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# Effects of different zinc levels on grain yield and some phenological characteristics of red lentil (*Lens culinaris* Medic.) under arid conditions

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**Abstract:** This research aimed to determine the effects of different zinc (Zn) levels on the grain yield and some phenological characteristics of the Fırat-87 red lentil variety (*Lens culinaris* Medic.). The study was conducted during the winter months of 2013–2014 and 2014–2015 in Zn-deficit areas of Şanlıurfa, Turkey. The experimental design was a randomized complete block design with 4 replicates. The Fırat-87 lentil variety and Zn sulfate ($ZnSO_4.7H_2O$) were used as the plant material and Zn source, respectively. The Zn levels used were the control (0 kg ha$^{-1}$ Zn), 5 kg ha$^{-1}$ Zn, 10 kg ha$^{-1}$ Zn, 15 kg ha$^{-1}$ Zn, 20 kg ha$^{-1}$ Zn, and 25 kg ha$^{-1}$ Zn. The Zn levels were significant ($P \leq 0.01$) for the harvest index, 1000-kernel weight, protein rate, and grain yield. All of the tested characteristics were positively affected by increasing applications of Zn. The grain, leaf, and soil Zn contents were higher with increasing levels of Zn. Although the highest grain yield was 15 kg ha$^{-1}$ Zn in both years, according to the regression analysis, the optimum Zn level was 17 kg ha$^{-1}$ Zn. However, the economic Zn level was determined as 15 kg ha$^{-1}$ Zn.

**Key words:** Arid conditions, grain yield, red lentil, zinc

## 1. Introduction

Lentils (*Lens culinaris* Medic.), which have high levels of protein, minerals, and vitamins, meet the food and nutritional needs of millions of people worldwide. They are also an important part of vegetarian and low-cholesterol diets, and they are widely used in animal feeding because of the high feed value of their straw. Lentil plants fix the free nitrogen from the air through rhizobium bacteria in their roots. They tolerate drought and can grow under arid climatic conditions. They are also capable of growing in low fertility soil types. For this reason, lentils are common in arid climate regions where they can obtain an acceptable yield. Zinc (Zn) is a very important element for human health. Generally, Zn deficiency is common among people who eat cereals. Significant symptoms of Zn deficiency include growth retardation in children, susceptibility to infectious diseases, increased disability or mortality rates, retardation of mental development, premature delivery of babies, or low birth weight (Hotz and Brown, 2004).

Fertilization is vital to attaining high yield in lentils. Macronutrients as well as micronutrients play a major role in plant nutrition. However, Zn deficiency in the plant decreases yield and causes significant economic loss. Plants are adversely affected by Zn deficiency because it reduces their protein synthesis. As Zn plays a role in cell prolongation, division, and differentiation, a lack of growth is seen in plants with Zn deficiency (Çakmak et al., 1989). Hence, fertilization with Zn can increase the yield and quality of plants.

Zn deficiency is found in 30% of the agricultural areas in the world (Ahmad et al., 2012) and is very common under dry climate conditions and in soils that have low organic matter. In addition, conditions such as high P, pH, lime, and clay cause Zn deficiency (Marschner, 2011). Zn deficiency is seen in the Southeastern Anatolia region of Turkey, where this research was conducted. Öktem and Öktem (2006) reported Zn deficiency in 37.5% of soil samples in the Southeastern Anatolia region and the soil Zn content ranged from 0.164 to 1.018 mg kg$^{-1}$. Generally, 0.5 mg Zn kg$^{-1}$ is regarded as the critical level of Zn available in the soil (Kacar and Katkat, 2007).

Some researchers have reported that grain yield and quality were positively affected by proper Zn applications. Abid et al. (2017) reported that the application of Zn fertilizer increased the lentil protein content and grain yield in dry areas. Ekiz et al. (1998) emphasized that grain yield increased with Zn applications under dry conditions. Zn deficiency is common in soils with a pH of 6.5–8.0 (Güneş et al., 2004). Quddus et al. (2014) reported that high yields could be obtained with suitable Zn applications.

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Meyveci et al. (2004) advised that 10–20 kg ha$^{-1}$ Zn should be applied to soil with low Zn content for chickpeas. Karan et al. (2014) recommended an application of 8–10 kg ha$^{-1}$ Zn for lentils. Öktem et al. (2012) explained that the application of Zn to the soil increased the grain yield, harvest index, and 1000-kernel weight of lentils. Hussain and Ahmad (2015) and Usman et al. (2014) stressed that a blanket dose application of Zn to the soil influenced yield characteristics of lentils such as the 1000-kernel weight, plant height, and harvest index.

In some other studies, the highest grain, straw, and biological yields were obtained with the application of 10 kg ha$^{-1}$ Zn (Singh and Bhalt, 2013). It has been reported that Zn applied to the soil increases the yield of wheat (Çakmak et al., 1999, 2010; Barut et al, 2017).

This study aimed to determine the effects of different Zn levels on the grain yield and some phenological characteristics of Fırat-87 red lentil cultivar to determine the most suitable Zn level for lentils in arid areas where Zn deficiency has been observed.

## 2. Materials and methods

The study was carried out in 2013–2014 and 2014–2015, during the winter months under arid conditions in Şanlıurfa, Turkey. The climatic characteristics of the research area are presented in Table 1, where it can be seen from the detailed climatic data that the weather was warm throughout the research period during the winter months and rainfall was rare. During the research period, the highest rainfall was in February 2013.

The soil of the research field was clay, slightly alkaline, and very low in salt content; pH was 7.77 and 7.69 in the 2013–2014 and 2014–2015 growing seasons, respectively. The organic matter of the research area was low. The research was carried out in Zn-deficient areas of Şanlıurfa. In both years, soil samples were taken prior to seeding from the experimental area and some chemical properties of the soil were analyzed using the method described by Rayment and Lyons (2010). The soil characteristics of the trial areas for both years are given in Table 2, where it can be seen that the Zn content of the experiment areas was 0.312 mg kg$^{-1}$ and 0.201 mg kg$^{-1}$ in the 2013–2014 and 2014–2015 growing periods, respectively. The Zn content of the research areas was under the critical Zn deficiency level of 0.5 mg kg$^{-1}$ (Aktaş, 2004).

Zn sulfate ($ZnSO_4.7H_2O$), which contains 21% Zn (active ingredient), was used as the Zn source. The Fırat-87 red lentil variety was used as the plant material in the study. The Fırat-87 variety is cold-tolerant, has medium maturation, and is resistant to grain pouring, and its blending, seed beetle resistance, and cooking properties are good (Öktem et al., 2012).

The experimental design was a randomized complete block design with 4 replications. The Zn levels used were the control (0 kg ha$^{-1}$ Zn), 5 kg ha$^{-1}$ Zn, 10 kg ha$^{-1}$ Zn, 15 kg ha$^{-1}$ Zn, 20 kg ha$^{-1}$ Zn, and 25 kg ha$^{-1}$ Zn. After the

**Table 1.** Some meteorological parameters of Şanlıurfa.

| Year | Parameters | 1 | 2 | 3 | 4 | 5 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|
| 2013 | Max. temp. (°C) | 16.4 | 19.5 | 24.9 | 34.3 | 36.4 | 32.0 | 27.0 | 16.9 |
| | Min. temp. (°C) | –3 | 2.9 | 0.8 | 7.8 | 11.7 | 10.8 | 5.7 | –2.5 |
| | Avg. temp. (°C) | 6.8 | 9.3 | 12.9 | 18.4 | 22.9 | 19.3 | 14.8 | 6.1 |
| | Humidity (%) | 69.5 | 73.6 | 54.6 | 44.9 | 43.4 | 48.6 | 57.5 | 54.6 |
| | Rainfall (mm) | 86.8 | 107.2 | 12.1 | 18.0 | 56.2 | - | 19.5 | 76.7 |
| 2014 | Max. temp. (°C) | 18.0 | 22.1 | 24.3 | 30.8 | 38.7 | 31.9 | 22.8 | 17.0 |
| | Min. temp. (°C) | 2.4 | –1.1 | 2.2 | 3.6 | 12.4 | 9.5 | 4.8 | 2.5 |
| | Avg. temp. (°C) | 8.6 | 10.0 | 144.2 | 18.5 | 24.0 | 20.3 | 12.1 | 9.5 |
| | Humidity (%) | 65.6 | 44.0 | 51.7 | 47.5 | 29.8 | 49.5 | 53.9 | 79.4 |
| | Rainfall (mm) | 44.3 | 20.8 | 91.6 | 33.3 | 6.0 | 25.7 | 78.6 | 55.4 |
| 2015 | Max. temp. (°C) | 17.2 | 18.2 | 24.8 | 29.9 | 36.9 | 33.0 | 24.3 | 20.0 |
| | Min. temp. (°C) | –3.1 | –0.6 | 2.5 | 4.7 | 11.8 | 12.7 | 6.8 | 0.5 |
| | Avg. temp. (°C) | 6.2 | 7.6 | 11.7 | 15.7 | 22.8 | 21.6 | 14.0 | 8.6 |
| | Humidity (%) | 68.8 | 74.3 | 58.9 | 49.7 | 38.0 | 50.5 | 48.1 | 50.8 |
| | Rainfall (mm) | 82.5 | 100.8 | 79.0 | 24.3 | 10.3 | 58.8 | 7.9 | 25.3 |

Months: January (1), February (2), March (3), April (4), May (5), October (10), November (11), December (12) (Turkish State Meteorological Service, 2015).

wheat, which was the preliminary plant, the test area was ploughed and cultivated, and then prepared for planting with a single pass of a disk-harrow. The sowing dates were 30 November 2013 and 3 December 2014. The harvesting dates were 28 May 2014 and 23 May 2015. The seed amount was 90 kg $ha^{-1}$ each year. A pneumatic seeder was used for planting. Each plot was 6 m × 1.6 m and consisted of 8 rows. The distance between the rows was 20 cm and the intrarow spacing was 3–4 cm. The seeds were sown at a depth of 4–5 cm. The nitrogen and phosphorus contents of the soil were determined before planting. Considering the amount of nitrogen and phosphorus in the soil, the fertilization amount was completed to 60 kg $ha^{-1}$ N and 60 kg $ha^{-1}$ $P_2O_5$ (Arslan and Öktem, 2004; Öktem et al., 2011). Banded nitrogen and phosphorous fertilizers were applied with sowing. The banded fertilizer was applied 50 mm to the side of the seed and 50 mm below.

The Zn was dissolved in water at the level specified for each dose, sprayed onto the parcel soil with the sprayer before sowing, and then mixed with the soil. After each application, the sprayer was cleaned. Only water was sprayed for the control application, to as much as the amount used in the other applications. To prevent passage of the fertilizer between the parcels, a distance of 5 m was left between the blocks and the parcel, and the parcels were surrounded by a border. Mechanical control of the weeds was carried out and the plants were harvested by hand. One row from the left and right sides and 0.5 m from the beginning and end of the plot were not harvested due to the corner effect. After harvesting, the grain yield was calculated per hectare. Observations of the tested characteristics were made on 10 plants that were randomly selected from each plot. Soil samples were collected from each parcel before sowing and after harvesting.

The years were evaluated separately due to the fact that they were not homogeneous according to the performed homogeneity test (Johnson and Bhattacharyya, 1992). Analysis of variance (ANOVA) was performed on the data for both years and the least significant difference (LSD) test was used (Cochran and Cox, 1992) to determine differences among the Zn levels. In addition, an economic analysis was conducted to determine the most economical Zn levels (Öktem et al., 2012). The Zn contents of the leaves and grain were also determined according to the method of Kacar and İnal (2008).

## 3. Results and discussion

### 3.1. Harvest index (%)

According to the ANOVA analysis, the harvest index was significantly affected ($P \leq 0.01$) by the Zn applications in both years (Table 3). The highest harvest index values were obtained from 15 kg $ha^{-1}$ Zn (31.9% and 36.0%,

**Table 2.** Some chemical traits at 0–20 cm soil depth of the research area.

| Years | Saturation (%) | Total salt (%) | pH | Lime (%) | $K_2O$ (kg $ha^{-1}$) | $P_2O_5$ (kg $ha^{-1}$) | Org. Mat. (%) | Usable Zn (mg $kg^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| 2013/14 | 60 | 0.88 | 7.77 | 24.1 | 154.4 | 4.36 | 0.35 | 0.312 |
| 2014/15 | 63 | 0.74 | 7.69 | 27.2 | 113.9 | 6.13 | 0.47 | 0.201 |

**Table 3.** Harvest index (%) and 1000-kernel weight (g) values at different Zn levels.

| Zn levels (kg $ha^{-1}$) | Harvest index (%) | | 1000-kernel weight (g) | |
|---|---|---|---|---|
| | 2013–2014** | 2014–2015** | 2013–2014** | 2014–2015** |
| 0 (control) | 25 c† | 26.6 e | 37.8 d | 38.9 d |
| 5 | 25.8 c | 28.4 d | 39.1 c | 39.9 cd |
| 10 | 26.2 c | 31.9 bc | 40.6 b | 41.4 b |
| 15 | 31.9 a | 36.0 a | 42.0 a | 42.7 a |
| 20 | 30.5 ab | 32.7 b | 40.3 b | 40.8 bc |
| 25 | 29.7 b | 30.9 c | 40.2 b | 40.8 bc |
| LSD | 1.60 | 1.51 | 0.97 | 1.06 |

† There is no significant difference between averages with the same letter as compared by LSD test at $P \leq 0.05$.
** Statistical significance at $P \leq 0.01$.

respectively), while the lowest values were found in the control parcels in both years (25% and 26.6%, respectively). In this study, the harvest index values increased with the Zn applications due to increases in the grain yield and 1000-kernel weight values. Some researchers have found similar results, where the harvest index was positively affected by Zn applications. Nakhzari et al. (2011) reported that the harvest index increased with 2 L/ha of 15% Zn solution. Usman et al. (2014) reported that the maximum harvest index for green gram (*Vigna radiata* L.) could be obtained from 20 kg $ha^{-1}$ Zn sulfate soil application. Moreover, Purushottam and Saren (2018) emphasized that Zn fertilizer had a significant effect on the harvest index. Azat et al. (1993) and Gangwar and Singh (1986) found that applications of Zn increased the harvest index. However, some research has reported that the application of Zn had no effect on the harvest index (Thiyagarajan et al., 2003; Singh et al., 2011; Singh and Bath, 2015).

### 3.2. Thousand-kernel weight (g)

Different Zn levels were significant for the 1000-kernel weight, at $P \leq 0.01$ in both years, as given in Table 3. These results were positively affected by different Zn applications. The highest 1000-kernel weight was obtained with 15 kg $ha^{-1}$ Zn in both years. It was observed that the 1000-kernel weight increased with increasing Zn levels from the control application to 15 kg $ha^{-1}$ Zn, but after that point, it was seen to decrease in both years. The 1000-kernel weights were positively affected by the increasing Zn levels. Rathi et al. (2009) explained that the application of Zn to legumes improved the 1000-kernel weight. Taban and Alpaslan (1996) and Öktem et al. (2012) determined that 1000-kernel weight increased with Zn applications when compared to control parcels. Khorgamy and Farina (2009) explained that the optimal level of Zn affected cell division, starch, and sugar formation, which was why the 1000-grain weight increased with the increasing of the size and weight of the seed. Zn levels lower than our findings for the 1000-kernel weight were reported by some researchers. Abid et al. (2017) reported that the maximum 1000-grain weight was observed with the application of 9 kg $ha^{-1}$ Zn. Quddus et al. (2014) reported that the highest 1000-seed weight of lentils was obtained with the application of 3.0 kg $ha^{-1}$ Zn.

### 3.3. Protein content (%)

The protein content (%) of lentil was significantly ($P \leq 0.01$) influenced by different levels of Zn, which are given in Table 4. The highest protein contents were obtained with 25 kg $ha^{-1}$ Zn (26.66% and 29.76%), while the lowest were found in the control parcels in both years (22.82% and 22.71%, respectively). In this study, the protein content of the seeds increased with Zn applications. The protein concentration of the seeds decreases under Zn deficiency, but it can increase with optimum Zn fertilization (Çakmak et al., 1989). Zn is an important microelement in protein synthesis (Esfandiari and Abdoli, 2016; Martinez et al., 2017). Pandey and Gautam (2009) reported that the protein content of seeds significantly increased with the application of Zn in lentils. Erdem (2011) explained that an application of 3 kg $da^{-1}$ Zn to the soil gave the highest protein content in corn. Hamurcu (2007) reported that the seed protein content of bean varieties increased with increasing doses of Zn. Moreover, water deficiency (Öktem and Şimşek, 2004; Öktem, 2007, 2008a) and high temperatures (Öktem, 2008b, 2008c) affect the grain protein content under semiarid and arid environments. An effective drought and hot climate in the grain filling period might result in low protein contents in grains under rain-fed conditions (Öktem and Öktem, 2019).

**Table 4.** Protein content (%) and grain yield (kg $ha^{-1}$) values at different Zn levels

| Zn levels (kg $ha^{-1}$) | Protein content (%) | | Grain yield (kg $ha^{-1}$) | |
|---|---|---|---|---|
| | 2013–2014** | 2014–2015** | 2013–2014** | 2014–2015* |
| 0 (control) | 22.82 e† | 22.71 e | 899 e | 1093 d |
| 5 | 23.71 d | 24.09 d | 942 de | 1153 d |
| 10 | 24.61 c | 24.94 d | 1133 c | 1273 c |
| 15 | 25.75 b | 26.53 c | 1398 a | 1485 a |
| 20 | 26.04 b | 28.71 b | 1268 b | 1463 ab |
| 25 | 26.66 a | 29.76 a | 1049 cd | 1370 bc |
| LSD | 0.399 | 0.857 | 127.3 | 112.7 |

† There is no significant difference between averages with the same letter as compared by LSD test at $P \leq 0.05$.

*, ** Statistical significance at $P \leq 0.05$ and $P \leq 0.01$, respectively.

### 3.4. Grain yield (kg $ha^{-1}$)

Zn levels were statistically significant for grain yield in 2013–2014 ($P \leq 0.01$) and 2014–2015 ($P \leq 0.05$). As seen in Table 4, the highest grain yield was obtained with 15 kg $ha^{-1}$ Zn in both years (1398 kg $ha^{-1}$ and 1485 kg $ha^{-1}$, respectively), while the lowest was seen in the control parcels in both years (899 kg $ha^{-1}$ and 1093 kg $ha^{-1}$, respectively). Grain yield was affected positively by the Zn applications (Figure 1). Grain yield can increase with Zn applications, which enhances plant growth due to the effects of Zn on photosynthesis and enzyme activation (Hussain and Ahmad, 2015). Moreover, grain yield is more affected by Zn deficiency than other plant parts (Güneş et al., 2004). Some research has emphasized that grain yield increased with Zn applications (Özbek and Özgümüş, 1997; Ekiz et al., 1998; Öktem et al., 2012; Singh and Bhalt, 2013, 2015). Some research has shown similar results with applications of Zn. Toğay and Anlarsal (2008) suggested an application of 15–30 kg $ha^{-1}$ Zn to lentils in soil with low Zn contents under the conditions of Van, Turkey. Abid et al. (2017) reported that the highest grain yield was obtained with the application of 9 kg $ha^{-1}$ Zn to lentils. Some researchers found lower Zn levels for lentils, such as the application of 12.5 kg $ha^{-1}$ Zn (Azat et al., 1993) and 10 kg $ha^{-1}$ Zn (Islam et al., 1989). Quddus et al. (2014) explained that the highest grain yield was recorded with the application of 3.0 kg $ha^{-1}$ Zn, whereas the lowest was found in the control parcels for lentils. Moreover, high temperature and water deficiency during the grain filling period have a great effect on grain yield under semiarid and arid environments (Öktem and Öktem, 2009a) and water deficits often limit grain yields (Öktem et al., 2003).

### 3.5. Regression analysis

In the regression analysis, a polynomial curve was obtained between grain yield and Zn levels. A relationship was found between the Zn levels and grain yield at $R^2 = 0.792$ ($R^2$ denotes the coefficient of determination). The equation of the relationship was $y = -1.401x^2 + 47.92x + 932.3$. In the regression analysis, the grain yield increased in parallel to the increasing amounts of Zn from the control application, and the regression curve increased to 17 kg $ha^{-1}$ Zn, but it tended to decrease after this point (Figure 2). According to the regression analyses, the optimum Zn application was 17 kg $ha^{-1}$ Zn.

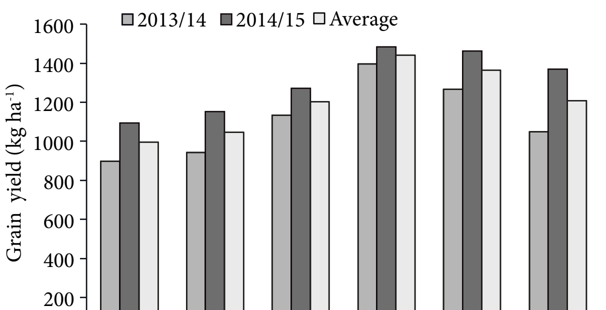


**Figure 1.** Grain yield values at different Zn levels.

### 3.6. Economic analysis

The best economic Zn level for the Fırat-87 lentil variety was calculated by adopting the equation $Y = a + bx + cx^2$, which was the result of regression analysis (Dernek, 1987). The economic fertilizer level was calculated using the equation of the relationship ($y = 932.3 + 47.92x - 1.401x^2$) and was 15 kg $ha^{-1}$ Zn. Kumlay et al. (2007) reported that the regression method was applicable and more reliable than other methods for economic dosage.

$$Eg = \frac{Fg - Fm^*b}{2^*Fm^*c}; \quad Eg = \frac{14.65 - 2.7^*47.92}{2^*2.7^*(-1.401)} = 15.2 \text{ kg ha}^{-1} \text{ Zn}$$

Here Eg is the economic fertilizer quantity, Fg is the fertilizer of unit price at (14.65 Turkish lira) \$5.10, Fm is the crop unit price at (2.7 lira) \$0.94, b is the fertilizer of linear effect, and c is the fertilizer of quadratic effect.

### 3.7. Leaf and seed analyses

Plant samples were taken from the upper leaves of plants that had matured at the beginning of flowering and analyzed according to the method of Kacar and İnal (2008). From the leaf analysis carried out in both trial years, it was observed that the content of leaf Zn increased with the Zn applications when compared to the control. The critical deficiency level of Zn in the leaves can be accepted as 15–20 mg $kg^{-1}$ (Güneş et al., 2004). While a Zn deficiency was observed in the leaf samples taken from the control plots, the deficiency was eliminated by Zn application (Table 5). This finding is important for receiving a high level of bioavailable protein. The Zn content of lentil seed increased with the application of increasing Zn levels (Table 5). Maqsood et al. (2015) explained that the application of Zn fertilizer generally increased the Zn concentration of seeds. Some researchers have reported that the application of Zn to the soil had a significant positive effect on seed Zn content (Arif et al., 2007; Harris et al., 2008; Kaya et al., 2009; Shivay et al., 2014). Moreover, arid conditions negatively affect grain Zn content due to water deficiency (Öktem, 2008d; Öktem and Öktem, 2009b).

### 3.8. Zn exchanges in the soil

In parallel with increased Zn levels, the content of the soil Zn increased. The highest Zn content was obtained with the application of 25 kg $ha^{-1}$ Zn (Table 6). In the control application, the Zn level in the soil was observed as below the preplanting Zn value in both years. However, the Zn content of the soil after harvest increased to the critical

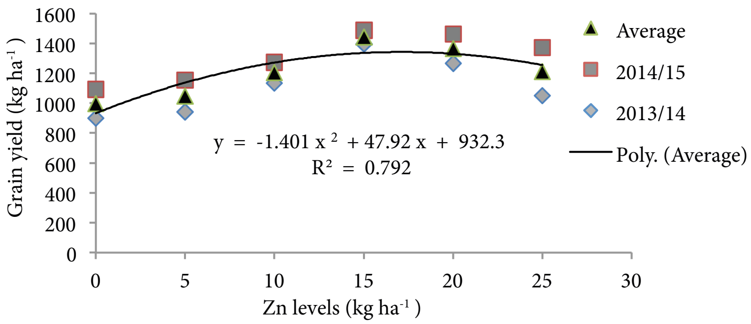


**Figure 2.** Relationship between Zn levels and grain yield.

**Table 5.** Zn content of the leaves and seeds of lentil at different Zn levels.

| Zn levels (kg ha$^{-1}$) | Zn levels (mg kg$^{-1}$) | | | |
|---|---|---|---|---|
| | Leaves | | Seeds | |
| | 2013–2014 | 2014–2015 | 2013–2014 | 2014–2015 |
| 0 (control) | 18.56 | 18.82 | 21.91 | 18.53 |
| 5 | 21.23 | 22.65 | 23.12 | 22.00 |
| 10 | 23.75 | 24.43 | 25.73 | 24.15 |
| 15 | 30.29 | 29.34 | 28.57 | 26.26 |
| 20 | 32.32 | 35.11 | 31.39 | 35.88 |
| 25 | 35.21 | 39.01 | 35.88 | 37.16 |

**Table 6.** Soil Zn levels before sowing and after harvest (mg kg$^{-1}$).

| Zn levels (kg ha$^{-1}$) | Zn levels (mg kg$^{-1}$) | | | |
|---|---|---|---|---|
| | 2013–2014 | | 2014–2015 | |
| | Before sowing | After harvest | Before sowing | After harvest |
| 0 (control) | 0.323 | 0.291 | 0.333 | 0.211 |
| 5 | 0.354 | 0.811 | 0.298 | 0.663 |
| 10 | 0.321 | 0.903 | 0.307 | 0.814 |
| 15 | 0.301 | 1.051 | 0.321 | 0.993 |
| 20 | 0.333 | 1.983 | 0.299 | 1.897 |
| 25 | 0.317 | 2.040 | 0.302 | 1.986 |

level of 0.5 mg kg$^{-1}$ (Aktaş, 2004), in parallel with increasing levels of Zn in both years. Erdem (2011) reported that Zn fertilizer should be applied to Zn-deficient soils before sowing.

### 3.9. Conclusions

As a result of the 2-year field research, it has been determined that Zn fertilization increased the grain yield taken per unit area in the lentils in Zn-deficient areas and under arid conditions. In this study, the highest grain yield and economic Zn level were obtained with 15 kg ha$^{-1}$ Zn, but according to the regression analyses, the optimum Zn level was 17 kg ha$^{-1}$ Zn for the Fırat-87 lentil variety under arid conditions. For Zn deficiency, in order to get the most effective results from Zn applications, it is necessary to carry out soil analysis before every Zn application to the soil. Zn should be applied to Zn-deficit soils.

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