DETERMINATION OF THE EFFECT OF LOCAL MICROBIAL AND CHEMICAL FERTILIZER TREATMENTS ON SOME VEGETATIVE AND QUALITY PROPERTIES IN TWO DIFFERENT TYPES OF SOYBEANS (*GLYCINE MAX* (L.) MERRILL)

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Abstract. This research was conducted at Konya in Selcuk University Cumra School of Applied Sciences in order to determine the vegetative and quality characteristics of microbial and chemical fertilizer treatments in two soybean varieties (Mersoy and Ilksoy). The fertilizer treatments were (T1: (Control), T2: Urea (200 mg kg^{-1}), T3: DAP (100 mg kg^{-1}), T4: Microbial fertilizer (MBF)+T2, T5:(MBF+T2+T3). The results revealed that fertilizer treatments had a statistically significant effect on all traits examined in the study, except K, Mg. The highest plant height and weight, root weight, total N, K values were obtained from T3; Mg, Mo values from T2; root length value from T4; Ca, B, Cu, Fe, Mn, Zn values from T5. The difference between the varieties in terms of plant and root dry weight, total N, Mg, B, Cu, Fe, Mn, Mo was found to be significant ($p<0.01$). The highest values in terms of plant height (24.7 cm), plant and root dry weight (1.70 g $plant^{-1}$ and 2.39 g $plant^{-1}$), total N (2.74%), P (0.97%), Mn (225.2 mg kg^{-1}) were obtained from Mersoy; The highest values in terms of root length (24.1 cm), K (3.84%), Ca (3.67%), Mg (1.18%), B (29.4 mg kg^{-1}), Cu (81.6 mg kg^{-1}), Fe (763.8 mg kg^{-1}), Zn (67.0 mg kg^{-1}), Mo (4.09 mg kg^{-1}) were determined from Ilksoy. The results of the study revealed that the addition of nitrogen with microbial fertilizer positively affected the root length and the addition of both nitrogen and phosphorus with microbial fertilizer increased the mineral matter uptake of the plant.
Keywords: *Bacillus pumilus #189, biofertilizer, mineral content, soy, variety*

Introduction

Soybean (*Glycine max* (L.) Merrill), an annual plant belonging to the legume family, which is an important industrial plant grown for its seeds rich in protein (40-45%) and oil (18-20%). Because of this feature, it is used in the food industry. Today, many soybean-based industrial products can be found in the markets of developed countries. Besides, many products can be obtained from soybean such as medicine, feed, pharmaceutical, insecticide, rubber, oil, anti-corrosion, anti-static agents, paste components, construction materials, concrete additives, maintenance oils, ink, wax, printing materials, pens, disinfectant, adhesive, electrical insulating agents, analytical chemicals, biodiesel fuel, etc. (Turhan, 2019). Also, in many scientific studies, soybean has been proven to be good for cancer, osteoporosis (Demirci, 2020), cholesterol, chronic kidney and heart diseases (Ozcan and Baysal, 2016; Ramdath, 2017; Karaca and Ozdemir, 2017). The flour and pulp of soybean, remaining after the oil is removed, are important in animal nutrition and very rich in protein (Arioglu, 2014). At the same time, grass, silage, straw and stubble are important source of forage in animal nutrition (Lardy et al., 2018). Besides, soybean prevents soil erosion and is also a good green manure plant. By adding nitrogen to the soil, it increases the yield of the crop to be planted and

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saves fertilizer. It helps to reduce weeds by growing fast after planting (Silva et al., 2013; Ozcan, 2022).

In addition to human and animal nutrition, the wide opportunities to use in the industry oblige the expansion of soybean agriculture. It is reported that soybean production at national level in Turkey is 137.5 thousand tonnes (TUIK, 2023) and yield per hectare is 4.14 tonnes (USDA, 2023). But this amount is not enough to meet the oil and protein deficits. In order to improve the cultivation areas, production and yield of this plant, it is necessary to determine the potential soybean growing areas by revealing the current situation in our country and the environmental conditions of the plant. Our farmers need to identify this valuable product more and expand soybean production by giving it a place in crop rotation. Organic and inorganic fertilization is an alternative technology needed to improve the productivity of the soybean plant and soils to support sustainable soybean cultivation in dry areas (Najafıkhan-Behbın et al., 2019). Studies have revealed that agricultural practices (Kahraman, 2017), especially fertilizer types (Jankowski et al., 2015), can cause significant changes in the elemental composition as well as the genetic structure of plants. One of the most important factors in increasing yield and quality is fertilization. However, it is reported that unconscious and unbalanced chemical fertilization not only reduces the yield in plant production, but also seriously affects the product quality, reduces the durability and flavor of the product, and the proportion of some compounds reach levels that threaten human health. Nitrogen, which is in the form of nitrate in the soil as a result of excessive nitrate fertilization, is taken by plants and reduced to nitrite form in humans, causing the conversion of hemoglobin in the blood to methemoglobin, thus preventing oxygen transport in the blood. It is known that nitrate, nitrite and some other compounds have toxic, mutagenic and carcinogenic effects by converting to nitro enzymes (nitrosamine) in the digestive systems of humans and animals (Karasahin, 2014; Chazelas et al., 2022).

The alkaline soils, which are very common in our country, are poor in terms of phosphorus that the plant can absorb. Phosphorus (P) fertilization is the most common way to provide plants with useful P in soils. However, the benefits of fertilizing with P are limited. A significant portion of the soluble phosphorus added to the soil combines with Ca and Mg and precipitates as Ca- and Mg-phosphates. High lime levels increase this situation even more. Lime both increases the surface area to which ortho-phosphate ions can adsorb and buffers the pH, limiting the neutral pH at which the availability of phosphorus with other plant nutrients is optimised. The use of strong acid in the phosphorus fertilizer production process releases cadmium (Cd) in the raw phosphate rock, which is the raw material for phosphorus fertilizer. Application of the high amounts of P fertilizers to the soil repetitively causes Cd to accumulate in the soil over time and to enter the food chain through the plant, thus negatively affect the health of living being (Grant et al., 2013; Das et al., 2023). Therefore, the organic ways to increase the available phosphorus level, especially in alkaline soils, should be investigated.

To bring the pH to neutral levels, alkaline soils require acidifying chemicals. Some producers use elemental sulfur to lower pH of the soil. However, this method is not economical for the Central Anatolia region. On the other hand, a pH lowering application such as microbial fertilization to be made in the rhizosphere region, where plant roots come into contact with the soil and plant nutrient intake is carried out, is more economical than an application to be made on the whole land. Ogut et al. (2011)

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observed that inoculation of a microbial strain (*Bacillus pumilus* #189) isolated from wheat rhizosphere into wheat decreased the rhizosphere pH, increased the plant-available P level in the rhizosphere and the plant's intake of phosphorus, potassium and magnesium, dry matter content and plant height. Bacterial inoculation can be considered as both an economic and environmentally friendly practice, as it will significantly reduce the use of chemical fertilizers. The effectiveness of this bacterium in agriculture has been confirmed by long-term trials and projects but there is no study on soybean plant.

The aim of this study was to determine the effect of local microbial and chemical fertilizer treatments on some vegetative and quality properties of two different soybean varieties and to determine the most suitable variety that can adapt to the region.

Materials and Methods

Establishing and conducting the research

In the study, registered Mersoy and Ilksoy varieties were used as material. Trial materials were obtained from Trakya Agricultural Research Institude. The research was carried out as a pot experiment on the open field in 2021 at the Selcuk University Cumra School of Applied Sciences. In the research, two locally registered soybean varieties (Mersoy and Ilksoy) and 5 different fertilizer treatments (T1: (Control) (No fertilizer), T2: Urea, T3: Diammonium phosphate (DAP), T4: Microbial Fertilizer (MBF)+T2, T5: (MBF) +T2+T3) were taken as a trial subject. Chemical fertilizers were applied as 200 mg kg^{-1} urea and 100 mg kg^{-1} DAP. Microbial fertilizer, which is isolated from the rhizosphere of the wheat (*Triticum aestivum* L.) plant grown in the Konya region, is locally produced and has an active content of *Bacillus pumilus* #189, was inoculated into the seeds before sowing and then they were planted (Ogut et al., 2011). *Bacillus pumilus* #189 is a bacterium that has the ability to dissolve P at high rates, while the carbon source is sugar or starch.

The research was conducted as a pot experiment with three replications according to the "Randomized Complete Block Design". The trial soil, consisting of a mixture of field soil and sand, was sifted through a sieve with a diameter of 4 mm, and after it reached dry weight, it was placed in plastic pots (15 cm in height, 17 cm in diameter). Sowing experiment was done on May 25, 2021, as ten seeds per pot. Two weeks after the plants were risen to the surface, thinning was done in such a way that three plants were left in each pot (Basdemir et al., 2022). Fertilizer treatments were made with planting. During the plant growth period (under normal daylight) the moisture content of the pots was checked regularly and kept at a moisture content close to the field water capacity with tap water. During the experiment, irrigation was carried out at intervals of 2 days until plant emergence and then as needed. Weeds seen after emergence in the pots were regularly removed by hand.

Observation and measurements

Harvest was done by cutting the plants just above the soil surface before the beginning of flowering on August 5, 2021, and whole plant samples were taken. Plant height, root length, plant and root dry weight and mineral content (macro and microelement) were determined in the samples taken. Plant height was taken as the average of three plants height per pot measured from the soil surface to the top-most

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growth point of plants. Root lengths of three plants taken from each pot were determined in cm after cleaning them from the soil. Plant and root dry weight were determined by weighing with a precision scales after being kept in an oven at 70 °C for 48 hours (Oden, 2012).

Mineral analysis

Total N, P, K, Ca, Mg, B, Fe, Cu, Mn, Mo and Zn were determined in the whole plant samples that was taken. Total N was analysed by Kjeldahl method; P was determined through yellow colour spectrophotometric method and K, Ca, Mg, B, Fe, Cu, Mn, Mo and Zn concentrations were determined by ICP/AAS method.

Statistical analysis

Statistical analysis of the characteristics discussed in the study were performed. The values obtained from the research result were subjected to variance analysis in the “TARIST” statistical program according to the "Randomized Complete Block Design in Split Plots" and the mean values of the processes of which differences were determined through F test were defined. Treatment means were compared by Least Significant Difference (LSD).

Results and Discussion

Plant height

The effect of fertilizer treatment on plant height was found to be statistically significant at 5% level (*Table 1*). The highest plant height (29.9 cm) was obtained from T3 and the lowest plant height (24.6 cm) from T5 (*Table 2*). In some studies conducted in different ecological conditions, it has been determined that P has a positive effect on plant height and P deficiency in soybean is directly related to a decrease in plant growth, yield and quality (Begum et al., 2015; Mo et al., 2022).

Table 1. *Results of variance analysis for measured characters in soybean varieties (F values)*

Source of variation	Degress of freedom	Plant height (cm)	Root lenght (cm)	Plant dry weight (g plant^{-1})	Root dry weight (g plant^{-1})
Replications	2	1.87	0.62	0.06	0.45
FT (A)	4	4.47*	1.36ns	4.23*	6.25*
Error (1)	8	-	-	-	-
Variety (B)	1	1.06ns	2.79ns	10.18**	14.67**
AxB Interaction	4	1.95ns	2.49ns	12.16**	8.51**
Error (2)	10	-	-	-	-
General	29	-	-	-	-

ns: nonsignificant, *: Significant at alfa level %5, **: Significant at alfa level %1, FT: Fertilizer Treatment

The difference between the varieties in terms of plant height was not found statistically significant (*Table 1*). In the study, the highest plant height was obtained from Mersoy and the lowest plant height from Ilksoy. Plant heights ranged between

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27.4-26.1 cm in varieties (*Table 2*). The results obtained from the study were found to be high according to the researchers stating that the plant height was between19.58-15.25 cm (Mwenye et al., 2018), lower than the researchers stating that it ranged between 69.53-57.65 cm (Krisnawati and Adie, 2015) and the results were consistent with researchers stating that it ranged was between 48.0-26.5 cm (Yang et al., 2021). Differences between the researchers and the findings obtained were observed. This may be due to the fact that plant height varies in different environments and ecologies depending on the genetic structure of the plants (Cirka et al., 2024).

Table 2. *Mean values and LSD grouping of the soybean varieties belonging to measured characters*

Characters	**Plant height (cm)**			**Root length (cm)**		
Varieties	Mersoy	Ilksoy	Mean	Mersoy	Ilksoy	Mean
Treatments						
T1	29.1	23.8	26.5 bc*	24.0	21.0	22.5
T2	28.8	22.7	25.2bc	21.7	27.0	24.3
T3	29.9	29.2	29.5a	20.3	24.0	22.2
T4	26.3	28.7	27.5ab	23.7	25.3	24.5
T5	23.2	26.0	24.6c	23.3	23.3	23.3
Mean	27.4	26.1		22.6	24.1	
	LSD(FT) at %5=2.89					
Characters	**Plant dry weight (g plant^{-1})**			**Root dry weight (g plant^{-1})**		
Varieties	Mersoy	Ilksoy	Mean	Mersoy	Ilksoy	Mean
Treatments						
T1	1.84a-d**	0.81g	1.32b*	1.43c-f**	0.57f	1.00b*
T2	1.52a-f	1.21d-g	1.37b	2.62bc	0.84ef	1.73b
T3	2.11a	1.71a-e	1.91a	4.64a	3.11b	3.87a
T4	1.90abc	1.33c-g	1.62ab	2.18b-e	1.19def	1.69b
T5	1.13efg	2.00ab	1.57ab	1.09ef	2.51bcd	1.80b
Mean	1.70a**	1.41b		2.39a**	1.65b	
	LSD(FT) at %5=0.369 LSD(V) at %1= 0.287 LSD(FTXV) at %1=0.641			LSD(FT) at %5 =1.417 LSD(V) at %1 =0.618 LSD(FTxV) at % 1=1.382		

Treatments: (T1: Control (no fertilizer), T2: Urea, T3: DAP, T4: Microbial Fertilizer (MBF)+T2, T5: (MBF+T2+T3), *: Significant at alfa level %5, **: Significant at alfa level %1

The effect of fertilizer treatment x variety interaction on plant height was found to be statistically insignificant (*Table 1*). In terms of fertilizer treatment x variety interaction, the highest plant height (29.9 cm) was obtained from Mersoy with T3 and the lowest plant height (22.7 cm) from Ilksoy with T2 (*Table 2*).

Root length

In the study, the effect of fertilizer treatment on root length was found to be statistically insignificant (*Table 1*). The highest root length (24.5 cm) was obtained from T4, the lowest root lenght (22.2 cm) from T3 (*Table 2*). Some studies show that root lenght in plants decreases by 14% in P deficiency (Lopez et al., 2023).

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The results of the study revealed that the combination of nitrogen and microbial fertilizer increased root length. In accordance with our research, Ogut and Er (2016) reported that *Bacillus pumilus* #189 inoculation increased root length.

The difference between varieties in terms of root length was found to be statistically insignificant (*Table 1*). In the study, the highest root length was obtained from Ilksoy and the lowest root length from Mersoy.

The root lengths of the varieties ranged between 24.1-22.6 cm (*Table 2*). These values were compatible with the researchers who reported that root lengths were 27.9-23.7 cm (Kurt et al., 2023). It can be said that factors such as genetics and climatic conditions are effective in the differences between the studies. Some researchers point out that root shape, structure and length differ between varieties and are under the influence of environmental conditions (Brar et al., 1990; Abdelhamid et al., 2009).

In terms of root length, fertilizer treatment x variety interaction was found to be statistically insignificant (*Table 1*). According to fertilizer treatment x variety interaction, the highest root length (27.0 cm) was obtained from Ilksoy with T2 and the lowest root length (20.3 cm) from Mersoy with T3 (*Table 2*).

Plant dry weight

In the study, the effect of fertilizer treatment on plant dry weight was found statistically significant at 5% level (*Table 1*). The highest plant dry weight (1.91 g plant^{-1}) was obtained from T3, the lowest plant dry weight (1.32 g plant^{-1}) from T1 (*Table 2*).

The difference between the varieties in terms of plant dry weight was statistically significant at 1% level (*Table 1*). In the study, the highest plant dry weight was obtained from Mersoy and the lowest plant dry weight from Ilksoy. The plant dry weights of the varieties ranged between 1.70-1.41 g plant^{-1} (*Table 2*). These values were found to be lower than the researchers stating that the shoot dry weight in soybean was 11.61-3.36 g plant^{-1} (Salim et al., 2022), higher than the researchers stating that the dry weight of the soybean plant was between 0.07-0.04 g plant^{-1} (Hakeem et al., 2012) and in accordance with the researchers stating that the plant dry weight varied between 1.59-1.37 g plant^{-1} (Mwenye et al., 2018).

In terms of plant dry weight, fertilizer treatment x variety interaction was found to be statistically significant at 1% level (*Table 1*). According to fertilizer treatment x variety interaction, the highest plant dry weight (2.11 g plant^{-1}) was obtained from Mersoy with T3 and the lowest plant dry weight (0.81 g plant^{-1}) from Ilksoy with T1 (*Table 2*).

Root dry weight

In the study, the effect of fertilizer treatment on root dry weight was found to be statistically significant at 5% level (*Table 1*). The highest root dry weight (3.87 g plant^{-1}) was obtained from T3 and the lowest root dry weight (1.00 g plant^{-1}) from T1 (*Table 2*).

The difference between the varieties in terms of root dry weight was statistically significant at 1% level (*Table 1*). In the study, the highest root dry weight was obtained from Mersoy and the lowest root dry weight from Ilksoy. The root dry weights of the varieties ranged between 2.39-1.65 g plant^{-1} (*Table 2*). These values were found to be lower than that of the researchers stating that the root dry weight was between 5.37-4.13 g plant^{-1} (Mwenye et al., 2018), higher than that of the researchers stating that the root dry weight was between 0.11-0.25 g plant^{-1} (Kurt et al., 2023) and compatible with the

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researchers stating that the root dry weight varied between 4.62-1.12 g plant^{-1} (Salim et al., 2022).

In terms of root dry weight, fertilizer treatment x variety interaction was found to be statistically significant at 1% level (*Table 1*). According to the fertilizer treatment x variety interaction, the highest root dry weight (4.64 g plant^{-1}) was obtained from Mersoy with T3 and the lowest root dry weight (0.57 g plant^{-1}) from Ilksoy with T1 (*Table 2*).

Determination of macroelements

Total nitrogen (N)

The effect of fertilizer treatment on Total N ratio was found to be statistically significant at 5% level (*Table 3*). The highest total N ratio (3.08%) was obtained from T3, the lowest total N ratio (2.11%) was obtained from T4 (*Table 4*). P are the main nutrient for plant growth and N metabolism is one of the primary forms of plant metabolism, which plays a vital role in quality and yield (Gu et al., 2022).

Table 3. *Results of variance analysis for macroelements in soybean varieties (F values)*

Source of variation	Degress of freedom	Total N (%)	P (%)	K (%)	Ca (%)	Mg (%)
Replications	2	0.42	2.02	2.31	1.63	1.58
FT (A)	4	5.86*	8.61**	0.64ns	2.42ns	1.45ns
Error (1)	8	-	-	-	-	-
Variety(B)	1	18.76**	2.38ns	1.19ns	0.01ns	10.89**
AxB Interaction	4	5.08*	4.46*	1.35ns	1.73ns	0.99ns
Error (2)	10	-	-	-	-	-
General	29	-	-	-	-	-

ns: nonsignificant, *: Significant at alfa level %5, **: Significant at alfa level %1, FT: Fertilizer Treatment

The difference between the varieties in terms of total N ratio was statistically significant at 1% level (*Table 3*). In the study, the highest amount of total N was obtained from Mersoy and the lowest amount of total N from Ilksoy. The total N amounts of the varieties ranged between 2.74-2.30% (*Table 4*). These values were found to be lower than the researchers stating that the N amount in soybean was between 5.50-4.25% (Hellal and Abdelhamid, 2013). The main reasons for the differences between the studies are genotype, fertilization, irrigation and environmental factors. Especially nitrogen uptake is greatly affected by climatic conditions. Different ecological conditions, air temperature and humidity affect nitrogen uptake and utilisation by plants (Staley and Perry, 1995).

In terms of total N ratio, fertilizer treatment x variety interaction was found to be statistically significant at 5% level (*Table 3*). According to fertilizer treatment x variety interaction, the highest amount of total N (3.72%) was obtained from Mersoy with T3 and the lowest amount of total N (2.07%) from Ilksoy with T1 and T4 (*Table 4*).

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Table 4. *Mean values and LSD grouping of the soybean varieties for macroelements (%)*

Characters	**Total N (%)**			**P (%)**			**K (%)**		
Varieties	Mersoy	Ilksoy	Mean	Mersoy	Ilksoy	Mean	Mersoy	Ilksoy	Mean
Treatments									
T1	2.42b-e*	2.07e	2.24bc*	1.02abc*	1.05a	1.04a**	3.79	3.71	3.75
T2	2.71b	2.21b-e	2.46bc	1.00a-d	0.98a-f	0.99a	3.91	3.86	3.88
T3	3.72a	2.43b-e	3.08a	0.92a-h	1.04ab	0.98a	3.91	3.88	3.90
T4	2.15e	2.07e	2.11c	0.98a-e	0.64j	0.81b	3.67	3.87	3.77
T5	2.71bc	2.71bcd	2.71ab	0.93a-g	0.86a-ı	0.89ab	3.53	3.86	3.69
Mean	2.74a**	2.30b		0.97	0.91		3.76	3.84	
	LSD(FT) at %5 = 0.520 LSD (V) at %1 =0.326 LSD(FTxV) at %5 =0.512			LSD(FT) at %1=0.147 LSD(FTxV) at %5=0.185					
Characters	**Ca (%)**			**Mg (%)**					
Varieties	Mersoy	Ilksoy	Mean	Mersoy	Ilksoy	Mean			
Treatments									
T1	3.21	3.66	3.44	1.03	1.17	1.10			
T2	3.86	3.35	3.60	1.17	1.16	1.17			
T3	3.56	3.59	3.57	1.06	1.17	1.11			
T4	3.50	3.68	3.59	1.04	1.19	1.11			
T5	4.14	4.05	4.10	1.11	1.19	1.15			
Mean	3.66	3.67		1.08b**	1.18a				
				LSD (V) at %1=0.092					

Treatments: (T1: Control (no fertilizer), T2: Urea, T3: DAP, T4: Microbial Fertilizer (MBF)+T2, T5: (MBF+T2+T3), *: Significant at alfa level %5, **: Significant at alfa level %1

Phosphorus (P)

The effect of fertilizer treatment on the P ratio was found to be statistically significant at 1% level (*Table 3*). The highest P ratio (1.04%) was obtained from T1 and the lowest P ratio (0.81%) from T4 (*Table 4*).

The difference between varieties in terms of P ratio was found to be statistically insignificant (*Table 3*). In the study, the highest amount of P was obtained from Mersoy and the lowest amount of P from Ilksoy. The P amounts of the varieties ranged between 0.97-0.91% (*Table 4*). These values were found to be higher than the researchers stating that the P content in soy is between 0.50-0.25% (Hellal and Abdelhamid, 2013), 0.37-0.20% (Mudlagiri et al., 2020). The reason why P content was higher in this study compared to other literatures is that phosphorus content of plants varies according to many factors such as fertilization, soil and plant variety, plant part, plant maturity (Aydeniz, 1972).

In the study, in terms of P ratio, fertilizer treatment x variety interaction was found to be statistically significant at the level of 5% (*Table 3*). According to fertilizer treatment x variety interaction, the highest amount of P (1.05%) was obtained from Ilksoy with T1 and the lowest amount of P (0.64%) from Ilksoy with T4 (*Table 4*).

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Potassium (K)

The effect of fertilizer treatment on K ratio was found to be statistically insignificant (*Table 3*). The highest K ratio (3.90%) was obtained from T3 and the lowest K ratio (3.69%) from T5 (*Table 4*).

The difference between varieties in terms of K ratio was found to be statistically insignificant (*Table 3*). In the study, the highest amount of K from Ilksoy and the lowest amount of K from Mersoy.

The K amounts of the varieties ranged between 3.84-3.76% (*Table 4*). These values were lower than the researchers stating that the K content in soy was between 5.62-4.0% (Mudlagiri et al., 2020) and 2.23% (Lukin et al., 2018), higher than the researchers stating that the K content in soy was between 2.5-1.70% (Hellal and Abdelhamid, 2013). The reason for the differences between studies in terms of K values depends on many factors. Plant species, age, developmental period, root growth, soil properties, types and amounts of elements available in the soil and applied agricultural methods are effective on the amount of K in plants (Rhem and Schimit, 2002; Karaman, 2012).

In terms of K ratio, fertilizer treatment x variety interaction was found to be statistically insignificant (*Table 3*). According to fertilizer treatment x variety interaction, the highest amount of K (3.91%) was obtained from Mersoy with T2 and T3, the lowest amount of K (3.53%) from Mersoy with T5 (*Table 4*).

Calcium (Ca)

The effect of fertilizer treatment on Ca ratio was found to be statistically insignificant (*Table 3*). The highest Ca ratio (4.10%) was obtained from T5 and the lowest Ca ratio (3.44%) from T1 (*Table 4*).

The difference between varieties in terms of Ca ratio was found to be statistically insignificant (*Table 3*). In the study, the highest amount of Ca was obtained from Ilksoy and the lowest amount of Ca from Mersoy. The Ca amounts of the varieties ranged between 3.67-3.66% (*Table 4*). These values were found to be higher than the researchers stating that the Ca rate in soy was between 2.5-1.70% (Hellal and Abdelhamid, 2013) and 0.81-0.51% (Mudlagiri et al., 2020). The reason for the difference between the results of the researches is that the Ca content of plants varies depending on the effect of various factors such as environmental conditions, plant variety and plant parts (Kacar and Katkat, 2010).

In terms of Ca ratio, fertilizer treatment x variety interaction was found to be statistically insignificant (*Table 3*). According to fertilizer treatment x variety interaction, the highest amount of Ca (4.14%) was obtained from Mersoy with T5 and the lowest amount of Ca (3.21%) from Mersoy with T1 (*Table 4*).

Magnesium (Mg)

The effect of fertilizer treatment on Mg ratio was found to be statistically insignificant (*Table 3*). The highest Mg ratio (1.17%) was obtained from T2 and the lowest Mg ratio (1.10%) was obtained from T1 (*Table 4*).

The difference between the varieties in terms of Mg ratio was statistically significant at 1% level (*Table 3*). In the study, the highest amount of Mg was obtained from Ilksoy and the lowest amount of Mg from Mersoy. The Mg amounts of the varieties ranged between 1.18-1.08% (*Table 4*). These values were found to be higher than the researchers stating that the Mg rate in soybean was between 1.00-0.26% (Hellal and

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Abdelhamid, 2013) and 0.54-0.45% (Mudlagiri et al., 2020). The reason why Mg values were found higher than other researchers is due to the fact that Mg concentration in plant tissues varies according to plant species and variety, plant developmental stage, environmental and climatic factors (Wilkson, 1987; Karaman, 2012). In addition, legumes accumulate Mg in their aboveground parts at a higher rate than herbaceous plants (Woodruff, 1972).

In terms of Mg ratio, fertilizer treatment x variety interaction was found to be statistically insignificant (*Table 3*). According to the fertilizer treatment x variety interaction, the highest amount of Mg (1.19%) was obtained from Ilksoy with T4 and T5, the lowest amount of Mg (1.03%) from Mersoy with T1 (*Table 4*).

Determination of microelements

Boron (B)

The effect of fertilizer treatment on the B ratio was found to be statistically significant at 1% level (*Table 5*). According to the research results, the highest B ratio (46.3 mg kg^{-1}) was obtained from T5 and the lowest B ratio (19.7 mg kg^{-1}) from T3 (*Table 6*).

Table 5. *Results of variance analysis for microelements in soybean varieties (F values)*

Source of variation	Degress of freedom	B (mg kg^{-1})	Cu (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Mo (mg kg^{-1})	Zn (mg kg^{-1})
Replications	2	0.13	0.18	1.14	0.34	0.24	3.58
FT (A)	4	113.35**	27.31**	15.96**	123.93**	69.87**	24.01**
Error (1)	8	-	-	-	-	-	-
Variety (B)	1	28.55**	1025.9**	166.37**	10.96**	206.22**	342.50**
AxB Interaction	4	431.39**	201.75**	19.34**	76.55**	64.97**	153.98**
Error (2)	10	-	-	-	-	-	-
General	29	-	-	-	-	-	-

**: Significant at alfa level %1, FT: Fertilizer Treatment

The difference between the varieties in terms of B ratio was statistically significant at 1% level (*Table 5*). In the study, the highest amount of B was obtained from Ilksoy and the lowest amount of B from Mersoy. The B amounts of the varieties ranged between 29.4-26.2 mg kg^{-1} (*Table 6*). These values were lower than the researchers stating that the amount of B in soybean leaves was between 141.76-83.70 mg kg^{-1} (Bruns, 2017) and 90.50-71.36 mg kg^{-1} (Mudlagiri et al., 2020). The reason why B values are lower than other researchers may be due to factors such as plant structure differences, soil and climate (Karaman, 2012).

In terms of B ratio, fertilizer treatment x variety interaction was found to be statistically significant at 1% level (*Table 5*). According to fertilizer treatment x variety interaction, the highest amount of B (72.7 mg kg^{-1}) was obtained from Ilksoy with T5 and the lowest amount of B (14.4 mg kg^{-1}) from Ilksoy with T3 (*Table 6*).

Copper (Cu)

The effect of fertilizer treatment on the Cu ratio was found to be statistically significant at 1% level (*Table 5*). According to the research results, the highest Cu ratio

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(81.3 mg kg^{-1}) was obtained from T5 and the lowest Cu ratio (57.9 mg kg^{-1}) from T3 (*Table 6*).

Table 6. *Mean values and LSD grouping of the soybean varieties belonging to microelements (mg kg^{-1})*

Characters	**B (mg kg^{-1})**			**Cu (mg kg^{-1})**			**Fe (mg kg^{-1})**		
Varieties	Mersoy	Ilksoy	Mean	Mersoy	Ilksoy	Mean	Mersoy	Ilksoy	Mean
Treatments									
T1	32.8b**	17.7ghı	25.3b**	52.7g**	82.8d	67.7b**	600.1fgh**	865.9a	733.0a**
T2	30.0bc	20.7efg	25.3b	52.5g	92.6ab	72.6b	747.7c	703.7cde	725.7a
T3	25.0d	14.4ı	19.7c	66.5ef	49.4g	57.9c	516.9h	669.7c-f	593.3b
T4	23.3de	21.6def	22.5bc	50.9g	88.6bc	69.8b	519.7h	720.7cd	620.2b
T5	19.9e-h	72.7a	46.3a	67.8e	94.8a	81.3a	658.0d-g	859.1ab	758.6a
Mean	26.2b**	29.4a		58.1b**	81.6a		608.5b**	763.8a	
	LSD(FT) at %1=4.713			LSD(FT) at %1=7.659			LSD(FT) at %1=88.008		
	LSD(V) at %1=1.919			LSD(V) at %1=2.330			LSD(V) at %1=38.169		
	LSD(FTxV) at %1=4.291			LSD(FTxV) at %1=5.210			LSD(FTxV) at %1=85.349		
Characters	**Mn (mg kg^{-1})**			**Mo (mg kg^{-1})**			**Zn (mg kg^{-1})**		
Varieties	Mersoy	Ilksoy	Mean	Mersoy	Ilksoy	Mean	Mersoy	Ilksoy	Mean
Treatments									
T1	190.1gh**	242.1cde	216.1b**	3.33efg**	4.58ab	3.96b**	61.4cde**	62.3bcd	61.9a**
T2	230.7ef	194.5g	212.6b	3.76d	4.97a	4.36a	39.9ghı	69.6b	54.8bc
T3	155.9ı	100.4i	128.1c	2.87h	3.64de	3.26c	43.4g	67.6bc	55.5b
T4	294.3ab	250.6cd	272.4a	3.63def	2.72h	3.18c	58.8def	42.0gh	50.4c
T5	256.2c	296.8a	276.5a	2.88h	4.56bc	3.72b	30.3ı	93.6a	62.0a
Mean	225.2b**	216.9b		3.29b**	4.09a		46.8**	67.0a	
	LSD(FT) at %1=25.608			LSD(FT) at %1=0.281			LSD(FT) at %1=4.804		
	LSD(V) at %1=8.212			LSD(V) at %1=0.177			LSD(V) at %1=3.472		
	LSD(FTxV) at %1=18.363			LSD(FTxV) at %1=0.395			LSD(FTxV) at %1=7.763		

Treatments: (T1: Control (no fertilizer), T2: Urea, T3: DAP, T4: Microbial Fertilizer (MBF)+T2, T5:(MBF+T2+T3), **: Significant at alfa level %1

The difference between the varieties in terms of Cu ratio was statistically significant at 1% level (*Table 5*). In the study, the highest amount of Cu was obtained from Ilksoy and the lowest amount of Cu from Mersoy. The Cu amounts of the varieties ranged between 81.6-58.1 mg kg^{-1} (*Table 6*). These values were found to be higher than the researchers stating that the Cu amount was between 12.86-8.31 mg kg^{-1} (Bruns, 2017), 1.94 mg kg^{-1} (Lukin et al., 2018) and Cu amount was between 9.50-5.50 mg kg^{-1} (Mudlagiri et al., 2020) in soybean leaves and straw. The reason why the results of the study differed from those of other researchers may be due to the variability of Cu content of soils. Indeed, Gomes et al. (2021) reported that Cu content varied between 10-150 mg kg^{-1} in soya bean leaves grown in soils containing different Cu levels (11.2, 52.31, 79.42, 133.53, 164.00, 205.10 or 243.86 mg kg^{-1}).

In terms of Cu ratio, fertilizer treatment x variety interaction was found to be statistically significant at 1% level (*Table 5*). According to fertilizer treatment x variety

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interaction, the highest Cu amount (94.8 mg kg^{-1}) was obtained from Ilksoy with T5 and the lowest Cu amount (49.4 mg kg^{-1}) from Ilksoy with T3 (*Table 6*).

Iron (Fe)

The effect of fertilizer treatment on the Fe ratio was found to be statistically significant at 1% level (*Table 5*). According to the research results, the highest Fe ratio (758.6 mg kg^{-1}) rate was obtained from T5 and the lowest Fe ratio (593.3 mg kg^{-1}) from T3 (*Table 6*). Thus, in a study conducted on soybean, a significant increase in leaf Fe content was observed with the application of bacteria and phosphorus (Oden, 2012).

The difference between the varieties in terms of Fe ratio was statistically significant at 1% level (*Table 5*). In the study, the highest amount of Fe was obtained from Ilksoy and the lowest amount of Fe from Mersoy. The Fe amounts of the varieties ranged between 763.8-608.5 mg kg^{-1} (*Table 6*). These values were found to be higher than the researchers stating that the amount of Fe in soy leaves was between 197-67.77 mg kg^{-1} (Mudlagiri et al., 2020) and 552.92-174.72 mg kg^{-1} (Bruns, 2017). The reason why the results of the research are higher than other literature may be due to the application, variety and different growth conditions (Kacar and Katkat, 2010).

In terms of Fe ratio, fertilizer treatment x variety interaction was found to be statistically significant at 1% level (*Table 5*). According to the fertilizer treatment x variety interaction, the highest amount of Fe (865.9 mg kg^{-1}) was obtained from Ilksoy with T1 and the lowest amount of Fe (516.9 mg kg^{-1}) from Mersoy with T3 (*Table 6*).

Manganese (Mn)

The effect of fertilizer treatment on the Mn ratio was found to be statistically significant at 1% level (*Table 5*). According to the research results, the highest Mn ratio (276.5 mg kg^{-1}) was obtained from T5 and the lowest Mn ratio (128.1 mg kg^{-1}) from T3 (*Table 6*).

The difference between the varieties in terms of Mn ratio was statistically significant at 1% level (*Table 5*). In the study, the highest amount of Mn was obtained from Mersoy and the lowest amount of Mn from Ilksoy. The Mn amounts of the varieties ranged between 225.2-216.9 mg kg^{-1} (*Table 6*). These values were found to be lower than the researchers stating that the amount of Mn in soybean leaves was between 726.3-388.5 mg kg^{-1} (Mudlagiri et al., 2020) and higher than the researchers stating that it was between 65.88-55.42 mg kg^{-1} (Bruns, 2017). The differences between the obtained findings and the results of other studies may be due to the variability of Mn content in plants according to plant species and age, soil water and pH (Karaman, 2012).

In terms of Mn ratio, fertilizer treatment x variety interaction was found to be statistically significant at 1% level (*Table 5*). According to the fertilizer treatment x variety interaction, the highest amount of Mn (296.8 mg kg^{-1}) was obtained from Ilksoy with T5 and the lowest amount of Mn (100.4 mg kg^{-1}) from Ilksoy variety with T3 (*Table 6*).

Molybdenum (Mo)

The effect of fertilizer treatment on the Mo ratio was found to be statistically significant at 1% level (*Table 5*). According to the research results, the highest Mo ratio

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(4.36 mg kg^{-1}) was obtained from T2 and the lowest Mo ratio (3.18 mg kg^{-1}) from T4 (*Table 6*).

The difference between the varieties in terms of Mo ratio was statistically significant at 1% level (*Table 5*). In the study, the highest amount of Mo was obtained from Ilksoy and the lowest amount of Mo from Mersoy.The Mo amounts of the varieties ranged between 4.09-3.29 mg kg^{-1} (*Table 6*). These values were higher than the researchers who reported that the Mo content of soya straw was 0.58 mg kg^{-1} (Lukin et al., 2018), and in parallel with the researcher who reported that it was 3-9 mg kg^{-1} in peas and beans. Mo content in plants varies according to variety, climate and soil structure (Karaman, 2012).

In terms of Mo ratio, fertilizer treatment x variety interaction was found to be statistically significant at 1% level (*Table 5*). According to fertilizer treatment x variety interaction, the highest amount of Mo (4.97 mg kg^{-1}) was obtained from Ilksoy with T2 and the lowest amount of Mo (2.72 mg kg^{-1}) from Ilksoy with T4 (*Table 6*).

Zinc (Zn)

The effect of fertilizer treatment on the Zn ratio was found to be statistically significant at 1% level (*Table 5*). According to the research results, the highest Zn ratio (62.0 mg kg^{-1}) was obtained from T5 and the lowest Zn ratio (50.4 mg kg^{-1}) from T4 (*Table 6*).

The difference between the varieties in terms of Zn ratio was statistically significant at 1% level (*Table 5*). In the study, the highest amount of Zn was obtained from Ilksoy and the lowest amount of Zn from Mersoy. The Zn amounts of the varieties ranged between 67.0-46.8 mg kg^{-1} (*Table 6*). These values were found to be lower than the researchers stating that the Zn amount in soybean leaf and straw was between 167.40-134.60 mg kg^{-1} (Mudlagiri, 2020) and higher than the researchers stating that it was 9.07 mg kg^{-1} (Lukin et al., 2018) and compatible with the researchers stating that it was between 66.72-58.05 mg kg^{-1} (Bruns, 2017). The reason why the Zn values obtained in this study were found to be different from the results of other researchers may be due to the differences variety and ecological conditions. Studies have revealed that Zn uptake in some plants is affected by light and metabolic inhibitors (Karaman, 2012) and Zn concentration in plants varies according to different genotypes of the same plant variety (Karaman et al., 2010).

In terms of Zn ratio, fertilizer treatment x variety interaction was found to be statistically significant at 1% level (*Table 5*). According to fertilizer treatment x variety interaction, the highest amount of Zn (93.6 mg kg^{-1}) was obtained from Ilksoy with T5 and the lowest amount of Zn (30.3 mg kg^{-1}) from Mersoy with T5 (*Table 6*).

Conclusions

According to the research results, the highest plant height, plant and root weight, total N and K values were obtained from DAP fertilization and the highest Mg and Mo values from Urea. The results of the study revealed that the addition of nitrogen with microbial fertilizer positively affected the root length and the addition of both nitrogen and phosphorus with microbial fertilizer increased the mineral matter uptake of the plant.

Soybean varieties (Mersoy and Ilksoy) used in the study were tested for the first time in Konya Cumra Province. With this study, it has been aimed to determine the most

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suitable variety that will be adaptable to the conditions of the region and to make recommendations to the local farmers by determining the most suitable fertilizer applications in terms of the examined characteristics in these varieties. In terms of plant height, plant and root weight, total N, P, Mn values, Mersoy; In terms of root length, K, Ca, Mg, B, Cu, Fe, Mo and Zn content, Ilksoy variety came into prominence. With its high mineral content, in animal feeding Ilksoy and with the desired root and ground surface parts and also high nitrogen and phosphorus content as an alternation and green manure plant Mersoy variety seem to be recommended for planting in the region.

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