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Effects of Different Organic Fertilizer Compositions (Leonardite and Vermicompost) on Chickpea (*Cicer arietinum* L.) Yield and Macro-Micro Nutrient Content

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ABSTRACT

Background: Organic fertilizers (leonardite and vermicompost) applied to soil have a positive impact on plant nutrient uptake and productivity. Understanding the effects of different organic fertilizer application rates on the legume chickpea (*Cicer arietinum* L.) is a crucial aspect of crop production that should not be overlooked.

Methods: The research was carried out in a farmer's field in the Artuklu district of Mardin during two growing seasons (2022-2023 and 2023-2024). Vermicompost was used at VC_1: 150, VC_2: 200, VC_3: 250 and VC_4: 300 kg da^{-1}, while Leonardite was used at L_1: 50, L_2: 100, L_3: 200 and L_4: 400 kg da^{-1}. Examined how various techniques used for chickpea affected its nutrient content and yield. Statistical analyses were performed to assess the significance of year, application and year*application interaction.

Result: The analyses indicated that year and application significantly affected most parameters, while the year*application interaction was generally not significant. Nutrient contents in chickpea plants varied as follows: total nitrogen (N) 2.98-3.61%, phosphorus (P) 3010-3833 mg kg^{-1}, potassium (K) 6625-7086 mg kg^{-1}, copper (Cu) 6.13-10.07 mg kg^{-1}, manganese (Mn) 21.8-24.1 mg kg^{-1}, iron (Fe) 51.7-70.1 mg kg^{-1} and zinc (Zn) 30.9-38.6 mg kg^{-1}. Grain yield ranged from 148.3 to 183.7 kg da^{-1}, with annual means of 156.0 and 170.0 kg da^{-1}, respectively. The lowest yield was observed in the control, whereas the highest yield was achieved with 400 kg da^{-1} leonardite application.

Key words: Chickpea (*Cicer arietinum* L.), Leonardite, Macro, Micro elements, Vermicompost, Yield.

INTRODUCTION

Legumes play a crucial role in human nutrition, especially in developing countries (Temba *et al*., 2016). Legumes are a cheap source of protein, especially in low-income countries. They are considered a healthier and more affordable option when protein sources in animal foods are high cost or unavailable (Egesel *et al*., 2006; Acharya *et al*., 2006; Lisciani *et al*., 2024). These plants play an important role not only in human food but also as animal feed (Kassie *et al*., 2009; Akibode and Maredia, 2012; Cömert-Acar *et al*., 2019). In addition to protein, they are rich in some nutritional minerals, fiber, carbohydrates and vitamins (Latham, 1997; Roy *et al*., 2010). In addition to their powerful antioxidant properties, bioactive peptides in chickpeas have been reported to increase angiotensin-converting enzyme activity (Xue *et al*., 2015; Otağ and Hayta, 2016; Çetiner and Bilek, 2018). Chickpeas, which hold an important place as an edible snack seed for humans and as animal feed, are plants that are well-adapted and suitable for production in arid and semi-arid areas (Üstün and Gülümser, 2003; Gül *et al*., 2006; Kayan *et al*., 2014). Chickpeas are particularly vital for their protein content today, especially given the current challenges of malnutrition in human nutrition (Wells *et al*., 2020; Nathawat *et al*., 2024). In recent years, the use of organic fertilizers has gained great importance for soil improvement and organic farming (Timsina, 2018; Uçar, 2019; Uçar *et al*., 2020a; Ceritoglu *et al*., 2021; Singh *et al*., 2022; Begum *et al*., 2025).

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MATERIALS AND METHODS

The study was conducted using the local chickpea variety Diyar-95, which was released in 1995 and originally bred in 1992 at the GAP International Agricultural Research and Training Center in Diyarbakır. Plants reached 50-75 cm in height, produced 19-28 pods per plant (with a mean of 1.7 seeds per pod), flowered 145-158 days after sowing in winter cultivation and reached physiological maturity within 182-204 days. Seeds were cream-colored, shaped like a "ram's head," and had a 100-seed weight of 40-45 g.

Registration trials reported a mean yield of 150-200 kg da^{-1} with no disease incidence (Anonymous, 2025). Leonardite and vermicompost were used as organic fertilizers. Leonardite contained 20% organic matter and 20% total humic+fulvic acids, with a low pH (4.5) and 20% moisture, enhancing nutrient availability. Vermicompost had a richer composition with 55% organic matter and 42% ash. Detailed properties of these fertilizers are presented in Table 1. Fertilizer analyses were carried out in the central research laboratory of Mardin Artuklu University.

The experiment was carried out during the 2022-2023 and 2023-2024 growing seasons in a farmer's field in Yukarı Aydınlı, Artuklu, Mardin. Selected soil physical and chemical properties are shown in Table 2.

Long-term climate data (1941-2024) indicated that Mardin has a Mediterranean-like climate, characterized by hot, dry summers and cold, rainy winters. The mean annual temperature was 16.2°C, with July (29.8°C) and August (29.7°C) being the hottest months and January (3.1°C) and February (4.2°C) the coldest. A summary of the long-term climate data is presented in Fig 1.

The experiment followed a split-plot design in randomized blocks with three replications (27 plots). Each plot measured 1×5 m (5 m^2), with five rows spaced 20 cm apart and 350 seeds m^2 were sown by hand. Leonardite was applied at L_1: 50, L_2: 100, L_3: 200 and L_4: 400 kg da^{-1} and vermicompost at VC_1: 150, VC_2: 200, VC_3: 250 and VC_4: 300 kg da^{-1}, along with a control (C_0). Measurements were taken from the central area of each plot (0.6× 4 m = 2.4 m^2) to minimize edge effects. Chickpea planting was carried out on November 20, 2022 and November 22, 2023 and harvests were carried out on May 20, 2023 and May 25, 2024. After grinding, plant samples were subjected to microwave-assisted wet ashing (HNO_3+H_2O_2) and the concentrations of P, K, Cu, Mn, Fe and Zn were determined using ICP-AES. Nitrogen (N) content was measured by the Kjeldahl method (Bremner, 1996). Analysis of variance (ANOVA) was used to evaluate the effects of different fertilizer applications and mean differences were compared using Waller-Duncan's multiple range test ($p \leq 0.05$). Statistical analyses were performed using SPSS 22.0.

RESULTS AND DISCUSSION

Changes in N, P and K concentrations in chickpea under organic fertilizer applications

According to the statistical analysis, N and P concentrations in chickpea were significantly affected by both year and organic fertilizer application ($p \leq 0.01$), whereas their interaction (year*application) was not significant. On the other hand, potassium concentration did not show any significant variation with respect to year, application, or their interaction (Table 3).

Nitrogen (N)

The effect of different doses of leonardite and vermicompost on total %N in chickpea varied between 2.98% and 3.61%, with the first-year mean being 3.16% N and the second-year mean 3.40% N. When overall mean was examined, the lowest nitrogen content (3.00% N) was recorded in the control plots, while the highest (3.46% N) was observed in plots receiving 400 kg da^{-1} leonardite (Table 3). Applications of leonardite and vermicompost resulted in higher nitrogen values compared to the control plots. This can be explained by the decomposition of organic materials providing nitrogen to the soil and increasing plant nitrogen uptake through mineralization processes. Azizzadeh *et al*. (2016) stated that leonardite

Table 1: Properties of leonardite and vermicompost fertilizers used in the experiment.

Property	Leonardite	Vermicompost
Organic matter (%)	20.0	55.0
Total humic + Fulvic acid (%)	20.0	12.0
Moisture (%)	20.0	40.0
pH	4.50	7.20
Ash content (%)	-	42.0
Total N (%)	2.00	1.60
P_2O_5 (%)	0.35	2.20
Ca (%)	0.28	5.00
Mg (%)	0.19	1.20
Fe (%)	-	1.50
Mn (mg kg^{-1})	65.2	73.0

Table 2: Some chemical and physical properties of the experimental soil.

Property	Test soil	References
pH	7.72	Kacar, 1995
Texture	Clay-Loam	Bouyoucus, 1952
Salt (%)	0.18	Soil Survey Staff, 1951
$CaCO_3$ (%)	33.4	Loeppert *et al.*, 1996
Organic Matter (%)	1.09	Kacar, 1995
Available P (mg P_2O_5 kg^{-1})	12.8	Olsen *et al.*, 1954
Available K (mg K_2O kg^{-1})	70.8	Richards 1954
Fe (mg kg^{-1})	24.2	Lindsay and Norvell,1978 (DTPA)
Cu (mg kg^{-1})	2.72	
Mn (mg kg^{-1})	55.4	
Zn (mg kg^{-1})	9.80	

applied wheat increased N and K concentrations. Joshi *et al*. (2013) observed an increase in protein and oil content in cereal grains following vermicompost application. Leonardite applications in *Allium sativum* L. plant had a positive effect especially on P and K concentrations (Sarıyıldız, 2020) and similarly, Akinremi *et al*. (2000) reported an increase in the concentrations of some macro (N, P and K) elements in bean, canola and wheat plants as a result of leonardite applications.

Phosphorus (P)

The effect of organic fertilizer applications on P in chickpea plants varied between 3010-3833 mg P kg^{-1}, with a mean of 3438 mg P kg^{-1} in the first year and 3651 mg P kg^{-1} in the second year. Considering the overall means, the lowest P content (3372 mg P kg^{-1}) was observed in vermicompost applied at 150 kg da^{-1}, while the highest P content (3697 mg P kg^{-1}) was obtained with 300 kg da^{-1} vermicompost applications (Table 3). Vermicompost application has been reported to increase N, P, K, Mn, Zn, Fe and S concentrations in lettuce (Özen and Sönmez, 2019). Another study on tomato plants showed that vermicompost significantly enhanced nutrient contents in plant tissues, with increases of 55% in K, 73% in P, 32% in Fe and 36% in Zn compared to the control plots (Azarmi *et al*., 2008). Leonardite applications have also been shown to positively influence P content in maize plants (Kaya *et al*., 2020).

Potassium (K)

The effect of different doses of leonardite and vermicompost on K in chickpea plants ranged from 6625 to 7086 mg K kg^{-1}, with the first-year mean being 6804 mg K kg^{-1} and the second-year mean 6921 mg K kg^{-1}. Considering the overall means, the lowest K content (6711 mg K kg^{-1}) was observed in the control plots, while the highest K content (6997 mg K kg^{-1}) was obtained with 400 kg da^{-1} leonardite application (Table 3). Vermicompost has been reported to increase K content in spinach (Gökmen Yılmaz *et al*., 2012; Demirer, 2019). David *et al*. (2014) reported that leonardite promotes root development in maize, increasing protein content and N, P and K uptake. Duval *et al*. (1998) also indicated that leonardite supports plant growth and

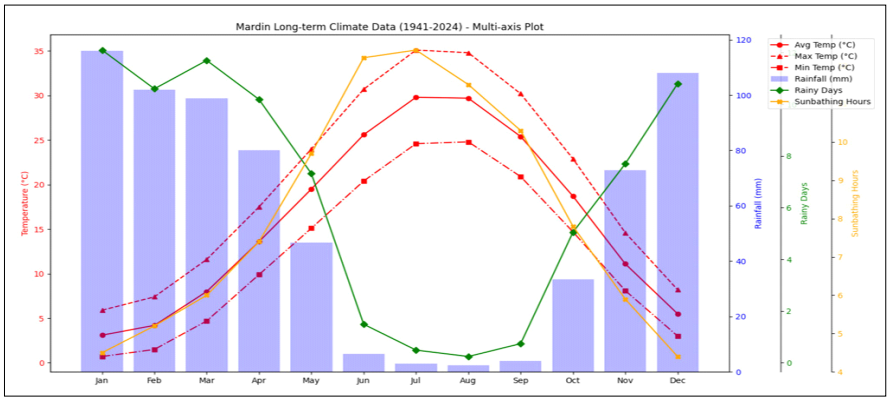


Fig 1: Long-term Mardin climate data.

Table 3: Effect of organic fertilizer applications on N, P and K its concentration in chickpea.

Treatment	N (%)		Mean	P (mg kg^{-1})		Mean	K (mg kg^{-1})		Mean
	1st year	2nd year		1st year	2nd year		1st year	2nd year	
C_0	2.98	3.02	3.00^{B}	3398^{f-h}	3367^{gh}	3383^{C}	6625	6798	6711
L_1	3.10	3.28	3.19^{AB}	3487^{d-h}	3583^{b-f}	3535^{AB}	6944	7034	6989
L_2	3.04	3.41	3.23^{AB}	3509^{d-h}	3680^{a-d}	3594^{AB}	6813	6902	6858
L_3	3.28	3.56	3.42^{A}	3568^{c-f}	3543^{c-h}	3556^{AB}	6893	7071	6982
L_4	3.30	3.61	3.46^{A}	3627^{b-e}	3600^{b-e}	3613^{AB}	6908	7086	6997
VC_1	3.13	3.29	3.21^{AB}	3010^{i}	3733^{a-c}	3372^{C}	6659	6831	6745
VC_2	3.27	3.41	3.34^{A}	3357^{h}	3783^{ab}	3570^{AB}	6872	6694	6783
VC_3	3.14	3.53	3.33^{A}	3427^{e-h}	3733^{a-c}	3580^{AB}	6870	7047	6959
VC_4	3.15	3.49	3.32^{A}	3560^{c-g}	3833^{a}	3697^{A}	6653	6826	6739
Mean	3.16	3.40		3438	3651		6804	6921	
Year		21.3**			63.3**			$1.63^{n.s.}$	
Application		3.01**			6.89**			$0.77^{n.s.}$	
Year*application		$0.57^{n.s.}$			$9.85^{n.s.}$			$0.18^{n.s.}$	

Means in the same column followed by different letters are significantly different at the 5% level.
(**): Statistically significant at p≤0.01, (n.s.): Not significant.

enhances the availability of several nutrients in the soil, especially N, P and K.

Changes in Cu and Mn concentrations in chickpea under organic fertilizer applications

The statistical analysis revealed that Cu concentration in chickpea was significantly affected by year ($p \leq 0.01$), whereas application and the year*application interaction had no significant effect. In contrast, Mn concentration was significantly influenced by application ($p \leq 0.05$), while no significant effects were observed for year and for the year*application interaction (Table 4).

Copper (Cu)

The effect of different doses of leonardite and vermicom-post on Cu in chickpea plants ranged from 6.13 to 10.07 mg Cu kg^{-1}, with the first-year mean of 7.56 mg Cu kg^{-1} and the second-year mean of 8.87 mg Cu kg^{-1}. Overall means indicated that the lowest Cu content (7.11 mg Cu kg^{-1}) was obtained in the control plots, whereas the highest Cu content (9.05 mg Cu kg^{-1}) was observed with 100 kg da^{-1} leonardite application (Table 4). Leonardite and vermicom-post applications provided higher Cu contents in plants compared to the control plots. This may be due to the ability of organic materials to enhance Cu solubility in the soil (Römheld and Marschner, 1991; Marschner, 2012). In a study on cherry trees, leonardite applications were reported to increase N, P, K, Ca, Mg, Fe, Cu, Zn and Mn contents (Demirer, 2019). Additionally, Zırığ and Eren (2025) reported that vermicompost applications at different doses increased Cu levels in two wheat cultivars compared to the respective control applications.

Table 4: Effect of organic fertilizer applications on Cu and Mn its concentration in chickpea.

Treatment	Cu (mg kg^{-1})		Mean	Mn (mg kg^{-1})		Mean
	1st year	2nd year		1st year	2nd year	
C_0	7.17	7.06	7.11	23.2	23.7	23.4^{AB}
L_1	7.37	8.70	8.03	22.4	22.8	22.6^{AB}
L_2	8.03	10.07	9.05	23.0	23.5	23.3^{AB}
L_3	8.20	9.60	8.90	23.3	24.1	23.7^{A}
L_4	7.47	9.40	8.43	23.6	24.1	23.9^{A}
VC_1	6.13	9.63	7.88	23.2	23.7	23.5^{AB}
VC_2	7.87	8.63	8.25	22.3	22.7	22.5^{AB}
VC_3	8.07	8.13	8.10	21.8	22.3	22.1^{B}
VC_4	7.70	8.60	8.15	22.3	22.7	22.5^{AB}
Mean	7.56	8.87		22.8	23.3	
Year		19.0**			$2.97^{n.s.}$	
Application		$1.58^{n.s.}$			2.18*	
Year*application		$1.49^{n.s.}$			$0.02^{n.s.}$	

Means in the same column followed by different letters are significantly different at the 5% level.
(*): Statistically significant at $p \leq 0.05$, (**): Statistically significant at $p \leq 0.01$, (n.s.): Not significant.

Table 5: Effect of organic fertilizer applications on Fe and Zn its concentration in chickpea.

Treatment	Fe (mg kg^{-1})		Mean	Zn (mg kg^{-1})		Mean
	1st year	2nd year		1st year	2nd year	
C_0	61.6^{a-d}	62.1^{a-d}	61.8^{AB}	33.2^{e-f}	30.9^{g}	32.1^{D}
L_1	57.7^{b-d}	61.2^{a-d}	59.4^{BC}	34.8^{b-f}	36.9^{a-d}	35.8^{A-C}
L_2	53.6^{cd}	56.9^{b-d}	55.2^{BC}	34.0^{c-g}	36.0^{a-f}	35.0^{BC}
L_3	66.1^{ab}	70.1^{a}	68.1^{A}	36.5^{a-e}	38.6^{a}	37.6^{A}
L_4	52.5^{d}	55.7^{b-d}	54.1^{C}	35.7^{a-f}	37.9^{ab}	36.8^{AB}
VC_1	60.0^{a-d}	63.6^{a-c}	61.8^{AB}	35.2^{b-f}	37.3^{a-c}	36.3^{A-C}
VC_2	51.7^{d}	54.8^{cd}	53.3^{C}	34.0^{c-g}	36.1^{a-f}	35.0^{BC}
VC_3	58.7^{b-d}	62.2^{a-d}	60.5^{BC}	33.8^{d-g}	35.9^{a-f}	34.9^{BC}
VC_4	58.7^{b-d}	62.3^{a-d}	60.5^{BC}	33.0^{f}	34.9^{b-f}	33.9^{CD}
Mean	57.9	61.0		34.5	36.1	
Year		4.80*			12.2**	
Application		4.75**			5.71**	
Year*Application		$0.06^{n.s.}$			$1.16^{n.s.}$	

Means in the same column followed by different letters are significantly different at the 5% level.
(*): Statistically significant at $p \leq 0.05$, (**): Statistically significant at $p \leq 0.01$, (n.s.): Not significant.

Manganese (Mn)

The effect of different doses of leonardite and vermicompost on Mn in chickpea plants ranged from 21.8 to 24.1 mg Mn kg^{-1}, with the first-year mean of 22.8 mg Mn kg^{-1} and the second-year means of 23.3 mg Mn kg^{-1}. Overall mean showed that the lowest Mn content (22.1 mg Mn kg^{-1}) was observed in the 250 kg da^{-1} vermicompost application, whereas the highest Mn content (23.9 mg Mn kg^{-1}) was obtained with 400 kg da^{-1} leonardite application (Table 4). Leonardite applications at 200 and 400 kg da^{-1} and vermicompost at 150 kg da^{-1} increased Mn content compared to the control plots. However, in other applications, Mn content was generally lower. This may be due to the high organic matter input, which can enhance Mn binding in the soil and limit its uptake by plants (Römheld and Marschner, 1991; Marschner, 2012). It has been reported that leonardite applications increased fruit yield in tomato plants and positively affected Fe, Zn and Mn contents in leaves (Topcuoglu and Onal, 2006).

Table 6: Effect of organic fertilizer applications on yield of chickpea (kg da^{-1}).

Treatment	Yield		Mean
	1st year	2nd year	
C_0	148.3^{i}	150.6^{hi}	149.4^{F}
L_1	150.7^{hi}	165.7^{de}	158.2^{E}
L_2	151.0^{hi}	166.1^{d}	158.6^{E}
L_3	155.0^{g}	170.5^{c}	162.8^{C}
L_4	167.0^{cd}	183.7^{a}	175.4^{A}
VC_1	154.0^{gh}	169.4^{cd}	161.7^{CD}
VC_2	151.7^{g-i}	166.8^{cd}	159.3^{DE}
VC_3	160.3^{f}	176.4^{b}	168.4^{B}
VC_4	162.0^{ef}	178.2^{b}	170.1^{B}
Mean	156.0	170.0	
Year		778**	
Application		102**	
Year*Application		8.77**	

Means in the same column followed by different letters are significantly different at the 5% level.

(**): Statistically significant at p≤0.01.

Changes in Fe and Zn concentrations in chickpea under organic fertilizer applications

The statistical analysis indicated that Fe concentration in chickpea was significantly affected by year (p≤0.05) and application (p≤0.01), whereas the year*application interaction was not significant. Similarly, Zn concentration was significantly influenced by both year and application (p≤0.01), while no significant effect was observed for the year*application interaction (Table 5).

Iron (Fe)

The effect of different doses of leonardite and vermicompost on Fe in chickpea plants ranged from 51.7 to 70.1 mg Fe kg^{-1}, with the first-year mean of 57.9 mg Fe kg^{-1} and the second-year mean of 61.0 mg Fe kg^{-1}. Overall means indicated that the lowest Fe content (53.3 mg Fe kg^{-1}) was observed with 200 kg da^{-1} vermicompost, while the highest Fe content (68.1 mg Fe kg^{-1}) was obtained from 200 kg da^{-1} leonardite application (Table 5). Except for the 200 kg da^{-1} leonardite application, all other applications generally showed a decrease in Fe levels compared to the control. This suggests that different doses may have variable effects on the amount of soluble Fe in the soil. Similar studies have reported that leonardite applications to rice soil have positive effects on yield and some yield parameters, including macronutrient (P and Mg) and micronutrient (Fe, Mn, Cu and Zn) concentrations (Litardo *et al*., 2022). Many researchers have reported that vermicompost applications to soil generally lead to increases in Fe concentrations in mustard (DeKock *et al*., 1960), soybean (Cieschi *et al*., 2019), wheat (Zırığ and Eren, 2025) and lettuce (Adiloğlu *et al*., 2015).

Zinc (Zn)

The effect of Leonardite and vermicompost applications with different structures on Zn in chickpea plants varied

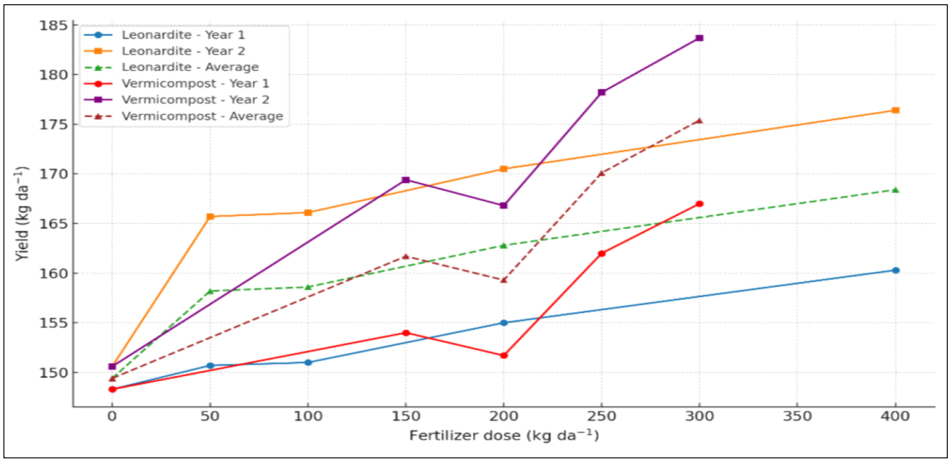


Fig 2: Effect of organic fertilizer applications on chickpea yield.

between 30.9 and 38.6 mg Zn kg^{-1}. The first year mean was determined to be 34.5 mg Zn kg^{-1} and the second year mean was determined to be 36.1 mg Zn kg^{-1}. Overall means indicated that the lowest Zn content (32.1 mg Zn kg^{-1}) was observed in the control, while the highest Zn content (37.6 mg Zn kg^{-1}) was obtained from the 200 kg da^{-1} leonardite application (Table 5). The applications generally increased Zn content compared to the control. Zinc is a critical micronutrient for plant metabolism and this increase suggests that organic amendments can enhance Zn availability (Alloway, 2008; Marschner, 2012). Leonardite applications have been reported to positively affect yield and yield parameters (grain/stem ratio, harvest index) in rice (Litardo *et al*., 2022). The presence of organic matter can dissolve otherwise insoluble Zn forms, improving its bioavailability (Smith, 2009). Vermicompost applications have been reported to promote growth, improve soil properties and increase Zn concentrations in various crops (Eryüksel, 2016). Furthermore, organic ligands in soil may lead to the formation of organic Zn complexes, which can either enhance or limit Zn uptake by plants (Hamzah Saleem *et al*., 2022).

Yield

Statistical analysis of the study indicated that year, application and the year*application interaction were all significant at the $p \leq 0.01$ level (Table 6).

The effects of different doses of leonardite and vermicompost on the yield of chickpea plants ranged from 148.3 to 183.7 kg da^{-1}, with the first-year mean being 156.0 kg da^{-1} and the second-year mean 170.0 kg da^{-1}. Considering overall means, the lowest yield (149.4 kg da^{-1}) was obtained in the control plots, while the highest yield (175.4 kg da^{-1}) was achieved with 400 kg da^{-1} leonardite application (Table 6 and Fig 2). Vermicompost applications have been reported to support root development, facilitate nutrient uptake and thereby increase yield. Moreover, the nutrients it contains are present in higher amounts and in more readily soluble forms compared to normal compost (Padmavathiamma *et al*., 2008; Pattnaik and Reddy, 2010). Organic materials have been noted to enhance soil organic matter content, positively affecting plant growth and consequently crop yield (Verlinden *et al*., 2009; El-Sayed *et al*., 2011). Research on leonardite applications in chickpea (*Cicer arietinum* L.) has shown positive effects on plant height, first pod height, number of pods, number of seeds per pod, 100-seed weight and seed yield, with the 100 kg da^{-1} dose providing the highest values and higher doses potentially being beneficial (Uçar *et al*., 2020). Leonardite applications have also been reported to increase yield and yield parameters in faba bean (*Vicia faba* L.) (Uçar *et al*., 2021).

CONCLUSION

Within the scope of this two-year study, the effects of leonardite and vermicompost applications on the nutrient content (N, P, K, Cu, Mn, Fe and Zn) and yield of chickpea (*Cicer arietinum* L.) were investigated. The findings indicate that both the applications and the annual variations produced significant results. Analysis of yield data provided important insights into the year, the treatment and how they interact. Control plots had the lowest yields, while plots receiving 400 kg da^{-1} leonardite and 250 to 300 kg da^{-1} vermicompost had significantly higher yields. This suggests that organic matter can contribute to better chickpea growth by making the soil more fertile. It's important to note that leonardite has a greater impact on yield, which is crucial. Investigating the cumulative effects of long-term applications on soil organic matter content, nutrient dynamics and biological activity is recommended for future studies.

Disclaimers

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Conflict of interest

The author declares that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

REFERENCES

Acharya, S.N., Kastelic, J.P., Beauchemin, K.A. and Messenger, D.F. (2006). A review of research progress on cicer milkvetch (*Astragalus cicer* L.). *Canadian Journal of Plant Science*. **86(1):** 49-62. doi: 10.4141/P04-174.

Adiloğlu, A., Eryılmaz Açıkgöz, F., Adiloðlu, S. and Solmaz, Y. (2015). Effects of aquaculture waste and vermicompost applications on yield, some nutrient element contents and some agronomic characters of lettuce (*Lactuca sativa* L. var. *crispa*). *Namık Kemal University Scientific Research Project*, Project No: NKUBAP.00.24.AR:15.

Akibode, C.S. and Maredia, M.K. (2012). Global and regional trends in production, trade and consumption of food legume crops. *Department of Agricultural, Food and Resource Economics Michigan State University*, East Lansing: **90.** doi: 10.22004/ag.econ.136293.

Akinremi, O.O., Janzen, H.H., Lemke, R.L. and Larney, F.J. (2000). Response of canola, wheat and green beans to leonardite additions. *Canadian Journal of Soil Science*. **80(3):** 437-443. doi: 10.4141/S99-058.

Alloway, B.J. (2008). Zinc in Soils and Crop Nutrition (2nd ed.). IZA and IFA, Brussels, Belgium and Paris, France.

Anonymous, (2025). Diyar 95 Chickpea Variety Certificate. https://arastirma.tarimorman.gov.tr/gaputaem/Belgeler/%C3%A7e%C5%9Fit%20belgeleri/t%C3%BCrk%C3%A7e/nohut/diyar%2095%20tr.pdf [Access date:15.02.2025].

Azarmi, R., Giglou, M.T. and Taleshmikail, R.D. (2008). Influence of vermicompost on soil chemical and physical properties in tomato (*Lycopersicum esculentum*) field. *African Journal of Biotechnology*. **7(14):** 2397-2401.

Azizzadeh, E., Naeini, S.A.R.M., Zeinali, E. and Roshani, G.A. (2016). Nitrogen, phosphor and potassium changes in soil and wheat under foliar application of Leonardite, N and K. *International Journal of Advanced Biological and Biomedical Research*. **4(2):** 193-201. doi: 10.26655/ijabbr.2016.6.12.

Begum, M., Kandali, G.G., Dutta, D. and Bey, C.K. (2025). Organic Fertilizer: A Key Component of Organic Agriculture-A Review. *Agricultural Reviews*. **46(2):** 280-287. doi: 10.18805/ag.R-2626.

Bouyoucus, G.J. (1952). A recalibration of hydrometer for making mechanical analysis of soils. *Agronomy Journal*. **43:** 434-438.

Bremner, J.M. (1996). Nitrogen total. *Methods of Soil Analysis: Part 3 Chemical Methods*. **5:** 1085-1121. doi: 10.2136/sssabookser5.3.c37.

Ceritoglu, M., Erman, M., Ceritoglu, F. and Bektas, H. (2021). The response of grain legumes to vermicompost at germination and seedling stages. *Legume Research*. **44(8):** 936-941. doi: 10.18805/LR-610.

Cieschi, M.T., Polyakov, A.Y., Lebedev, V.A., Volkov, D.S., Pankratov, D.A., Veligzhanin, A.A. and Lucena, J.J. (2019). Eco-friendly iron-humic nanofertilizers synthesis for the prevention of iron chlorosis in soybean (*Glycine max*) grown in calcareous soil. *Frontiers in Plant Science*. **10:** 413. doi: 10.3389/fpls.2019.00413.

Cömert-Acar, M., Kirkpinar, F., Shayan, Y. and Mert, S. (2019). Organic feeds and alternative organic feed protein sources. In *VI. Organic Agriculture Symposium*. 15-17 May, Izmir-Türkiye. pp 159-165.

Çetiner, M. and Bilek, S.E. (2018). Plant protein sources. *Çukurova Journal of Agriculture and Food Science*. **33(2):** 111-126.

David, J., Šmejkalová, D., Hudecová, Š., Zmeškal, O., von Wandruszka, R., Gregor, T. and Kuèerík, J. (2014). The physico-chemical properties and biostimulative activities of humic substances regenerated from lignite. *Springer Plus*. **3(1):** 156.

DeKock, P.C., Hall, A. and McDonald, M. (1960). A relation between the ratios of phosphorus to iron and potassium to calcium in mustard leaves. *Plant and Soil*. **12(2):** 128-142. doi: 10.1007/BF01377366.

Demirer, T. (2019). Effect of leonardite application on leaf nutrient content and fruit chemical parameters of cherry (*Prunus avium* L.). *Journal of Plant Nutrition*. **42(19):** 2532-2538. doi: 10.1080/01904167.2019.1659352.

Duval, J.R., Dainello, F.J., Haby, V.A. and Earhart, D.R. (1998). Evaluating leonardite as a crop growth enhancer for turnip and mustard greens. *HortTechnology*. **8(4):** 564-567.

Egesel, C.Ö., Kahrıman, F. and Tayyar, Ş. (2006). The feasibility of growing chickpea as a winter crop in the Çanakkale region. *Uludağ University Journal of Faculty of Agriculture*. **20(1):** 57-66.

El-Sayed, H.E.A., Saif-el-Dean, A., Ezzat, S. and El-Morsy, A.H.A. (2011). Responses of productivity and quality of sweet potato to phosphorus fertilizer rates and application methods of the humic acid. *International Research Journal of Agricultural Science and Soil Science*. **1(9):** 383-393.

Eryüksel, S. (2016). The effect of different rates of vermicompost application on the nutrient content of some vegetables. Master's Thesis, *Namık Kemal University, Institute of Science*, Tekirdağ. (Unpublished)

Gökmen Yılmaz, F., Harmankaya, M. and Gezgin, S. (2012). The effects of different iron compounds and TKI-Humas treatments on iron uptake and growth of spinach. *Sakarya University Journal of Arts and Science*. **1:** 217-231.

Gül, M.K., Egesel, C.Ö., Kahrıman, F. and Tayyar, Ş. (2006). Winter production possibilities of chickpea in Çanakkale Province. *Journal of Agricultural Faculty of Bursa Uludağ University*. **20(1):** 57-66.

Hamzah Saleem, M., Usman, K., Rizwan, M., Al Jabri, H. and Alsafran, M. (2022). Functions and strategies for enhancing zinc availability in plants for sustainable agriculture. *Frontiers in Plant Science*. **13:** 1033092. doi: 10.3389/fpls.2022.1033092.

Joshi, R., Vig, A.P. and Singh, J. (2013). Vermicompost as soil supplement to enhance growth, yield and quality of *Triticum aestivum* L.: A field study. *International Journal of Recycling of Organic Waste in Agriculture*. **2(1):** 16. doi: 10.1186/22517715-2-16.

Kacar, B. (1995). Chemical Analyses of Plants and Soils, III. Soil Analyses. Publications of the Agricultural Faculty of Ankara University, Education, Research and Development Foundation, No:3, Ankara: **705.**

Kassie, M., Shiferaw, B., Asfaw, S., Abate, T., Muricho, G., Ferede, S. and Assefa, K. (2009). Current situation and future outlooks of the chickpea sub-sector in Ethiopia. *ICRISAT and EIAR*: 43.

Kaya, C., Şenbayram, M., Akram, N.A., Ashraf, M., Alyemeni, M.N. and Ahmad, P. (2020). Sulfur-enriched leonardite and humic acid soil amendments enhance tolerance to drought and phosphorus deficiency stress in maize (*Zea mays* L.). *Scientific Reports*. **10(1):** 6432. doi: 10.1038/s41598-020-62669-6.

Kayan, N., Olgun, M., Kutlu, İ., Ayter, N. and Gülmezoğlu, N. (2014). Determination growth progress of chickpea (*Cicer arietinum* L.) under irrigation and no-irrigation conditions. *Journal of Agricultural Sciences*. **20(4):** 387-398. doi: 10.15832/tbd.67352.

Latham, M.C. (1997). Human Nutrition in the Developing World. No. 29. Food and Agriculture Org., New York. p 510.

Lindsay, W.L. and Norvell, W.A. (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal*. **42:** 421-428. doi: 10.2136/sssaj1978.03615995004200030009x.

Lisciani, S., Marconi, S., Le Donne, C., Camilli, E., Aguzzi, A., Gabrielli, P. and Ferrari, M. (2024). Legumes and common beans in sustainable diets: Nutritional quality, environmental benefits, spread and use in food preparations. *Frontiers in Nutrition*. **11:** 1385232. doi: 10.3389/fnut.2024.1385232.

Litardo, R.C.M., Bendezú, S.J.G., Zenteno, M.D.C., Pérez-Almeida, I.B., Parismoreno, L.L. and García, E.D.L. (2022). Effect of mineral and organic amendments on rice growth and yield in saline soils. *Journal of the Saudi Society of Agricultural Sciences*. **21(1):** 29-37. doi: 10.1016/j.jssas.2021.06.015.

Loeppert, R.H. and Suarez, D.L. (1996). Carbonate and Gypsum. In: Methods of Soil Analysis, Part 3, Chemical Methods. [D.L. Sparks (Ed.)], Madison, Wisconsin, USA. pp 437-474. doi: 10.2136/sssabookser5.3.c15.

Marschner, H. (2012). Marschner's Mineral Nutrition of Higher Plants (3rd ed.). Academic Press.

Nathawat, B.D.S., Sharma, O.P., Kumari, M. and Shivran, H. (2024). Effect of nutrients on wilt in chickpea. *Legume Research*. **47(1):** 152-155. doi: 10.18805/LR-4490.

Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate US Dept. *Agric. Washington Circ*. **939:** 19.

Otağ, F.B. and Hayta, M. (2016). Effects of ultrasound, microwave, fermentation and heat treatments on angiotensin-I converting enzyme activity of chickpea bioactive peptides. *The Journal of Food*. **41(1):** 9-14. doi: 10.15237/gida.GD15030.

Özen, N. and Sönmez, S. (2019). The effects of vermicompost application on the nutrient elements contents of lettuce plant during different incubation periods. *Mediterranean Agricultural Sciences*. **32:** 115-119. doi: 10.29136/mediterranean.559339.

Padmavathiamma, P.K., Li, L.Y. and Kumari, U.R. (2008). An experimental study of vermi-biowaste composting for agricultural soil improvement. *Bioresource Technology*. **99(6):** 1672-1681. doi: 10.1016/j.biortech.2007.04.028.

Pattnaik, S. and Reddy, M.V. (2010). Nutrient status of vermicompost of urban green waste processed by three earthworm species-*Eisenia fetida*, *Eudrilus eugeniae* and *Perionyx excavatus*. *Applied and Environmental Soil Science*. **2010(1):** 967526. doi: 10.1155/2010/967526.

Richards, L.A. (1954). Diagnosis and improvement of saline and alkali soils. *United States Department of Agriculture Handbook*. **60:** 94.

Roy, F., Boye, J.I. and Simpson, B.K. (2010). Bioactive proteins and peptides in pulse crops: Pea, chickpea and lentil. *Food Research International*. **43:** 432-442. doi: 10.1016/j.foodres.2009.09.002.

Römheld, V. and Marschner, H. (1991). Function of Micronutrients in Plants. In: *Micronutrients in Agriculture*. **4:** 297-328. doi: 10.2136/sssabookser4.2ed.c9.

Sarıyıldız, T. (2020). Effects of leonardite and mineral fertilizer applications on plant growth and soil quality of garlic (*Allium sativum* L.). *Turkish Journal of Agriculture-Food Science and Technology*. **8(8):** 1763-1772. doi: 10.24925/turjaf.v8i8.1763-1772.3504.

Singh, M., Rana, R.K., Monga, S. and Singh, R. (2022). Organic and natural farming-a critical review of challenges and prospects. *Bhartiya Krishi Anusandhan Patrika*. **37(4):** 295-305. doi: 10.18805/BKAP569.

Smith, S.R. (2009). A critical review of the bioavailability and impacts of heavy metals in municipal solid waste composts compared to sewage sludge. *Environment International*. **35(1):** 142-156. doi: 10.1016/j.envint.2008.06.009.

Soil Survey Staff. (1951). Soil Survey Manual. U.S. Department of Agriculture, Handbook No.18, Washington, D.C.

Temba, M.C., Njobeh, P.B., Adebo, O.A., Olugbile, A.O. and Kayitesi, E. (2016). The role of compositing cereals with legumes to alleviate protein energy malnutrition in Africa. *International Journal of Food Science and Technology*. **51(3):** 543-554. doi: 10.1111/ijfs.13035.

Timsina, J. (2018). Can organic sources of nutrients increase crop yields to meet global food demand? *Agronomy*. **8(10):** 214. doi: 10.3390/agronomy8100214.

Topcuoglu, B. and Onal, M.K. (2006). The effects of leonardite application on yield, quality and mineral contents of tomato plant in greenhouse conditions. III. *In Organic Farming Symposium*, Yalova-Türkiye.

Uçar, Ö. (2019). The importance of fertilizers containing organic matter in chickpea cultivation. *ISPEC Journal of Agricultural Sciences*. **3(1):** 116-127.

Uçar, Ö., Soysal, S. and Erman, M. (2020). The effects of different leonardite doses on the yield and some yield properties of chickpea (*Cicer arietinum* L.). *European Journal of Science and Technology*. **20:** 917-921. doi: 10.31590/ejosat.822906.

Uçar, Ö., Soysal, S. and Erman, M. (2020a). The effects of solid vermicompost applications on the yield and yield components of chickpea (*Cicer arietinum* L.) in the ecological conditions of Siirt. *Turkish Journal of Nature and Science*. **9(2):** 91-95. doi: 10.46810/tdfd.806329.

Uçar, Ö., Soysal, S. and Erman, M. (2021). Effects of leonardite application on yield of broad beans (*Vicia faba* L.) under low input rainfed semi-arid Mediterranean highland condition of Turkey. *Legume Research-An International Journal*. **44(8):** 942-946. doi: 10.18805/LR-636.

Üstün, A. and Gülümser, A. (2003). Determination of optimum sowing time for chickpeas in the Black Sea region. *Journal of Agricultural Faculty of Gaziosmanpaşa University*. **20(2):** 133-143.

Verlinden, G., Pycke, B., Mertens, J., Debersaques, F., Verheyen, K., Baert, G. and Haesaert, G. (2009). Application of humic substances results in consistent increases in crop yield and nutrient uptake. *Journal of Plant Nutrition*. **32(9):** 1407-1426. doi: 10.1080/01904160903092630.

Wells, J.C., Sawaya, A.L., Wibaek, R., Mwangome, M., Poullas, M.S., Yajnik, C.S. and Demaio, A. (2020). The double burden of malnutrition: Aetiological pathways and consequences for health. *The Lancet*. **395(10217):** 75-88. doi: 10.1016/S0140-6736(19)32472-9.

Xue, Z., Wen, H., Zhai, L., Yu, Y., Li, Y., Yu, W. and Kou, X. (2015). Antioxidant activity and anti-proliferative effect of a bioactive peptide from chickpea (*Cicer arietinum* L.). *Food Research International*. **77:** 75-81. doi: 10.1016/j.foodres.2015.09.027.

Zırığ, B. and Eren, A. (2025). Effect of vermicompost applications on quality, yield and some macro and micro elements content of bread wheat. *ISPEC Journal of Agricultural Sciences*. **9(2):** 470-483. doi: 10.5281/zenodo.15023755.