Therefore, the results of both micro and macro element analyses revealed that vermicompost did not affect nutrient uptake. Indeed, plants formed more vegetative parts as a result of the positive effect of vermicompost, and increased vegetative parts yielded more rose flower yield. Because the rose plant is perennial, the entire plant could not be harvested, and thus biomass determination could not be demonstrated. Observations, on the other hand, support better plant growth in areas where vermicompost is applied. When the leaf analysis is examined in terms of nutrients, it is seen as a positive result that the nutrients do not decrease radically although more biomass is formed. When the nutritional status of the plants was evaluated, it was considered that it was a positive result that no deficiency occurred in the plants, even though more yields were obtained. Parameters other than yield are not taken into consideration by farmers; however, the highest yield is not provided the highest additional income. Dry matter loss in the vermicompost process is lower than in conventional composting. As a result, rather than purchasing this vermicompost, farmers may be encouraged to engage to produce vermicompost in their facilities. Animal wastes, pruning, and harvest residues as well as rose leaves processing residues to have a great deal for raw materials. In subsequent studies, it may be recommended to determine the effect of vermicompost on essential oil content. Results obtained revealed that the use of vermicompost in oily rose agriculture would be beneficial to improve yield; therefore income and the vermicompost dose of 2000 kg ha^{-1} may be recommended to farmers.

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