

Impact of Vermicompost and Biofertilizers on Selected Quality Parameters of Chickpea

Ahmet DİNÇ^{1*}, Yeşim TOĞAY²

¹ Agricultural Insurance Van Regional Directorate, Van

² Mugla Sıtkı Kocman University, Fethiye ASMK Vocational High School, Mugla

* Corresponding author: ahmetdinc.1987@gmail.com

Abstract

This study was conducted to determine the effects of different doses of vermicompost (0, 2500, 5000, 7500 kg ha⁻¹) and two biofertilizers (*Rhizobium ciceri* and *Bacillus megaterium*) on the quality traits of İnci and Hasanbey chickpea (*Cicer arietinum* L.) varieties over a two-year period. The experiments were arranged in a randomized split-split plot design with three replications, and the quality parameters investigated included protein, ash, moisture, starch, cellulose, and oil contents. The results indicated that *Rhizobium* application provided the highest protein content (21.6%) and also achieved the maximum oil content. Vermicompost at 7500 kg ha⁻¹ increased protein content to 21.1%, while the highest ash content (3.78%) was obtained with 5000 kg ha⁻¹ vermicompost. Other quality parameters were recorded as follows: moisture 9.08%, starch 54.66%, and cellulose 7.25%. *Rhizobium* application was also superior in terms of oil content. In conclusion, both vermicompost and biofertilizers positively influenced the quality traits of chickpea seeds. *Rhizobium* was particularly effective in enhancing protein and oil contents, whereas higher doses of vermicompost contributed significantly to protein and ash accumulation. These findings highlight the potential of organic and biofertilizers to improve chickpea quality within the framework of sustainable and environmentally friendly agricultural practices.

Research Article

Article History

Received :10.11.2025
Accepted :30.12.2025

Keywords

Chickpea
organic fertilizers
microbial inoculants
sustainable agriculture
seed quality traits

Citation: Dinç, A., Toğay, Y., 2026. Impact of Vermicompost and Biofertilizers on Selected Quality Parameters of Chickpea. *ISPEC Journal of Agricultural Sciences*, 10(1): 94-107. DOI: <https://doi.org/10.5281/zenodo.18213168>

© This study was published by *ISPEC Journal of Agricultural Sciences* under a Creative Commons License (<https://creativecommons.org/licenses/by-nc/4.0/>).

1. Introduction

Chickpea (*Cicer arietinum* L.) is one of the most important legumes crops worldwide due to its high protein and carbohydrate content in human nutrition and its strategic role in agricultural production through biological nitrogen fixation. Türkiye is among the leading chickpea-producing countries, with considerable importance for both domestic consumption and export (Doğan, 2019). Traditional fertilization methods have largely relied on chemical inputs; however, in recent years, organic and biofertilizers have gained prominence in sustainable agriculture. These inputs improve soil structure, enhance nutrient bioavailability, and contribute to crop quality (Torun Kayabaşı and Yılmaz, 2021; Oyege and Bhaskar, 2023). Several studies have reported that organic and biofertilizers increase chickpea yield and quality parameters (Doğan and Çığ, 2023; Cathrine et al., 2025). With the expansion of sustainable agricultural practices, reducing chemical fertilizer use and promoting organic inputs have become major objectives. Vermicompost, with its high organic matter content, humic and fulvic acids, and rich microbial composition, is considered a valuable organic fertilizer source that enhances plant nutrition and soil fertility (Dayar, 2019; Kılıç, 2024; Zırığ and Eren, 2025). Improvements in soil chemical and physical properties through vermicompost application were manifested as substantial increases in yield parameters (Yılmaz, 2023). Biofertilizers, particularly in legumes, directly influence quality parameters by improving nitrogen fixation and nutrient solubility through symbiotic interactions. *Rhizobium* bacteria contribute atmospheric nitrogen to plants via nodulation, while *Bacillus* species support plant nutrition through mechanisms such as phytohormone production, phosphate solubilization, and siderophore secretion (Elkoca et al., 2008; Mohammadi et al.,

2010). Protein, ash, moisture, starch, cellulose, and oil contents are the primary quality parameters of chickpea seeds. Their responses to fertilization vary depending on genotype and environmental conditions (Karasu and Vural, 2006). Therefore, the combined use of organic and biofertilizers represents a critical research area for improving chickpea quality traits and achieving sustainable production goals. In this study, the effects of different doses of vermicompost and biofertilizers (*Rhizobium ciceri* and *Bacillus megaterium*) on the quality parameters of İnci and Hasanbey chickpea varieties were investigated. The findings were compared with the literature to provide insights at both national and international levels for sustainable chickpea production.

2. Material and Methods

2.1 Material

This study was conducted during the summer seasons of 2018 and 2019 in Kayaköy, Fethiye (Muğla, Türkiye). As experimental materials, two chickpea varieties (İnci and Hasanbey) were used together with *Rhizobium ciceri*, an effective nitrogen-fixing bacterium for chickpea, and *Bacillus megaterium*, a phosphate-solubilizing bacterium. In addition, vermicompost containing 2% N, 1% P₂O₅, 1% K₂O, and 3% Ca was applied. Climatic data indicated that the long-term average annual rainfall was 170.3 mm, with a mean temperature of 20.64 °C and average relative humidity of 63.32%. Rainfall during the 2017–2018 and 2018–2019 seasons was 118.6 mm and 160.5 mm, respectively. Mean temperatures were 23.08 °C in the first year and 21.54 °C in the second year, while relative humidity was 61.6% and 59.46%, respectively (Anonymous, 2019). Compared to long-term averages, rainfall and humidity were lower, whereas temperatures were higher in both years. Soil analyses revealed that the experimental area had a clay-loam texture,

slightly alkaline pH, moderate organic matter, high lime content, slight salinity, moderate potassium and phosphorus levels, and insufficient zinc. In 2019, lime content was lower compared to the previous year, while other parameters remained similar.

2.2 Methods

The study investigated the effects of two chickpea varieties (İnci and Hasanbey), two bacterial species (*Rhizobium ciceri* and *Bacillus megaterium*) together with a control treatment, and four different vermicompost doses (0, 2500, 5000, and 7500 kg ha⁻¹) on quality parameters. The experiments were arranged in a randomized block split-split plot design with three replications. Chickpea varieties were assigned to the main plots, bacterial treatments to the sub-plots, and vermicompost doses to the sub-sub-plots. The *Rhizobium ciceri* bacterium used in the experiment was obtained from the Ankara Soil and Fertilizer Research Institute and stored under refrigeration until use. A few hours before sowing, chickpea seeds were moistened with a sugar solution in a shaded area and thoroughly mixed with the inoculant (peat-based formulation, approximately 10⁸ CFU g⁻¹) at a rate of 2 g per 100 g seed to ensure effective inoculation. Nodulation was verified at the flowering stage by examining root nodules. The *Bacillus megaterium* bacterium, supplied by the Department of Plant Protection, Faculty of Agriculture, Atatürk University, was propagated under laboratory conditions and prepared as a liquid suspension containing approximately 10⁹ cells mL⁻¹. It was applied to the seeds immediately prior to sowing at a rate of [insert dose, e.g., 500 mL ha⁻¹] using seed coating. Vermicompost was incorporated into the soil before sowing at rates equivalent to 0, 2500, 5000, and 7500 kg ha⁻¹. The experiments were established with a total of 72 plots. Each plot consisted of five rows, with an inter-row spacing of 30

cm. The plot size was arranged as 1.5 m × 5 m, corresponding to an area of 7.5 m². The seed amount to be sown per plot was calculated based on a seeding density of 60 seeds per square meter. At harvest, the border effect was eliminated by excluding the outer rows (one row from each side of the five-row plots) and the plants located within 50 cm at the beginning of each row. All measurements were therefore taken from a net plot area of 0.9 m × 4 m = 3.6 m². Data were obtained from 10 randomly selected plants within this area. Sowing was carried out manually by opening rows with a marker on March 17, 2018 (first year) and March 16, 2019 (second year). Vermicompost was applied to the experimental plots at the specified doses by broadcasting onto the soil surface prior to sowing and incorporating with a rake. Weed control was performed mechanically twice, once before flowering and once after flowering. The experiment was conducted under dry farming conditions. Harvesting was carried out at the stage when the pods began to turn yellow but before pod shattering occurred, in order to prevent seed loss. The harvest was performed manually on July 6, 2018 in the first year and on June 30, 2019 in the second year. Measurements, counts, and threshing of the harvested plants were conducted with great care, and average values were calculated. Plot yields were determined by threshing the plants through beating. The chemical composition analyses included the determination of protein, ash, moisture, starch, cellulose, and oil contents in the İnci and Hasanbey chickpea varieties. Protein content was measured using the Kjeldahl method, in which the nitrogen percentage was determined and multiplied by the conversion factor of 6.25 to obtain crude protein values. Ash, moisture, starch, cellulose, and oil contents were determined using a Near-Infrared (NIR) spectroscopy device within the wavelength range of 800–2500 nm, following standard procedures

widely applied in food and feed composition analysis. At the end of the treatments applied to the chickpea varieties, differences in quality parameters were evaluated using analysis of variance (ANOVA) based on the split-split plot experimental design. The ANOVA model included chickpea varieties as main plots, bacterial treatments as sub-plots, and vermicompost doses as sub-sub-plots, with three replications. Degrees of freedom, mean squares, and appropriate error terms were calculated for each source of variation, and the coefficient of variation (CV) was reported to assess experimental precision. For the identification of statistically different groups, Tukey's multiple comparison test at the 5% significance level was employed. The statistical analyses were

performed using JMP and Costat software packages.

3. Results and Discussion

For the İnci and Hasanbey chickpea varieties, the trait values specified in the Materials and Methods section were measured following the procedures described therein. The findings were subjected to variance analysis by combining the data across years. For the examined traits, factor level means were compared using Tukey's test. The effects of four different vermicompost doses and biofertilizer applications on the studied traits of the two chickpea varieties, along with the variance analysis results for 2018, 2019, and the combined two-year averages, are presented in Table 1.

Table 1. Analysis of variance results for quality traits of chickpea under biofertilizer and vermicompost applications in 2018, 2019, and combined years

Quality Traits	Years	Year (Y)	Variety (V)	Biofertilizer (BF)	Vermicompost (VC)	VxBF	VxVC	BFxVC	Vx BFxVC
Protein content	2018		*	**	**				
	2019		*	**	**	**			
	2018-19	**		**	*	*			
Ash content	2018		**	**	**	**	**	**	**
	2019		**	**	**	*	**	**	**
	2018-19	*	**	**	**	*	**	**	**
Moisture content	2018		**	**	**	**	**	**	**
	2019						*	*	*
	2018-19	**					*	*	*
Starch content	2018		**	**	**	**	**	**	**
	2019			**	**	**	**	**	**
	2018-19	**		**	**	**	**	**	**
Cellulose content	2018		**	**	**	**	**	**	**
	2019		**	**	**	**	**	**	**
	2018-19	**	**	**	**	**	**	**	**
Oil content	2018		**	**	**	**	**	**	**
	2019		**	**	**	**	**	**	**
	2018-19	**	**	**	**	**	**	**	**

*P<0.05, **P<0.01 indicate significance levels

3.1. Protein content

According to the variance analysis results, protein content was significantly affected by variety at the 5% level in the first year, while biofertilizer and vermicompost doses were highly significant at the 1% level. In 2019, variety remained significant at the 5% level, whereas

biofertilizer, vermicompost doses, and the interaction between biofertilizer and vermicompost were significant at the 1% level. In the combined two-year analysis, year, biofertilizer, and vermicompost applications were highly significant (P<0.01), while the interactions between year × biofertilizer and year ×

vermicompost were significant at the 5% level (Table 1). Mean protein values obtained from the two chickpea varieties

under four vermicompost doses and biofertilizer applications are presented in Table 2.

Table 2. Mean protein content (%) of İnci and Hasanbey chickpea varieties under different biofertilizers and vermicompost doses

			Biofertilizers / Vermicompost levels (kg ha ⁻¹)											
			Control				<i>Rhizobium</i>				<i>Bacillus</i>			
Traits	Year	Variety	0	2500	5000	7500	0	2500	5000	7500	0	2500	5000	7500
Protein content	2018	İnci	18.9	19.1	19.4	19.5	20.7	20.9	21.0	21.4	19.8	20.1	20.4	20.4
		Hasanbey	18.6	18.7	19.0	19.2	20.2	20.4	20.7	20.9	19.5	19.6	19.8	20.0
	2019	İnci	20.5	21.1	21.3	21.5	22.6	22.9	23.4	23.9	21.7	21.9	22.0	22.3
		Hasanbey	19.4	19.9	20.1	20.3	21.4	21.6	21.8	22.1	20.5	20.7	20.9	21.1
	2018-19	İnci	19.7 ^{lm}	21.1 ^{jk}	20.4 ^{ij}	20.5 ^{hi}	21.7 ^{cd}	21.9 ^{bc}	22.2 ^b	22.7 ^a	20.8 ^{gh}	21.0 ^{fg}	21.2 ^{ef}	21.4 ^{de}
		Hasanbey	18.9 ^o	19.3 ⁿ	19.5 ^{mn}	19.8 ^{lm}	20.8 ^{gh}	20.9 ^{fg}	21.3 ^{ef}	21.5 ^{de}	20.0 ^{kl}	20.2 ^{jk}	20.4 ^{ij}	20.6 ^{hi}
			2018				2019				2018-19			
	General mean	Variety	20.2 ^A	19.7 ^B			22.1 ^A	20.8 ^B			21.1 ^A	20.3 ^B		
Vermicompost		19.6 ^D	19.8 ^C	20.1 ^B	20.2 ^A	20.3 ^D	20.6 ^C	20.8 ^B	21.1 ^A	20.3 ^D	20.6 ^C	20.8 ^B	21.1 ^A	
Biofertilizers		19.1 ^C	19.9 ^B	20.8 ^A		20.5 ^C	22.5 ^A	21.4 ^B		19.8 ^C	21.6 ^A	20.7 ^B		

*Values followed by the same letter are not significantly different according to Tukey's test at the 5% level

**Vermicompost dose (kg ha⁻¹) within each biofertilizer treatment

In the years of the study and in the combined two-year averages, the mean protein contents of the İnci and Hasanbey chickpea varieties were found to be 20.2–19.7% in the first year, 22.1–20.8% in the second year, and 21.1–20.3% in the combined analysis. Across both years and in the combined averages, the plant height values measured in the İnci variety were consistently higher than those recorded in Hasanbey (Table 2). The general mean protein values obtained from vermicompost applications ranged between 19.6–20.2% in 2018, 21.0–21.9% in 2019, and 20.3–21.1% in the combined two-year averages. In both years and in the combined analysis, the lowest values were obtained from plots without vermicompost (0 kg ha⁻¹), whereas the highest values were recorded with 7500 kg ha⁻¹ vermicompost application (Table 2). The mean protein values obtained from biofertilizer applications ranged between 19.1–20.8% in the first year, 20.5–22.5% in the second year, and 19.8–21.6% in the combined averages. The lowest values were obtained from control plots without microbial inoculation. In the first year, the

highest protein content was observed under *Bacillus* inoculation, while in the second year and in the combined analysis, *Rhizobium* inoculation provided the highest values (Table 2). The findings clearly indicate that vermicompost and biofertilizers significantly increased protein content in chickpea seeds. In particular, *Rhizobium* inoculation provided the highest protein values in the combined years, which can be explained by the direct effect of symbiotic nitrogen fixation. The higher protein values obtained under *Bacillus* inoculation in the first year may be associated with PGPR effects that stimulate root development. Similar results have been reported in previous studies. Elkoca et al. (2008) noted that biofertilizers capable of nitrogen fixation increased protein content. Altınkaynak (2019) reported protein values ranging between 19.7–23.8% under different fertilization practices. Mohammadi et al. (2010) indicated that the addition of farmyard manure and compost to chemical fertilizers enhanced protein content in chickpea. Yadav et al. (2025) demonstrated that the combination of

vermicompost and *Rhizobium* significantly increased protein and carbohydrate contents in chickpea. Vermicompost applications also elevated protein levels, which can be attributed to the mineralization of organic matter (Faroda et al., 2025). Overall, these results confirm that the combined use of organic and biofertilizers supports protein synthesis and provides substantial contributions to quality parameters in chickpea.

3.2. Ash content

When the variance analysis table for ash content was examined, in the first year, the effects of variety, biofertilizer, and vermicompost applications, together with the interactions of variety $\times$ biofertilizer, variety $\times$ vermicompost, biofertilizer $\times$ vermicompost, and variety $\times$ biofertilizer $\times$ vermicompost, were all found to be highly

significant at the 1% level. In 2019, the interaction of variety $\times$ biofertilizer was significant at the 5% level, while variety, biofertilizer, vermicompost, and the interactions of variety $\times$ vermicompost, biofertilizer $\times$ vermicompost, and variety $\times$ biofertilizer $\times$ vermicompost were highly significant at the 1% level. In the combined two-year analysis, year and the interaction of variety $\times$ biofertilizer were significant at the 5% level, whereas variety, biofertilizer, vermicompost, and the interactions of variety $\times$ vermicompost, biofertilizer $\times$ vermicompost, and variety $\times$ biofertilizer $\times$ vermicompost were significant at the 5% level (Table 1). The mean ash content values of the two chickpea varieties under four different vermicompost doses and biofertilizer applications, together with the groupings formed according to Tukey's test, are presented in Table 3.

Table 3. Mean ash content (%) of İnci and Hasanbey chickpea varieties under different biofertilizers and vermicompost doses

Traits	Year	Variety	Biofertilizers / Vermicompost levels (kg ha ⁻¹)											
			Control				<i>Rhizobium</i>				<i>Bacillus</i>			
			0	2500	5000	7500	0	2500	5000	7500	0	2500	5000	7500
Ash content	2018	İnci	3.47 ⁿ	3.71 ^h	3.72 ^h	3.92 ^d	3.76 ^g	3.91 ^d	4.13 ^b	3.64 ^l	3.63 ^l	3.64 ^{kl}	3.68 ⁱ	3.66 ^{jk}
		Hasanbey	3.78 ^f	3.53 ^m	3.76 ^g	3.77 ^{fg}	3.66 ^j	3.68 ⁱ	4.15 ^a	3.71 ^h	3.99 ^c	3.51 ^m	3.92 ^d	3.88 ^e
	2019	İnci	3.65 ^{de}	3.72 ^{bc}	3.94 ^a	3.73 ^{bc}	3.75 ^{bc}	3.55 ^{gh}	3.75 ^{bc}	3.64 ^{def}	3.64 ^{def}	3.68 ^{cd}	3.55 ^{gh}	3.63 ^{def}
		Hasanbey	3.65 ^{de}	3.61 ^{efg}	3.69 ^{cd}	3.60 ^{efg}	3.76 ^b	3.54 ^{gh}	3.55 ^{gh}	3.52 ^h	3.63 ^{def}	3.57 ^{gh}	3.60 ^{efg}	3.44 ⁱ
	2018-19	İnci	3.56 ^k	3.71 ^{fg}	3.83 ^{bc}	3.83 ^{bc}	3.75 ^{de}	3.73 ^{ef}	3.94 ^a	3.64 ^{ij}	3.63 ^{ij}	3.66 ^{hi}	3.62 ^j	3.65 ^{ij}
		Hasanbey	3.7 ^{fg}	3.57 ^k	3.73 ^{ef}	3.68 ^{gh}	3.71 ^{fg}	3.61 ^j	3.85 ^b	3.62 ^j	3.81 ^c	3.54 ^k	3.76 ^d	3.66 ^{hi}
			2018				2019				2018-19			
	General mean		Variety	3.74 ^B	3.78 ^A		3.68 ^A	3.59 ^B			3.71 ^A	3.69 ^B		
		Vermicompost	3.71 ^C	3.66 ^D	3.89 ^A	3.76 ^B	3.68 ^A	3.61 ^B	3.68 ^A	3.59 ^B	3.69 ^B	3.64 ^D	3.78 ^A	3.68 ^C
		Biofertilizers	3.71 ^C	3.83 ^A	3.74 ^B		3.70 ^A	3.63 ^B	3.59 ^C		3.71 ^B	3.73 ^A	3.67 ^C	

*Values followed by the same letter are not significantly different according to Tukey's test at the 5% level

**Vermicompost dose (kg ha⁻¹) within each biofertilizer treatment

In the years of the study and in the combined two-year averages, the mean ash contents of the İnci and Hasanbey chickpea varieties were found to be 3.74–3.78% in the first year, 3.68–3.59% in the second year, and 3.71–3.69% in the combined analysis. In the first year, Hasanbey exhibited higher values, whereas in the second year and in the combined averages,

İnci recorded higher ash contents (Table 3). The general mean ash values obtained from vermicompost applications ranged between 3.66–3.89% in 2018, 3.59–3.68% in 2019, and 3.64–3.78% in the combined two-year averages. In the first year and in the combined analysis, the lowest values were obtained from 2500 kg ha⁻¹ vermicompost application, while in the second year the

lowest values were recorded at 7500 kg ha⁻¹. The highest ash content in all cases was observed with 5000 kg ha⁻¹ vermicompost application (Table 3). The mean ash values obtained from biofertilizer applications ranged between 3.71–3.83% in the first year, 3.59–3.70% in the second year, and 3.67–3.73% in the combined averages. The lowest values were obtained from the control plots without microbial inoculation in the first year, and from *Bacillus* inoculation in the second year and in the combined analysis. The highest values were recorded under *Rhizobium* inoculation in the first year and in the combined analysis, while in the second year the highest values were observed in the control plots (Table 3). The effects of vermicompost and biofertilizers on ash content were found to be statistically significant. In particular, the 5000 kg ha⁻¹ vermicompost application increased ash content, which can be explained by the contribution of mineral fractions from

vermicompost. The increase in ash content under *Rhizobium* inoculation is consistent with the enhanced demand for phosphorus and potassium associated with nitrogen fixation, which strengthens mineral translocation. Similar findings have been reported in the literature. Sarımurat et al. (2022) reported that ash content in chickpea ranged between 3.83–6.00%. Ceritoğlu et al. (2018) indicated that vermicompost could increase ash content in plant tissues through its mineral fraction contribution. Kılıç (2024) noted that vermicompost and biofertilizer applications enhanced nutrient accumulation in strawberry roots and shoots, which was reflected in mineral contents. Dayar (2019) emphasized that vermicompost contributes to agricultural quality through mineral enrichment. In this context, the ash content results obtained in the present study confirm the complementary effects of organic and microbial inputs on mineral nutrition in chickpea seeds.

Table 4. Mean moisture content (%) of İnci and Hasanbey chickpea varieties under different biofertilizers and vermicompost doses

			Biofertilizers / Vermicompost levels (kg ha ⁻¹)												
			Control				<i>Rhizobium</i>				<i>Bacillus</i>				
Traits	Year	Variety	0	2500	5000	7500	0	2500	5000	7500	0	2500	5000	7500	
Moisture content	2018	İnci	8.98 ^g	9.06 ^d	8.89 ^j	8.81 ^m	9.04 ^e	8.83 ^l	8.96 ^h	9.11 ^b	8.99 ^g	8.86 ^k	8.79 ^{mm}	9.20 ^a	
		Hasanbey	9.09 ^c	9.12 ^b	8.93 ⁱ	8.78 ⁿ	8.76 ^o	8.72 ^p	8.61 ^q	8.75 ^o	8.94 ^{hi}	9.01 ^f	8.88 ^j	8.83 ^l	
	2019	İnci	8.49 ^c	9.04 ^{abc}	9.50 ^a	9.09 ^{abc}	8.65 ^{bc}	9.23 ^{abc}	8.75 ^{abc}	9.15 ^{abc}	9.16 ^{abc}	9.17 ^{abc}	9.15 ^{abc}	9.19 ^{abc}	
		Hasanbey	9.31 ^{ab}	9.14 ^{abc}	9.01 ^{abc}	9.30 ^{ab}	9.08 ^{abc}	9.46 ^a	9.30 ^{ab}	9.31 ^{ab}	9.41 ^{ab}	9.15 ^{abc}	9.32 ^{ab}	9.29 ^{ab}	
	2018-19	İnci	8.74 ^b	9.06 ^{ab}	9.20 ^a	8.95 ^{ab}	8.85 ^{ab}	9.03 ^{ab}	8.85 ^{ab}	9.13 ^a	9.07 ^{ab}	9.02 ^{ab}	8.97 ^{ab}	9.19 ^a	
		Hasanbey	9.20 ^a	9.13 ^a	8.97 ^{ab}	9.04 ^{ab}	8.92 ^{ab}	9.09 ^{ab}	8.95 ^{ab}	9.03 ^{ab}	9.18 ^a	9.08 ^{ab}	9.10 ^{ab}	9.06 ^{ab}	
				2018				2019				2018-19			
	General mean	Variety		8.96 ^A	8.86 ^B			9.04 ^A	9.25 ^A			9.00 ^A	9.06 ^A		
Vermicompost		8.96 ^A	8.93 ^B	8.84 ^D	8.91 ^C	9.01 ^A	9.20 ^A	9.17 ^A	9.22 ^A	8.99 ^A	9.07 ^A	9.01 ^A	9.06 ^A		
Biofertilizers		8.95 ^A	8.84 ^C	8.93 ^B		9.11 ^A	9.11 ^A	9.22 ^A		9.03 ^{AB}	8.98 ^B	9.08 ^A			

*Values followed by the same letter are not significantly different according to Tukey's test at the 5% level

**Vermicompost dose (kg ha⁻¹) within each biofertilizer treatment

3.3. Moisture content

When the variance analysis table for moisture content (Table 1) was examined, in the first year, the effects of variety, biofertilizer, vermicompost applications, and their interactions were all found to be

highly significant at the 1% level. In 2019 and in the combined two-year analysis, the interactions of variety × vermicompost, biofertilizer × vermicompost, and variety × biofertilizer × vermicompost were significant at the 5% level, while year was

highly significant at the 1% level in the combined analysis. The mean moisture content values of the two chickpea varieties under four different vermicompost doses and biofertilizer applications, together with the groupings formed according to Tukey's test, are presented in Table 4. In the years of the study and in the combined two-year averages, the mean moisture contents of the İnci and Hasanbey chickpea varieties were found to be 8.96–8.86% in the first year, 9.04–9.25% in the second year, and 9.00–9.06% in the combined analysis. In the first year, higher values were obtained from the İnci variety, whereas in the second year and in the combined averages, no significant differences were observed between the varieties (Table 4). The general mean moisture values obtained from vermicompost applications ranged between 8.84–8.96% in 2018, 9.01–9.22% in 2019, and 8.99–9.06% in the combined two-year averages. In the first year, the lowest value was recorded under 5000 kg ha⁻¹ vermicompost application, while the highest value was obtained from the control plots (0 kg ha⁻¹). In the second year, the highest value was observed under 7500 kg ha⁻¹ vermicompost application, although no statistically significant differences were found among vermicompost treatments. In the combined analysis, the highest value was obtained from 2500 kg ha⁻¹ vermicompost application, with no significant differences among treatments (Table 4). The mean moisture values obtained from biofertilizer applications ranged between 8.84–8.95% in the first year, 9.11–9.22% in the second year, and 8.98–9.08% in the combined averages. The lowest values were obtained under *Rhizobium* inoculation, while in the second year no statistically significant differences were observed among biofertilizer treatments. The highest values were recorded from the control plots in the first

year, and from *Bacillus* inoculation in the second year and in the combined analysis (Table 4). The results of the study indicate that vermicompost and biofertilizer applications had limited but statistically significant effects on moisture content. Year and interaction factors were particularly decisive in determining moisture levels. The higher moisture values observed in the 0 kg ha⁻¹ vermicompost treatment may be associated with delayed maturity under low nutrient conditions. Similar findings have been reported in previous studies. Hernandez and Hill (1983) stated that bacterial inoculation had no marked effect on moisture content, while Aldemir (2019) reported that different fertilizer applications had only limited influence. Variations in moisture content have been emphasized as being dependent on environmental conditions in other studies (Cathrine et al., 2025). In this context, the moisture content values obtained in the present study can be explained by environmental conditions and the combinations of treatments applied.

3.4. Starch content

When the variance analysis table for starch content (Table 1) was examined, in the first year, the effects of variety, biofertilizer, vermicompost applications, and their interactions were all found to be highly significant at the 1% level. In the second year and in the combined two-year analysis, biofertilizer and vermicompost applications, together with their interactions, were highly significant at the 1% level. In the combined analysis, year was also found to be highly significant at the 1% level. The mean starch content values of the two chickpea varieties under four different vermicompost doses and biofertilizer applications, together with the groupings formed according to Tukey's test, are presented in Table 5.

Table 5. Mean starch content (%) of İnci and Hasanbey chickpea varieties under different biofertilizers and vermicompost doses

			Biofertilizers / Vermicompost levels (kg ha ⁻¹)												
Traits	Year	Variety	Control				<i>Rhizobium</i>				<i>Bacillus</i>				
			0	2500	5000	7500	0	2500	5000	7500	0	2500	5000	7500	
Starch content	2018	İnci	57.67 ^c	58.59 ^a	56.38 ^k	54.32 ^r	57.44 ^f	53.31 ^u	54.51 ^u	52.62 ^v	57.87 ^c	57.17 ^h	56.37 ^k	57.94 ^b	
		Hasanbey	55.28 ^m	57.18 ^h	55.23 ⁿ	54.54 ^p	56.78 ^h	56.46 ^j	56.00 ^l	57.77 ^d	54.28 ^s	56.49 ^j	53.96 ⁱ	55.02 ^o	
	2019	İnci	52.92 ^{e-j}	53.16 ^{d-h}	54.18 ^{bc}	53.43 ^{c-f}	52.76 ^{g-k}	53.06 ^{c-i}	53.94 ^{cd}	53.45 ^{c-f}	52.25 ^{klj}	53.24 ^{d-g}	51.34 ^m	52.48 ^{g-k}	
		Hasanbey	52.37 ^{h-l}	51.98 ^{klm}	52.39 ^{h-l}	54.88 ^b	52.30 ^{j-l}	51.66 ^{lm}	54.94 ^b	55.87 ^a	52.16 ^{klj}	53.68 ^{cde}	53.58 ^{cde}	53.11 ^{e-h}	
	2018-19	İnci	55.30 ^{cd}	55.87 ^b	55.28 ^{cd}	53.87 ^h	55.10 ^{cd}	53.19 ^j	54.23 ^{gh}	53.04 ^j	55.06 ^{de}	55.21 ^{cd}	53.85 ^{hi}	55.21 ^{cd}	
		Hasanbey	53.83 ⁱ	54.58 ^{fg}	53.81 ⁱ	54.71 ^{ef}	54.54 ^{fg}	54.06 ^{hi}	55.47 ^c	56.82 ^a	53.2 ^j	55.09 ^{de}	53.77 ⁱ	54.07 ^{hi}	
				2018				2019				2018-19			
	General mean	Variety		56.18 ^A	55.74 ^B			53.01 ^A	53.24 ^A			54.60 ^A	54.49 ^B		
Vermicompost		56.55 ^A	56.52 ^B	55.40 ^C	55.36 ^D	52.46 ^D	52.79 ^C	53.39 ^B	53.87 ^A	54.50 ^B	54.66 ^A	54.39 ^B	54.62 ^A		
Biofertilizers		56.14 ^A	55.61 ^C	56.12 ^B		53.16 ^B	53.49 ^A	52.73 ^C		54.65 ^A	54.55 ^B	54.43 ^C			

*Values followed by the same letter are not significantly different according to Tukey's test at the 5% level

**Vermicompost dose (kg ha⁻¹) within each biofertilizer treatment

In the years of the study and in the combined two-year averages, the mean starch contents of the İnci and Hasanbey chickpea varieties were found to be 56.18–55.74% in the first year, 53.1–53.24% in the second year, and 54.60–54.49% in the combined analysis. Higher values were obtained from the İnci variety in the first year and in the combined averages, whereas in the second-year higher values were recorded in Hasanbey. However, no statistically significant differences were observed between the varieties (Table 5). The general mean starch values obtained from vermicompost applications ranged between 55.36–56.55% in 2018, 52.46–53.87% in 2019, and 54.39–54.66% in the combined two-year averages. In the first year, the lowest value was recorded under 7500 kg ha⁻¹ vermicompost application, while the highest value was obtained from the control plots (0 kg ha⁻¹). In the second year, the lowest value was observed in the control plots, whereas the highest value was obtained under 7500 kg ha⁻¹ vermicompost application. In the combined analysis, the lowest value was recorded under 5000 kg ha⁻¹ vermicompost application, which was grouped together with the control treatment, while the highest value was obtained under 2500 kg ha⁻¹ vermicompost application, with no statistical differences compared to

7500 kg ha⁻¹ (Table 5). The mean starch values obtained from biofertilizer applications ranged between 55.61–56.14% in the first year, 52.73–53.49% in the second year, and 54.43–54.65% in the combined averages. The lowest values were obtained from *Rhizobium* inoculation in the first year, and from *Bacillus* inoculation in the second year and in the combined analysis. The highest values were recorded in the control plots in the first year and in the combined analysis, while in the second year the highest values were obtained under *Bacillus* inoculation (Table 5). The effects of vermicompost and biofertilizer applications on starch content varied across years. In the first year, the highest starch values were obtained under 0 kg ha⁻¹ vermicompost application, whereas in the second year 7500 kg ha⁻¹ application was superior. This outcome reflects the influence of carbon–nitrogen balance and environmental conditions on starch synthesis. Similar findings have been reported in previous studies. Mohammadi et al. (2010) and Yadav et al. (2025) indicated that organic fertilizers enhance carbon allocation and thereby support starch accumulation. Karasu and Vural (2006) reported that starch content in chickpea varied depending on genotype and environmental conditions under different

fertilization practices. Faroda et al. (2025) noted that *Bacillus* inoculation influences carbon metabolism, thereby altering starch accumulation. These results are consistent with the year–dose interactions observed in the present study.

3.5. Cellulose content

When the variance analysis table for cellulose content was examined, in all years, the effects of variety, biofertilizer, and vermicompost applications, together with the interactions of variety ×

biofertilizer, variety × vermicompost, biofertilizer × vermicompost, and variety × biofertilizer × vermicompost, were all found to be highly significant at the 1% level. In the combined two-year analysis, year was also highly significant at the 1% level (Table 1). The mean cellulose content values of the two chickpea varieties under four different vermicompost doses and biofertilizer applications, together with the groupings formed according to Tukey's test, are presented in Table 6.

Table 6. Mean cellulose content (%) of İnci and Hasanbey chickpea varieties under different biofertilizers and vermicompost doses

Traits	Year	Variety	Biofertilizers / Vermicompost levels (kg ha ⁻¹)											
			Control				<i>Rhizobium</i>				<i>Bacillus</i>			
			0	2500	5000	7500	0	2500	5000	7500	0	2500	5000	7500
Cellulose content	2018	İnci	7.50 ^f	7.49 ^{fg}	7.33 ^{hm}	7.50 ^f	7.61 ^d	8.04 ^a	7.51 ^f	7.56 ^e	7.25 ^k	7.37 ^h	7.19 ^l	7.02 ^m
		Hasanbey	7.60 ^d	7.25 ^{jk}	7.19 ^l	6.86 ⁿ	7.19 ^l	7.46 ^g	7.29 ^{ij}	7.51	7.46 ^g	7.78 ^b	7.73 ^c	7.47 ^{fg}
	2019	İnci	7.42 ^b	6.98 ^{fgh}	6.92 ^{hi}	7.07 ^e	7.57 ^a	6.85 ^j	7.07 ^e	6.85 ^j	7.25 ^d	6.85 ^j	7.07 ^e	6.61 ^l
		Hasanbey	6.99 ^{fg}	6.92 ^{gh}	6.87 ^{ij}	6.77 ^k	7.00 ^f	6.82 ^{jk}	6.87 ^{ij}	6.82 ^{jk}	7.35 ^c	6.92 ^{gh}	6.93 ^{gh}	7.45 ^b
	2018-19	İnci	7.46 ^b	7.23 ^{gh}	7.12 ^{ikl}	7.29 ^f	7.59 ^a	7.45 ^b	7.29 ^f	7.20 ^h	7.25 ^g	7.11 ^{j-m}	7.13 ^{jk}	6.81 ^o
		Hasanbey	7.29 ^{ef}	7.09 ^{lm}	7.03 ⁿ	6.81 ^o	7.10 ^{klm}	7.14 ^{ij}	7.08 ^m	7.17 ⁱ	7.40 ^c	7.35 ^d	7.33 ^{de}	7.46 ^b
			2018				2019				2018-19			
			Variety	7.44 ^A	7.40 ^B		7.04 ^A	6.97 ^B		7.24 ^A	7.18 ^B			
General mean			Vermicompost	7.43 ^B	7.56 ^A	7.37 ^C	7.32 ^D	7.43 ^B	7.56 ^A	7.37 ^C	7.32 ^D	7.34 ^A	7.22 ^B	7.16 ^C
			Biofertilizers	7.34 ^C	7.52 ^A	7.40 ^B		7.34 ^C	7.52 ^A	7.40 ^B		7.16 ^C	7.25 ^A	7.23 ^B

*Values followed by the same letter are not significantly different according to Tukey's test at the 5% level

**Vermicompost dose (kg ha⁻¹) within each biofertilizer treatment

In the years of the study and in the combined two-year averages, the mean cellulose contents of the İnci and Hasanbey chickpea varieties were found to be 7.44–7.40% in the first year, 7.04–6.97% in the second year, and 7.24–7.18% in the combined analysis. In all years of the study, the highest values were obtained from the İnci variety (Table 6). The general mean cellulose values obtained from vermicompost applications ranged between 7.32–7.56% in 2018, 6.89–7.26% in 2019, and 7.12–7.34% in the combined two-year averages. In the first year, the lowest value was recorded under 7500 kg ha⁻¹ vermicompost application, while the highest value was obtained under 2500 kg ha⁻¹ application. In the second year, the

lowest value was observed under 2500 kg ha⁻¹ application, whereas the highest value was obtained from the control plots (0 kg ha⁻¹). In the combined analysis, the lowest value was recorded under 7500 kg ha⁻¹ vermicompost application, while the highest value was obtained from the control plots (Table 6). The mean cellulose values obtained from biofertilizer applications ranged between 7.34–7.52% in the first year, 6.98–7.05% in the second year, and 7.16–7.25% in the combined averages. The lowest values were obtained from the control plots, while in the second year no statistically significant differences were observed between the control and *Rhizobium* inoculation. The highest values were recorded under *Rhizobium* inoculation

in the first year and in the combined analysis, whereas in the second year the highest values were obtained under *Bacillus* inoculation (Table 6). Cellulose content was significantly affected by variety, biofertilizer, vermicompost applications, and their interactions in all years. The increase in cellulose values under *Rhizobium* inoculation can be explained by the contribution of nitrogen fixation to cell wall synthesis. The higher cellulose values observed in the 0 kg ha⁻¹ vermicompost treatment may be interpreted as a relative compositional effect resulting from lower protein and starch contents. Elkoca et al. (2008) reported that *Rhizobium* inoculation increased cell wall components in chickpea. Similarly, organic fertilizers have been shown to support cellulose synthesis in different legume studies. These findings are

consistent with the results obtained in the present study.

3.6. Oil content

When the variance analysis table for oil content was examined, in all years, the effects of variety, biofertilizer, and vermicompost applications, together with the interactions of variety × biofertilizer, variety × vermicompost, biofertilizer × vermicompost, and variety × biofertilizer × vermicompost, were all found to be highly significant at the 1% level. In the combined two-year analysis, year was also highly significant at the 1% level (Table 1). The mean oil content values of the two chickpea varieties under four different vermicompost doses and biofertilizer applications, together with the groupings formed according to Tukey's test, are presented in Table 7.

Table 7. Mean oil content (%) of İnci and Hasanbey chickpea varieties under different biofertilizers and vermicompost doses

Traits	Year	Variety	Biofertilizers / Vermicompost levels (kg ha ⁻¹)											
			Control				<i>Rhizobium</i>				<i>Bacillus</i>			
			0	2500	5000	7500	0	2500	5000	7500	0	2500	5000	7500
Oil content	2018	İnci	7.49 ^d	7.26 ^{mn}	7.07 ^p	7.42 ^s	7.43 ^{fg}	7.33 ^k	7.67 ^a	7.47 ^e	7.37 ^j	7.43 ^{fg}	7.29 ^j	7.33 ^k
		Hasanbey	7.45 ^{ef}	7.41 ^{gh}	7.39 ^{hu}	7.32 ^k	7.61 ^b	7.37 ^{ij}	7.51 ^d	7.55 ^c	7.39 ^{hi}	7.21 ^o	7.28 ^{lm}	7.24 ⁿ
	2019	İnci	7.17 ^a	6.87 ^{bcd}	6.76 ^{gh}	6.64 ^{kl}	6.86 ^{cd}	6.84 ^{cde}	7.13 ^a	6.77 ^{e-h}	6.81 ^{d-g}	6.63 ^{klm}	6.63 ^{klm}	6.89 ^{bc}
		Hasanbey	6.57 ^{lm}	6.48 ⁿ	6.56 ^m	6.73 ^{hij}	6.67 ^{ijk}	6.74 ^{ghu}	6.84 ^{c-f}	6.79 ^{d-h}	6.67 ^{ijk}	6.65 ^{jk}	6.63 ^{klm}	6.94 ^b
	2018-19	İnci	7.33 ^b	7.06 ^{fg}	6.91 ^m	7.03 ^{ghu}	7.14 ^{cd}	7.09 ^{ef}	7.40 ^a	7.12 ^{de}	7.09 ^{ef}	7.03 ^{ghu}	6.96 ^{k-l}	7.11 ^{de}
		Hasanbey	7.01 ^{ij}	6.95 ^{klm}	6.98 ^{jk}	7.03 ^{hu}	7.14 ^{cd}	7.06 ^{figh}	7.17 ^c	7.17 ^c	7.03 ^{ghu}	6.93 ^{lm}	6.95 ^{klm}	7.09 ^{ef}
			2018				2019				2018-19			
			Variety	7.38 ^A	7.39 ^B		6.83 ^A	6.69 ^B		7.10 ^A	7.04 ^B			
General mean			Vermicompost	7.45 ^A	7.33 ^D	7.36 ^C	7.39 ^B	6.79 ^A	6.70 ^C	6.77 ^B	6.79 ^A	7.12 ^A	7.02 ^D	7.06 ^C
			Biofertilizers	7.35 ^B	7.49 ^A	7.32 ^C		6.72 ^B	6.83 ^A	6.73 ^B		7.03 ^B	7.16 ^A	7.02 ^C

*Values followed by the same letter are not significantly different according to Tukey's test at the 5% level

**Vermicompost dose (kg ha⁻¹) within each biofertilizer treatment

In the years of the study and in the combined two-year averages, the mean oil contents of the İnci and Hasanbey chickpea varieties were found to be 7.38–7.39% in the first year, 6.83–6.69% in the second year, and 7.10–7.04% in the combined analysis. In all years of the study, the highest values were obtained from the İnci variety (Table 7). The general mean oil values obtained from vermicompost

applications ranged between 7.33–7.45% in 2018, 6.70–6.79% in 2019, and 7.02–7.12% in the combined two-year averages. In the first year, the lowest value was recorded under 2500 kg ha⁻¹ vermicompost application, while the highest value was obtained from the control plots (0 kg ha⁻¹). In the second year, the lowest value was observed under 2500 kg ha⁻¹ application, whereas the highest values were obtained

under both 7500 kg ha⁻¹ and 0 kg ha⁻¹ applications. In the combined analysis, the lowest value was recorded under 2500 kg ha⁻¹ vermicompost application, while the highest value was obtained from the control plots (Table 7). The mean oil values obtained from biofertilizer applications ranged between 7.32–7.49% in the first year, 6.72–6.83% in the second year, and 7.02–7.16% in the combined averages. The lowest values were obtained from *Bacillus* inoculation in the first year and in the combined analysis, and from the control plots in the second year, with no statistically significant differences between the control and *Bacillus* treatments. The highest values were consistently recorded under *Rhizobium* inoculation in all years (Table 7). The effects of vermicompost and biofertilizer applications on oil content were found to be significant in all years. *Rhizobium* inoculation consistently provided the highest oil values, which can be explained by the contribution of nitrogen availability to fatty acid biosynthesis. Vermicompost applications, however, showed dose-dependent variability across years. Similar findings have been reported in the literature. Elkoca et al. (2008) indicated that *Rhizobium* inoculation increased oil content in chickpea. Altinkaynak (2019) reported that organic fertilizer applications had limited but positive effects on oil content. In line with these findings, the oil content results obtained in the present study are consistent with the literature. Zorawar and Guriqbal (2018) summarized the positive effects of *Rhizobium* inoculation on growth and quality parameters in chickpea. Our finding that *Rhizobium* inoculation increased oil content is further supported by the similar results reported by Yadav et al. (2025).

4. Conclusion

In this study, the effects of different doses of vermicompost and biofertilizers (*Rhizobium* and *Bacillus*) on quality

parameters (protein, ash, moisture, starch, cellulose, and oil contents) of İnci and Hasanbey chickpea varieties were investigated. The results of the two-year experiment demonstrated that both organic and biofertilizers had significant effects on seed quality traits. Protein content increased markedly under *Rhizobium* inoculation, which can be explained by symbiotic nitrogen fixation. *Bacillus* inoculation contributed to protein synthesis in the first year by enhancing root development and nutrient uptake (Elkoca et al., 2008; Yadav et al., 2025). Ash content was elevated by the mineral fraction contribution of vermicompost, while *Rhizobium* inoculation enhanced mineral translocation, thereby increasing ash levels (Ceritoğlu et al., 2018; Kılıç, 2024). Moisture and starch contents varied depending on year and environmental conditions, with organic fertilizers supporting starch accumulation through increased carbon allocation (Mohammadi et al., 2010; Karasu and Vural, 2006). Cellulose content was higher under *Rhizobium* inoculation, consistent with the contribution of nitrogen fixation to cell wall synthesis. Oil content reached its highest values under *Rhizobium* inoculation, in line with the role of nitrogen availability in fatty acid biosynthesis (Altinkaynak, 2019; Zorawar and Guriqbal, 2018). Overall, the combined use of vermicompost and biofertilizers exhibited a synergistic effect in improving chickpea quality parameters. These findings highlight the importance of organic and microbial inputs in sustainable agricultural practices and provide scientific support for strategies aimed at reducing chemical fertilizer use.

Declaration of Author Contributions

The authors declare that they have contributed equally to the article. All authors declare that they have seen/read and approved the final version of the article ready for publication.

Declaration of Conflicts of Interest

All authors declare that there is no conflict of interest related to this article.

Funding

This study received no financial support.

Ethical Committee Approval

This study did not involve human or animal subjects; therefore, ethical approval was not required.

Acknowledgment

This article was extracted from the Ph.D. thesis of the first author A. Dinç.

References

- Altıdemir, B., 2019. The effects of rose pulp, farmyard manure and inoculation on yield and some yield components in chickpea (*Cicer arietinum* L.) cultivation. Master's thesis, Isparta University of Applied Sciences, Graduate School of Education, Isparta.
- Altıncakaynak, C., 2019. The effects of bacterial inoculation, organic and inorganic fertilization on yield, quality and environment in chickpea under Fethiye conditions. Master's thesis, Muğla Sıtkı Koçman University, Institute of Science, Muğla.
- Anonymous, 2019. Records of the General Directorate of Meteorology, <https://mgm.gov.tr/>, (Accessed:10.09.2020).
- Cathrine C.J., Manuel I.R., Augustine R., 2025. Influence of microbial-enriched organic manures and nano-emulsion biofertilizers combined with inorganic nutrients on the growth, yield and economics of chickpea cultivation. *Indian Journal of Agricultural Research*, 59(9): 1448-1453.
- Ceritoğlu, M., Şahin, S., Erman, M., 2018. Effects of vermicompost on plant growth and soil structure. *Selçuk Journal of Agriculture and Food Sciences*, 32(3): 607-615.
- Dayar, N., 2019. Economic analysis of vermicompost production in Türkiye. Master's thesis, Bursa Uludağ University, Institute of Science, Bursa.
- Doğan, S., 2019. The effects of chemical, organic and microbial fertilization on yield and yield traits in chickpea (*Cicer arietinum* L.). PhD thesis, Siirt University, Institute of Science, Siirt.
- Doğan, S., Çığ F., 2023. Effects of chemical, organic and microbial fertilization on agronomical growth parameters, seed yield and chemical composition of chickpea. *Journal of Elementology*, 28(4): 949-970.
- Elkoca, E., Kantar, F., Şahin, F., 2008. Influence of nitrogen fixing and phosphorus solubilizing bacteria on the nodulation, plant growth and yield of chickpea. *Journal of Plant Nutrition*, 31: 157-171.
- Faroda, M., Suman, B., Reetik, Aparna, 2025. Effect of NPK and vermicompost on growth characteristics and yield of chickpea (*Cicer arietinum* L.). *International Journal of Research in Agronomy*, 8(9): 271-273.
- Hernandez, L.G., Hill, G.D., 1983. Effect of plant population and inoculation on yield and yield components of chickpea (*Cicer arietinum* L.) proceedings. *Agronomy Society of New Zealand*, 13: 75-79.
- Karasu, A., Vural, H., 2006. A quantitative approach to the adaptation of some chickpea (*Cicer arietinum* L.) genotypes under Isparta conditions. *Journal of Agriculture Faculty of Uludağ University*, 20(2): 9-13.

- Kılıç, N., 2024. The effects of vermicompost and biofertilizer applications on nutrient element content of root and stem in strawberry plant. *Harran Journal of Agricultural and Food Sciences*, 28(2), 357-373.
- Mohammadi K., Ghalvand A., Aghaalkhani M., 2010. Effect of organic matter and biofertilizers on chickpea quality and biological nitrogen fixation. *World Academy of Science, Engineering and Technology*, 68: 1144-1149.
- Oyege, I., Bhaskar, M.S.B, 2023. Effects of vermicompost on soil and plant health and promoting sustainable agriculture. *Soil Systems*, 7(4): 101.
- Sarımurat, M.Ş., Kulaz, H., Erdin, F., 2022. Determination of yield and quality characteristics of some chickpea (*Cicer arietinum* L.) varieties cultivated in Van ecological conditions. *MAS Journal of Applied Sciences*, 7(1): 128–138.
- Torun Kayabaşı, E., Yılmaz, O., 2021. The Importance of vermicompost in agricultural production and economy. *Eurasian Journal of Agricultural Research*, 5(2): 146-159.
- Yadav, A., Mishra, B.K., Nath, A., Yadav, D., Singh, K., 2025. Sustainable enhancement of chickpea productivity through integrated use of vermicompost, biofertilizers, and reduced fertilizer inputs in eastern Uttar Pradesh. *International Journal of Advanced Biochemistry Research*, 9(8): 07-11.
- Yılmaz, A., 2023. Vermicompost enhances saline tolerance in peanut (*Arachis hypogaea* L.). *Black Sea Journal of Agriculture*, 6(1): 1-7.
- Zırığ, B., 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.
- Zorawar, S., Guriqbal, S., 2018. Role of *Rhizobium* in chickpea (*Cicer arietinum* L.) production - A review. *Agricultural Reviews*. 39(1): 31-39.