

# Effect of chemical and organic fertilisation on yield and macro-micro content of Chickpea (*Cicer arietinum* L.) cultivars

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## Abstract

Due to its valuable nutritional content, chickpea is expected to become the most important crop for an increasing global population. Therefore, this research was conducted to investigate the effects of organic (vermicompost, farmyard manure, and chicken manure) and chemical (DAP and NPK+Zn) fertilisers on grain yield and nutrient content in two chickpea varieties (Arda and Botan) during the 2019-2020 growing season. The experiment was organised according to a randomised complete split block design with three replications. Results were expressed as mean values. The application of chicken manure significantly improved yield and yield components. The results showed that the Arda chickpea variety plot, where chicken manure was applied, had the highest yield (3272 kg ha<sup>-1</sup>), whereas the control plot of the Botan chickpea variety had the lowest yield (2302 kg ha<sup>-1</sup>). The application of organic fertilizers resulted in significant increases in plant height, 100-grain weight, grain yield, harvest index, and protein ratio. Additionally, there was a significant increase in the concentration of Mg, Na, Zn, Cu, K, and Ca in the grains. Thus, it was concluded that organic fertilizer can be used as a suitable alternative to chemical fertiliser in chickpea cultivation in order to create a sustainable agricultural system, increase productivity, and maintain and improve soil properties. In our country, where fertilizer resources are limited, organic applications to widely cultivated plants such as chickpeas would be extremely beneficial for the economy, environment, and soil structure.

**Keywords:** Chemical fertilizer, Organic fertilizer, Chickpea, Yield, Macro-micro nutrient

## INTRODUCTION

Legumes, containing over which contain more than 20% protein in their dry seeds and exhibit a digestibility of 32-78%, play a vital role have a place in human diets and are an important source of animal feed. An adult human needs to consume 8 amino acids (isoleucine, lysine, leucine, methionine, phenylalanine, threonine, tryptophan, and valine) in sufficient quantities daily. Edible grain legumes are important in human nutrition as they contain essential amino acids that cannot be stored in the body and protein content ranges between 18-32% of their protein content. Additionally, they are rich in vitamins A, B, C, and D (Geçit, 1995). Chickpeas, one of the first cultivated plants among edible legumes, originate from the gene centre in India, Indonesia, and the Eastern Mediterranean, including Turkey (Akçin, 1988; Soysal, 2020).

The use of chemical fertilisers has had a negative impact on the natural balance of the soil, environmental pollution, and groundwater resources. In our country, there is generally no conscious practice in the use of commercial fertilisers. In agricultural areas where chemical fertilisers are used intensively, it is believed that increasing the amount of fertiliser will lead to a corresponding increase in crop production (Güçdemir, 2004). Therefore, increasing agricultural yield has been associated with the use of chemical fertilisers. Due to incorrect practices, environmental problems have emerged, including the accumulation of heavy metals in the soil, increased salinisation, decreased microorganism density, nutrient imbalances, groundwater pollution, and the release of nitrogen and sulphur-containing gases that cause air pollution (Sönmez et al., 2008). As society becomes more aware of the issue, people's eating habits and product preferences are changing towards sustainable agricultural products. It is important to note that this shift in demand is a result of increased awareness. These products are produced using methods that do not disrupt natural balances and do not leave toxic residues in the human body. The market share of products grown using organic and good agricultural practices has gradually increased worldwide in line with these demands.

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The growing conditions and methods used for producing healthy products have varied accordingly. Chickpeas, which are rich in protein, vitamins, and minerals, are an important source of edible grain legumes for both human and animal nutrition, promoting sustainable agriculture. Research into enhancing the yield and quality of organic matter applications in chickpea cultivation is ongoing. To ensure sustainable agricultural production, it is crucial to utilise natural resources in an environmentally friendly manner, as they are finite. To achieve this goal, it is important to balance high crop yields with maintaining soil fertility and sustainability. Therefore, it is crucial to protect the soil's sustainable properties while aiming for high crop production. This study highlights the significance of organic fertilisation and edible grain legumes in agricultural production.

The main function of organic fertilizers is to preserve soil biodiversity and soil aggregate stability (Gleń-Karolczyk et al. 2018). Farmyard manure (FYM) is a valuable substitute for mineral fertilizers, as it has a beneficial impact on the physical, chemical, and biological structure of the soil. It is crucial for increasing the amount of organic matter in the soil. Organic amendments can enhance soil pH and water-holding capacity by improving microbial activity, increasing aeration, and altering chemical composition. This promotes nutrient uptake by plant roots (Ceritoglu et al. 2018, Bice Ataklı et al. 2022). Chicken manure is a rich source of macro and micronutrients, making it an excellent fertilizer for plant growth. However, excessive application of various salts can lead to their accumulation in the soil, which can have a toxic effect on the plants that are grown (Shapovalov et al., 2020). Vermicompost is a type of organic fertilizer that is produced from the excrement of earthworms. It is rich in nutrients and does not contain any chemical compounds that can harm living organisms, weed seeds, or toxic elements (Şahin & Ceritoglu, 2020; Gudeta et al., 2022). Vermicompost is an organic fertiliser that improves and develops soil without disrupting its natural chemistry, making it ideal for sustainable agriculture. Its organic substances positively affect the soil's natural balance and provide valuable plant nutrients. This makes it a great option for areas where organic products are grown (Demir et al., 2010). Plant nutrition and fertilisation activities in agricultural production should aim not only for high yields but also for the production of healthy products that protect human health, while using environmentally friendly practices (Karaçal and Tüfenkçi, 2010).

The objective of this study was to investigate the impact of chemical and organic fertilisation on the yield of chickpeas, which are an important edible grain legume. The aim is to reduce the use of chemical inputs in agricultural production, popularise the use of organic fertilisers, protect soil structure with environmentally friendly practices, prevent pollution of underground water resources, encourage sustainable agriculture, and produce healthy and quality products for people.

## **MATERIALS AND METHODS**

### **Experimental materials**

The field experiment was conducted during the 2019-2020 winter chickpea growing season at the trial fields of the GAP International Agricultural Research and Training Centre. The study utilized seeds of two registered chickpea varieties, Arda and Botan. Three different organic fertilizers (vermicompost, farmyard manure, and chicken manure) and two inorganic fertilizers (NPK 13-25-5+10SO<sub>3</sub>+Zn and DAP 18-46) were applied.

### **Characteristics of chickpea varieties and fertilisers used in the research**

**Arda Variety:** Suitable for winter sowing in Southeastern Anatolia and Coastal regions, plant height 64-85 cm, first pod height 33-37 cm, upright growing, medium early, tolerant to drought, cold, and blight (*Ascochyta* blight). Under favorable climatic conditions in the region, the average yield is approximately 2500 kg ha<sup>-1</sup>, and the yield potential can reach up to 3500 kg ha<sup>-1</sup> (Anonymous, 2021). **Botan Variety:** The plant is upright and grows to a height of 35-65 cm. It is suitable for both summer and winter sowing in Southeastern Anatolia and Coastal regions. The first pod height is 12-30 cm and it is an early, drought-, and cold-tolerant variety. It is moderately susceptible to blight (*Ascochyta* blight). Under favorable climatic conditions in the region, the average yield is approximately 2770 kg ha<sup>-1</sup>, and the yield potential can reach up to 3730 kg ha<sup>-1</sup> (Anonymous, 2021).

### **Organic and inorganic fertiliser sources used in practice**

**Vermicompost:** Vermicompost is 100% organic material produced by California culture worms (*Eisenia foetida*). Worms consume nutrients and pass them through their digestive system, resulting in excretion through feces. The resulting material had a pH of 8.14 and contains 39.68% organic matter, 1-2.1% total nitrogen, 1.5-3% total potassium (% K<sub>2</sub>O), and 2-2.74% total phosphorus (% P<sub>2</sub>O<sub>5</sub>).

**Chicken manure:** pH 5.2-7.2, 55% organic matter, 3% total nitrogen, 3% phosphorus and 1.5% potassium.

**Farm fertilizer:** pH 8.2, 68.6% organic matter, 1% total nitrogen and 0.6% phosphorus.

**DAP (Diammonium Phosphate) fertiliser:** 18% nitrogen (N) and 46% phosphorus (P<sub>2</sub>O<sub>5</sub>). **NPK 13-25-5+(10SO<sub>3</sub>)+Zn (Super crop fertiliser):** 13% nitrogen (N), 25% phosphorus (P<sub>2</sub>O<sub>5</sub>), 5% potassium (K<sub>2</sub>O), 10% sulphur (SO<sub>3</sub>), 0.5% zinc (Zn).

### **Location of the research site**

The research site was located in the province of Diyarbakır, which is bordered by Mardin to the south, Siirt and Muş to the east, Şanlıurfa, Adıyaman, and Malatya to the west, and Elazığ and Bingöl to the north. Diyarbakır is situated at the northern end of Mesopotamia and in the central part of the Southeastern Anatolia Region. Its area is 1516200,00 km<sup>2</sup> and it is located

in the region between “37,905199” and “40,231934” north latitudes and 40.37 and 41.20 east longitudes. The province has an elevation of 660 metres above sea level. It features fertile plains that are suitable for agriculture, surrounded by relatively low mountains.



**Figure 1.** Location of the area where the experiment was conducted



**Figure 2.** The area where the experiment was conducted

#### Climatic characteristics of the research site.

The province of Diyarbakir, where the experiments will be carried out, has a continental climate with hot and dry summers, and experiences four distinct seasons. Precipitation is irregular, with some months (June to October) receiving almost no rainfall, while autumn and spring periods experience intense precipitation. Overall, precipitation patterns are not consistent across months.

#### Soil properties of the research area.

Area were analysed by taking soil samples from a depth of 0-30 cm in the experimental area and sending them to the soil analysis laboratory of GAP International Agricultural Research and Training Centre. The results of the analyses are presented in Table 2.

**Table 1.** Some physical and chemical properties of the soils of the research area

| Depth                                                                 | Sand  | Silt | Clay  | Texture            | pH   | Lime                   | Phosphorus              | Potassium | Organic matter |       |
|-----------------------------------------------------------------------|-------|------|-------|--------------------|------|------------------------|-------------------------|-----------|----------------|-------|
| (cm)                                                                  | (%)   | (%)  | (%)   | Class(1:2.5 water) | (%)  | (kg ha <sup>-1</sup> ) | ((kg ha <sup>-1</sup> ) | Item(%)   | Salt (%)       |       |
| 0-30                                                                  | 31.12 | 21.6 | 47.28 | Clay               | 8.06 | 9.90                   | 7.4                     | 641.3     | 0.96           | 0.027 |
| (alkaline) (middle) (very little) (adequate) (very little) (unsalted) |       |      |       |                    |      |                        |                         |           |                |       |

According to the results of soil analyses carried out on soil samples taken at a depth of 0-30 cm from the area where the research was carried out, the soils where the experiment was established were found to be moderately calcareous, salt-free, alkaline reaction, very low in organic matter, sufficient in potassium and very low in phosphorus.

**Table2.** Some climate data for 2019, 2020 and the long-term average (LTA) for the plant growing period in Diyarbakır province (MGT, 2022)

| Months         | Precipitation (mm) |            | Average temperature (°C) |              |
|----------------|--------------------|------------|--------------------------|--------------|
|                | 2019-2020          | UYO**      | 2019-2020                | UYO          |
| September      | 8.7                | 8.4        | 25.2                     | 25.0         |
| October        | 52                 | 37.3       | 19.1                     | 17.8         |
| November       | 9                  | 54.3       | 9.7                      | 9.3          |
| December       | 185.4              | 75.2       | 6.8                      | 3.8          |
| January        | 89.4               | 63.6       | 3.6                      | 2.1          |
| February       | 58.6               | 66.8       | 3.7                      | 3.8          |
| March          | 164.8              | 67.5       | 10.6                     | 8.7          |
| April          | 110                | 63.1       | 13.5                     | 13.5         |
| May            | 63.2               | 50.0       | 19.3                     | 18.9         |
| June           | 0.6                | 10.8       | 26.2                     | 26.3         |
| <b>Total</b>   | <b>741.7</b>       | <b>497</b> |                          |              |
| <b>Average</b> |                    |            | <b>13.77</b>             | <b>13.85</b> |

## METHOD

The trials were designed as a split-plot experimental design with 3 replications. The main plots consisted of varieties, and the sub-plots consisted of fertiliser treatments.

### Organic and inorganic fertiliser treatments.

I. Treatment: control (no fertiliser applied)

II: Application vermicompost 2 t ha<sup>-1</sup>,

III. Application: farmyard manure 40 t ha<sup>-1</sup>,

IV. Application of chicken manure 2 t ha<sup>-1</sup>,

V. Application: NPK 13-25-5+(10SO<sub>3</sub>)+Zn fertiliser 240 kg ha<sup>-1</sup>,

VI. Application: DAP 18-46 fertiliser 140 kg ha<sup>-1</sup>,

The plots were formed with four rows, each 6 m in length, with a spacing of 30 cm between rows and 5 cm above rows. A space of 1 m was left between the plots and 2 m between the blocks. Sowing was carried out on 27th January 2020 with a trial harvester using 45 seeds per square metre. No insecticides or fungicides were applied to the seeds used in the experiment. During the harvest, measurements and weighings were conducted over a 3 square metre area. This area was determined by removing 0.5 m of side effects from one row on each side of the plots and from the heads of the plots. The harvesting process was completed on 8 July using a parcel combine harvester. In the research area, the first tillage was carried out with a plough to a depth of 25 cm after the wheat harvest. In autumn, when the soil was at the right level, a surface plough was used to prepare the seedbed for sowing. The fertilisers used in the study were applied to the soil at the prescribed rates before sowing, mixed into the soil with a tractor hoe and the seedbed prepared. Narrow-leaved weeds were sprayed when the plants were at the seedling stage. Broadleaved weeds were harvested by hand. Harvested plants were measured, counted and threshed in the laboratory and averaged. As the experiment was conducted under rainfall conditions, irrigation was not used.

### Laboratory analyses

Grain protein content: From the samples taken from each subplot, 0.250 g of the sample was ground and the % N content was determined by the micro-Kjeldahl method and the protein content was obtained by multiplying this figure by 6.25 (Kjeldahl 1883). Macro and micro elemental analyses were carried out at the MAU Central Research Laboratory. After the plants were harvested, the grain samples were weighed to approximately 0.25 g. Samples were digested in a microwave oven (Mars Xpress) using 8 mL of 65% and 2 mL of for 30 minutes. The resulting solution was diluted to 20 mL with ultrapure water and filtered through blue band filter paper (Hussaini et al., 2008). Macro and micro elemental analyses of these samples were then carried out using ICP-OES (ICP-20113107, England).

## Statistical analysis

The data obtained in the study were subjected to analysis of variance using the programme "JMP 5.0" statistical package according to the random block experimental design, and the "LSD (0.05) Multiple Comparison" test was used to compare the means.

## RESULTS AND DISCUSSION

Analysis of variance data of chickpea varieties are shown in Table 4 and mean data obtained from chickpea varieties are shown in Table 5.6.7.8

**Table 4.** The results of the variance analysis (mean of squares)

| Source | Variety    | Error 1 | Fertiliser | V*F Int.  | Error 2   | Total     | C.V(%) |
|--------|------------|---------|------------|-----------|-----------|-----------|--------|
| PH     | 273.3*     | 4.62    | 93.3**     | 5.97ns    | 2.37      | 379.6     | 2.71   |
| 100GW  | 43.23*     | 1.93    | 8.80**     | 2.85ns    | 1.59      | 58.4      | 3.16   |
| GY     | 1064.8ns   | 387.41  | 5075.5**   | 279.4**   | 68.9      | 6872.1    | 2.85   |
| Hİ     | 3.07 ns    | 4.80    | 314.06*    | 5.89ns    | 28.91     | 361.48    | 3.07   |
| PR     | 1.587ns    | 0.4787  | 1.288ns    | 1.820ns   | 1.2947    | 6.4692    | 5.14   |
| Ca     | 23154.7ns  | 46502.1 | 50852.0ns  | 54257.7ns | 25159.0   | 52.15     | 23.65  |
| Cu     | 20.62ns    | 8.79    | 15.03*     | 3.85ns    | 3.85      | 52.15     | 23.65  |
| K      | 3690241ns  | 627755  | 1501532**  | 99799.5ns | 303486 ns | 6222813.5 | 5.68   |
| Mg     | 85069.4ns  | 12437.2 | 18102.2ns  | 6968.6ns  | 13708.9   | 136286.34 | 7.61   |
| Mn     | 35.4ns     | 6.1     | 17.6ns     | 4.7ns     | 7.1       | 71.0      | 10.85  |
| Na     | 7909.14ns  | 29830.9 | 6905.2ns   | 2814.1ns  | 3420.9    | 50880.29  | 18.9   |
| Zn     | 97.2196 ns | 30.6492 | 30.8343*   | 12.049 ns | 205.29653 | 376.04863 | 9.07   |

\*\*: P< 0.01 probability level, \*:P< 0.05 probability level. ns: not significant, PH: plant height, 100GW: 100 grain weight, GY: grain yield, Hİ: harvest index, PR: protein ratio, Ca: calcium, Cu: copper, K: potassium, Mg: magnesium, Mn: manganese, Na: sodium, Zn: zinc

### Plant height

Table 5 shows that the plant height of the Arda variety was 59.6 cm, while the Botan variety was 54.10 cm. The difference between the two varieties was statistically significant. Owing to the use of different organic and inorganic fertilizers, the average height of chickpea plants varied between 50.6-62.8 cm. The tallest plants, measuring 62.8 cm, were observed in plots treated with chicken manure, whereas the shortest plants, measuring 50.6 cm, were observed in the control plots. When examining studies on plant height in different varieties, Mart et al. (2017) reported an average value ranging from 63.8-78.3 cm, Biçer et al. (2017) reported an average value ranging from 49.5-60.7 cm, and Doğan and Çığ (2023), reported average values ranging from 48.9-63.3 cm. According to Cubero (1987), environmental factors play a crucial role in variation in chickpea plant height.

In their study on the effects of organic and inorganic fertilizer applications on plant height, Doğan and Çığ (2023) found that the lowest plant height was observed in the control plots, whereas the highest was observed in the plots treated with chicken manure. This study used various organic, inorganic, and microbial fertilizer sources for chickpea varieties. Zeidan (2007) found that organic fertiliser application increased plant height in lentil. In contrast, Yeşilbaş (2015) reported that the highest plant height was achieved through chicken manure application, whereas the control plot had the lowest value. These results support the findings of the present study.

### 100-grain weight(g)

Table 5 shows that the effect of fertiliser on 100 grain weight was significant at the 1% level. Additionally, the effect of cultivar was significant at the 5% level, while the cultivar × fertilizer interaction was found to be insignificant. Table 6 shows that the Botan variety had a 100-grain weight of 40.9 g, whereas the Arda variety had a 100-grain weight of 38.7 g. Differences between the two varieties were statistically significant. Mart et al. (2017) reported that the 100 grain weight varied between 35.3-50.0 g, while Sönmez (2021) reported a range of 35.28-41.25 g. The results of our study were consistent with those of previous studies. Although grain weight may differ among varieties, environmental conditions are believed to have a significant impact on this phenomenon.

Regarding the impact of organic and inorganic fertiliser applications on 100 grain weight, the plots where chicken manure was used had the highest average value of 41.5 g, while the control plots had the lowest value of 37.9 g. In their study on the application of organic and inorganic fertilizers, Doğan and Çığ (2023) found that the highest 100-grain weight in chickpeas was obtained from the application of chicken manure, while the lowest weight was observed in the control plots. According to Yeşilbaş (2015), the highest 100-grain weight value in lentil crops was obtained from the application of chicken manure, while the lowest value was observed in the control plots. The use of organic and inorganic fertilizers also affected crop

weight. However, according to Elsheikh and Elzidany (1997), the use of chicken manure resulted in an increase in pod yield and 100-grain weight. Zeidan (2007) found in his study that the thousand kernel weight was directly proportional to the amount of organic fertiliser applied and that there was an increase in 100 kernel weight with the increase in the amount of fertiliser applied. In a study conducted by Göksu (2012) on the effects of organic, chemical, and microbial fertilizer applications on peas, the control plots yielded the lowest 100 grain weights. The application of chicken manure resulted in a statistically significant difference in 100 grain weight. The researchers' findings are consistent with those of our study.

**Table 5.** The mean values for plant height, 100-grain weight, and grain yield, as well as their respective groups, were analysed

| Fertiliser                   | Plant height (cm) |        |         | 100 grain weight (g) |        |         | Grain yield (kg ha <sup>-1</sup> ) |         |        |
|------------------------------|-------------------|--------|---------|----------------------|--------|---------|------------------------------------|---------|--------|
|                              | Arda              | Botan  | Avage   | Arda                 | Botan  | Avage   | Arda                               | Botan   | Avage  |
| Control                      | 52.9              | 48.3   | 50.6 D  | 36.2                 | 39.7   | 37.9 C  | 2451e                              | 2302 f  | 2376 C |
| Vermicompost                 | 59.3              | 54.2   | 56.9 BC | 38.9                 | 41.0   | 39.9 B  | 2768 cd                            | 2694 c  | 2731B  |
| Farmyard manure              | 61.8              | 54.4   | 58.1 B  | 40.4                 | 40.8   | 40.6 AB | 2785 cd                            | 2863 c  | 2824B  |
| Chicken manure               | 67.0              | 58.6   | 62.8 A  | 41.1                 | 41.9   | 41.5 A  | 3272 a                             | 3024 b  | 3148 A |
| NPK+Zn                       | 57.1              | 53.9   | 55.5 C  | 37.5                 | 41.1   | 39.3 BC | 3272 a                             | 3010 b  | 3141 A |
| DAP                          | 59.3              | 55.1   | 57.2 BC | 38.3                 | 41.0   | 39.6 B  | 2731 cd                            | 2733 cd | 2732 B |
| <b>Average</b>               | 59.6 A            | 54.1 B |         | 38.7 B               | 40.9 A |         | 2880                               | 2771    |        |
| <b>Lsd(0.05) Variety</b>     | 3.08*             |        |         | 1.99*                |        |         | N.S                                |         |        |
| <b>(Lsd(0.05) Fertiliser</b> | 1.85**            |        |         | 1.52**               |        |         | 9.70**                             |         |        |
| <b>Lsd(0.05) V*F Int</b>     | N.S               |        |         | N.S                  |        |         | 13.72**                            |         |        |

\*\* : P< 0.01 probability level, \* :P< 0.05 probability level. ns: not significant,

### Grain yield (kg ha<sup>-1</sup>)

The results of the analysis of variance on grain yield of two different chickpea varieties using different organic and inorganic fertilizer types are shown in Table 4, and the means and groups are shown in Table 5. The impact of various organic and inorganic fertilizers on the grain yield of chickpea varieties, along with the interaction between fertilizer application and variety, was found to be significant at the 1% level. However, the statistical effect of variety was deemed insignificant. The Arda variety had an average yield of 2880 kg ha<sup>-1</sup>, whereas the Botan variety had an average yield of 2771 kg ha<sup>-1</sup>. The average grain yield from both organic and inorganic fertiliser applications ranged from 2346 to 3148 kg ha<sup>-1</sup>.

Of the fertilizer treatments, the control plots yielded the lowest grain yield, followed by vermicompost, DAP fertilizer, farmyard manure, and NPK 13-25-5+(10SO<sub>3</sub>)+Zn fertilizer. The highest yield of 3148 kg ha<sup>-1</sup> was achieved through the application of chicken manure. Furthermore, there was no statistically significant difference between chicken manure and NPK 13-25-5+(10SO<sub>3</sub>)+Zn fertilizer.

In a study on the effects of organic and inorganic fertilizer applications on grain yield, Bulut (2013) found that the lowest yield was obtained from control plots, whereas the highest yield was obtained from the application of chicken manure. This study examined the effects of organic fertilizer application on bean plants. According to Yeşilbaş (2015), the highest grain yield in lentil cultivation was achieved through the application of chicken manure, whereas the lowest yield was observed in control plots without any fertilizer. Both organic and inorganic fertilizers were used in this study. Doğan and Çığ (2023), conducted a study on the impact of organic, inorganic, and microbial fertilizer applications on chickpea grain yield. The results showed that the highest grain yield was obtained from the application of chicken manure, whereas the lowest yield was observed in the control plots without any fertilizer application. The findings of these studies are consistent with each other.

### Harvest index

Table 4 shows that the effect of fertiliser applications on harvest index was significant at the 1% level, while cultivar and cultivar x fertiliser interaction were found to be statistically insignificant. Table 6 shows that the harvest index of chickpeas was 39.5% for the Arda variety and 38.9% for the Botan variety when the effects of organic and inorganic fertilizer applications were examined. The differences between the two varieties were not statistically significant. The application of organic and inorganic fertilizers resulted in an average change in the harvest index between 34.7% and 43.5%. The control plot yielded the lowest value (34.7%), whereas the highest value (43.5%) was obtained from the plot treated with chicken manure. Doğan and Çığ (2023), conducted a study on the effect of organic and inorganic fertilizer applications on the harvest

index of chickpeas. The study found that the plots with chicken manure application had the highest harvest index value, while the control plot had the lowest. The study found that the plots with chicken manure application had the highest harvest index value, while the control plot had the lowest. The study found that the plots with chicken manure application had the highest harvest index value, while the control plot had the lowest. These findings were consistent with those of our previous study. In a study on lentils, Yeşilbaş (2015) investigated the impact of organic and inorganic fertilizer applications on the harvest index. The highest harvest index value was obtained from the chicken manure application, whereas the lowest value was obtained from the control plot. These findings are consistent with those of previous studies.

**Table 6.** The mean values for protein ratio, calcium and copper, as well as their respective groups, were analysed

| Fertiliser                   | Harvest index (%) |       |        | Protein ratio (%) |       |      | Ca (mgkg <sup>-1</sup> ) |        |        |
|------------------------------|-------------------|-------|--------|-------------------|-------|------|--------------------------|--------|--------|
|                              | Arda              | Botan | Ort    | Arda              | Botan | Ort  | Arda                     | Botan  | Ort    |
| Control                      | 35.7              | 33.7  | 34.7 D | 23.3              | 21.5  | 22.4 | 894.7                    | 847.3  | 871.0  |
| Vermicompost                 | 38.3              | 37.0  | 37.7 C | 23.3              | 22.4  | 22.8 | 1079.0                   | 1208.3 | 1143.7 |
| Farmyard manure              | 39.7              | 39.7  | 39.7 B | 21.9              | 22.7  | 22.3 | 1156.7                   | 958.0  | 1057.3 |
| Chicken manure               | 43.7              | 43.3  | 43.5A  | 22.4              | 21.3  | 21.8 | 967.7                    | 1194.7 | 1081.2 |
| NPK+Zn                       | 42.0              | 42.2  | 42.1A  | 21.9              | 21.5  | 21.7 | 1167.0                   | 973.0  | 1070.0 |
| DAP                          | 37.7              | 37.7  | 37.7 C | 21.2              | 22.1  | 21.7 | 1173.3                   | 952.7  | 1063.0 |
| <b>Average</b>               | 39.5              | 38.9  |        | 22.3              | 21.9  |      | 1073.1                   | 1022.3 |        |
| <b>Lsd(0.05) Variety</b>     | NS                |       |        | NS                |       |      | NS                       |        |        |
| <b>(Lsd(0.05) Fertiliser</b> | 1.45*             |       |        | NS                |       |      | NS                       |        |        |
| <b>Lsd(0.05) V*F İnt</b>     | NS                |       |        | NS                |       |      | NS                       |        |        |

\*\*: P< 0.01 probability level, \*:P< 0.05 probability level. ns: not significant

### Protein ratio (%)

Table 4 displays the results of the analysis of variance of the data obtained using different organic and inorganic fertilizer types in the two different chickpea varieties. Table 6 shows the mean values and groups. Statistical analysis revealed that the effects of fertilizer application, variety, and variety × fertilizer interactions on protein yield were not statistically significant. The Arda variety had an average value of 22.3%, whereas the Botan variety had an average value of 21.9%. No significant differences were observed between the two varieties. When examining the effects of organic and inorganic fertilizer applications on protein yield, the average protein yield ranged from 21.7% to 22.8%. The highest average value was obtained with vermicompost application, whereas the lowest values were obtained with DAP fertilizer application. In general, it was found that the plots with organic fertilizer application had better results in terms of protein yield than those with inorganic fertilizer application, but the difference between the treatments was statistically insignificant. Akçin (1988) reported that the protein ratio in chickpea varieties ranged from 22.2% to 23.9% for both the fodder and edible types. It has been reported that differences in soil structure and climatic conditions of the place of cultivation may cause variations in the protein ratio among genotypes, in addition to the number of varieties used (Doğan and Çiğ, 2023). However, when examining studies on the application of organic and inorganic fertilizers, Singh et al. (2012) reported that the protein ratio in chickpeas ranged from 23.9-24.5% when different fertilizer types were used. The plots that used vermicompost showed better protein ratio results than the control plots. These results support the findings of the present study.

### Grain Ca content

There were no significant differences in the calcium (Ca) content in the grains between cultivars and treatments. The highest mean values were 1073.1 mg kg<sup>-1</sup> in the Arda variety and 1022.3 mg kg<sup>-1</sup> in the Botan variety. Regarding the sources of organic and inorganic fertilizers, the grain showed the lowest Ca effect at 871.0 mg kg<sup>-1</sup> in the control plots and the highest at 1143.7 mg kg<sup>-1</sup> in vermicompost. However, the difference between the treatments was not statistically significant (Table 6). Compared with the control plots, the application of other fertilizers had a positive effect on the calcium content of the grain. Studies have shown that both organic and inorganic fertilization have a positive effect on the amount of Ca in grains (Gonzales et al., 2002; Margaretha et al., 2014; Dogan et al., 2019). The researchers' results partially supported our findings. The use of organic fertilizers, such as chicken manure, farmyard manure, and vermicompost, has positive effects on the physical, chemical, and biological properties of the soil. Organic matter improves soil physical properties by acting as an adhesive for loose soil particles or as an aggregate stabilising compound (Shen and Yang, 2008).

### Grain Cu content

Regarding Cu content, fertilization had a significant effect at the 5% level, whereas cultivar and cultivar  $\times$  fertilization interactions were found to be insignificant (Table 4). Table 7 shows that the Arda variety had a mean value of 9.0 mg kg<sup>-1</sup>, while the Botan variety had a mean value of 7.5 mg kg<sup>-1</sup>. In various fertilizer applications, the Cu content ranged from 6.1 mg kg<sup>-1</sup> in control samples to 10.0 mg kg<sup>-1</sup> in chicken manure. Cu is essential for the utilization of iron and enzyme functions in the body. The recommended daily intake of copper is 0.6-2.0 mg (Demirci, 2003). Karayel et al. (2020) reported that the chickpea plant had the highest Cu content in the control plot and farmyard manure treatments. However, in their study on maize plants with organic and inorganic fertiliser sources, Doğan et al. (2021) found that the lowest Cu ratio in the grain was obtained in the control plots, while the Cu ratio was high in the organic fertiliser applications. The results obtained partially resemble those of the present study.

**Table 7.** The mean values for potassium, magnesium and manganese, as well as their respective groups, were analysed

| Fertiliser                    | Cu (mg kg <sup>-1</sup> ) |       |        | K (mg kg <sup>-1</sup> ) |        |           | Mg (mg kg <sup>-1</sup> ) |        |        |
|-------------------------------|---------------------------|-------|--------|--------------------------|--------|-----------|---------------------------|--------|--------|
|                               | Arda                      | Botan | Ort    | Arda                     | Botan  | Ort       | Arda                      | Botan  | Ort    |
| Control                       | 6.7                       | 5.5   | 6.1 B  | 9028                     | 8329.6 | 8678.8B   | 1489.3                    | 1370.3 | 1429.8 |
| Vermicompost                  | 12.3                      | 8.1   | 10.2 A | 10207                    | 9553.3 | 9880.1A   | 1647.3                    | 1506.7 | 1577.0 |
| Farmyard manure               | 8.8                       | 7.2   | 8.0 AB | 10401                    | 9341.0 | 9871.0 A  | 1633.7                    | 1507.3 | 1570.5 |
| Chicken manure                | 9.8                       | 8.1   | 10.0 A | 10323.6                  | 9691.6 | 10007.7 A | 1578.3                    | 1554.7 | 1566.5 |
| NPK+Zn                        | 8.4                       | 6.3   | 7.3 B  | 10069.3                  | 9535.3 | 9802.3A   | 1625.3                    | 1453.7 | 1539.5 |
| DAP                           | 8.4                       | 7.8   | 8.1 AB | 10037.3                  | 9773.3 | 9905.3 A  | 1539.3                    | 1537.3 | 1538.3 |
| <b>Average</b>                | 9.0                       | 7.5   |        | 10011.0                  | 9370.7 |           | 1585.0                    | 1488.3 |        |
| <b>Lsd(0.05) Variety</b>      | NS                        |       |        | NS                       |        |           | NS                        |        |        |
| <b>(Lsd(0.05) Fertiliser)</b> | 2.36*                     |       |        | 663.4**                  |        |           | NS                        |        |        |
| <b>Lsd(0.05) V*F int</b>      | NS                        |       |        | NS                       |        |           | NS                        |        |        |

\*\* : P < 0.01 probability level, \* : P < 0.05 probability level. ns: not significant

### Grain K content

For the K ratio, the effect of fertilisation was significant at the 1% level, while the variety and variety  $\times$  fertilisation interactions were not significant (Table 4). Table 7 shows that the Arda variety had a mean value of 10011.0 mg kg<sup>-1</sup>, while the Botan variety had a mean value of 9370.7 mg kg<sup>-1</sup>. In various fertilizer applications, the grain with the lowest amount of K was obtained in the control group, at 8678.8 mg kg<sup>-1</sup>, while the highest amount of K in grain was obtained from chicken manure, at 10007.7 mg kg<sup>-1</sup>. DAP, vermicompost, farmyard manure, and NPK+Zn fertilizer, respectively, and the difference between them was not statistically significant. In their study on chickpea, Doğan and Çığ (2023) found that the control plots had the lowest grain potassium ratio, whereas the highest ratio was observed in the plots where farmyard manure was applied. Saket et al. (2014) investigated the effect of organic and inorganic fertilization on yield parameters in lentils. The study found that the lowest potassium content in grain was obtained from control plots, whereas the highest potassium content was obtained in plots where farmyard manure was applied. The results of this study were consistent with these findings.

### Grain Mg content

Variety, fertilisation, and the interaction between variety and fertilisation were found to have no significant effect on the Mg content, as shown in Table 4. Table 7 shows that the Arda variety had a mean value of 1585.0 mg kg<sup>-1</sup>, whereas the Botan variety had a mean value of 1488.3 mg kg<sup>-1</sup>. In different fertiliser treatments, the lowest Mg content in grain was 1429.8 mg kg<sup>-1</sup> in control plots, while the highest Mg content in grain was 1577.0 mg kg<sup>-1</sup> in vermicompost and the difference between fertiliser treatments was statistically insignificant. The application of fertilizer resulted in an increase in the magnesium content of the grains when compared to the control plots. Magnesium is an essential element for chlorophyll synthesis during photosynthesis and plays a crucial role in nitrogen fixation during nodule formation in legumes (Papenbrock et al., 2000).

In their study on the effects of organic and inorganic fertilizer sources on maize plants, Doğan et al. (2021) found that control plots had the lowest Mg ratio in the grain. However, the Mg ratio in the grains was positive in both organic and inorganic fertilizer applications. Doğan et al. (2019) found that the lowest Mg ratio in maize grain was obtained from plots without fertilizer, whereas the highest Mg ratio was obtained from plots treated with chicken manure, farm manure, and DAP fertilizer. However, our findings are only partially compatible with the study conducted by Yağmur and Okur (2018), which

reported an increase in the total Mg content of maize leaves with increasing doses of compost and barnyard manure application in the green parts of the plant under greenhouse conditions.

### Grain manganese content

Variety, fertilisation, and the interaction between variety and fertilisation were found to have no significant effect on Mn content, as shown in Table 4. Table 8 shows that the Arda variety had a mean value of 25.7 mg kg<sup>-1</sup>, whereas the Botan variety had a mean value of 23.7 mg kg<sup>-1</sup>. In various fertiliser applications, the Mn content in grain ranged from 21.4 mg kg<sup>-1</sup> in control plots to 26.0 mg kg<sup>-1</sup> in vermicompost and chicken manure. However, the difference in Mn content between the fertiliser applications was not statistically significant. Doğan et al. (2021) reported that the control plots had the lowest mean values for manganese (Mn) content in maize grain, while the highest mean values were obtained in standard and organic fertiliser applications, which were in the same group. Doğan et al. (2019) found that the Mn content in grain was lowest in plots without fertiliser and highest in plots with commercial fertiliser. The Mn content in plots with chicken manure and farmyard manure was also high, but not significantly different from that in plots with commercial fertilizer. Our findings are partially consistent with these studies.

**Table 8.** The mean values for sodium and zinc as well as their respective groups, were analysed

| Fertiliser                   | Mn (mg kg <sup>-1</sup> ) |       |      | Na (mg kg <sup>-1</sup> ) |       |       | Zn (mg kg <sup>-1</sup> ) |       |         |
|------------------------------|---------------------------|-------|------|---------------------------|-------|-------|---------------------------|-------|---------|
|                              | Arda                      | Botan | Ort  | Arda                      | Botan | Ort   | Arda                      | Botan |         |
| Control                      | 21.6                      | 21.2  | 21.4 | 238.8                     | 260.8 | 249.8 | 30.5                      | 31.9  | 31.2 B  |
| Vermicompost                 | 26.9                      | 25.1  | 26.0 | 346.1                     | 329.7 | 337.9 | 38.3                      | 33.2  | 35.8 A  |
| Farmyard manure              | 26.6                      | 22.3  | 24.4 | 397.3                     | 289.2 | 343.3 | 38.6                      | 32.0  | 35.3 A  |
| Chicken manure               | 26.5                      | 25.3  | 26.0 | 328.7                     | 292.4 | 310.5 | 38.4                      | 36.8  | 37.6 A  |
| NPK+Zn                       | 27.5                      | 23.4  | 25.5 | 328.8                     | 301.1 | 315.0 | 37.1                      | 32.4  | 34.7 AB |
| DAP                          | 24.9                      | 24.6  | 24.8 | 300.4                     | 289.0 | 294.7 | 38.7                      | 35.46 | 37.0 A  |
| <b>Average</b>               | 25.7                      | 23.7  |      | 323.4                     | 293.7 |       | 36.9                      | 33.7  |         |
| <b>Lsd(0.05) Variety</b>     | NS                        |       |      | NS                        |       |       | NS                        |       |         |
| <b>(Lsd(0.05) Fertiliser</b> | NS                        |       |      | NS                        |       |       | 3.85*                     |       |         |
| <b>Lsd(0.05) V*F İnt</b>     | NS                        |       |      | NS                        |       |       | NS                        |       |         |

\*\*: P< 0.01 probability level, \*:P< 0.05 probability level. ns: not significant,

### Grain Na content

Variety, fertilization, and the interaction between variety and fertilization were found to have no significant effect on Na content, as shown in Table 4. Table 8 shows that the Arda variety had a mean value of 323.4 mg kg<sup>-1</sup>, whereas the Botan variety had a mean value of 293.7 mg kg<sup>-1</sup>. In the various fertiliser treatments, the grain's lowest Na content was 249.8 mg kg<sup>-1</sup> in the control plot, while the highest Na content in grain was 26.0 mg kg<sup>-1</sup> in the Farm fertiliser treatment. The difference between fertilizer treatments was statistically insignificant, but all fertilizer treatments had a higher Na content than the control plot. Studies on the subject (Gonzales et al., 2002; Margaretha et al., 2014; Dogan et al., 2019) reported that the lowest average Na value was obtained in control plots, whereas commercial and organic fertilizers had a positive effect on Na content. These results support the findings of the present study.

### Grain Zinc content

The impact of fertilization on Zn content in chickpea cultivars was significant at the 1% level, while the interactions between cultivar and fertilization, as well as cultivar alone, were found to be insignificant (Table 4). Table 8 shows that the Arda variety had a mean value of 36.9 mg kg<sup>-1</sup>, whereas the Botan variety had a mean value of 33.7 mg kg<sup>-1</sup>. In various fertiliser treatments, the grain's lowest Zn content was 31.2 mg kg<sup>-1</sup> in the control plot, while the highest Zn content in grain was 37.6 mg kg<sup>-1</sup> in the chicken fertiliser treatment. DAP fertilizer, vermicompost fertilizer, farmyard manure, and NPK+Zn treatments followed, and the difference between them was statistically insignificant. All fertilizer treatments had a higher Zn content than that of the control plot. In their studies on the subject, Karayel et al. (2020) reported that the application of organic fertiliser increased the amount of Zn in grain compared to control plots in their study on chickpea plants. Similarly, Dogan et al. (2019) found that organic fertilizer application significantly increases the concentrations of K, Ca, Cu, Fe, Mn, Zn, Ni, and Mg (Gonzales et al., 2002; Margaretha et al., 2014).

## CONCLUSIONS

The intensive use of chemical inputs in agricultural production poses a threat to the ecosystem, natural resources, and environment, in addition to its economic impact. This is because of the potential harm it can cause to living organisms and the pollution it can create. Therefore, it is important to consider alternative production methods that are more sustainable and environmentally friendly. To encourage sustainable agriculture and produce healthy, high-quality products, it is necessary to increase the use of organic fertilizers and adopt environmentally friendly practices to protect soil structure. This includes reducing the use of chemical inputs in agriculture to prevent pollution of underground water resources. However, the use of chickpea plants in this study is valuable in terms of leaving nitrogen-advantaged soil for the following cultivated plants in rotation planting and using fewer chemical fertilizers than other cereal crops in the cultivated areas. This study, which we are undertaking on the basis of sustainable agriculture, aims to reduce the use of chemical fertilizers by capturing the benefits of organic fertilization and using it as an alternative fertilizer source. This study investigated the effects of chemical and organic fertilizer application on the yield and yield characteristics of chickpea plants. The results showed that the Arda chickpea variety had the highest grain yield of 3272 kg/ha when chicken manure was applied, whereas the lowest yield of 2302 kg/ha was obtained from the control plot of the Botan variety. The effects of organic fertilizer application are believed to vary depending on the properties examined. They can contribute to chickpea production by improving the soil structure, increasing soil organic matter levels, and providing nutrients. The application of organic fertilizers resulted in significant increases in plant height, 100-grain weight, grain yield, harvest index, and protein ratio. Additionally, there was a significant increase in the concentration of Mg, Na, Zn, Cu, K, and Ca in the grains. In our country, where fertilizer resources are limited, organic applications to widely cultivated plants such as chickpeas would be extremely beneficial for the economy, environment, and soil structure.

## Conflict of Interest

The authors declare no conflicts of interest.

## Author Contribution

All authors contributed equally to the study design, data collection, analysis, and manuscript preparation.

## Thesis Information

In this study, a part of Engin DEMİR's master's thesis was used.

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