The Effects of Different Fertilizer Treatments on Kohlrabi (*Brassica oleracea* L. var. gongylodes) Cultivation

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Abstract: The effects of different fertilizers (chemical fertilizer-CF, bacterial formulation- BF, plant activator-PA, seaweed-SW, vermicompost-VC, liquid organic fertilizer-LOF, farm manure –FM and control-C) on the yield, quality and mineral matter content of kohlrabi were examined in 2014-2015. The effect of fertilizers on the parameters examined was found statistically significant. According to the average of the years, the highest plant weight, leaf number, leaf weight, stem yield, stem length, stem diameter, stem dry weight, root fresh weight, root dry weight and vitamin C were obtained from the CF treatment, and other treatments also provide close results to CF. In regard to these parameters, the increases obtained from the treatments as compared to the control were 4.16 (PA) – 43.36% (FM), 0.77 (VC) – 6.54% (FM), 3.94 (SW) – 31.27% (FM), 25.66 (PA) – 54.64% (FM), 3.96 (LOF) – 7.87% (FM), 4.42 (LOF) – 9.60% (VC), 4.16 (LOF)- 22.24% (PA), 9.03 (SW)- 17.16% (VC), 11.86 (SW) – 24.51% (BF) and 3.37 (VC) – 12.45% (SW) respectively, except for CF. According to the average, the stem ratio, stem index, stem dry matter ratio, root dry matter ratio, total soluble solid (TSS) and chlorophyll content were increased to 7.58 (FM) – 19.70% (PA), 1.50 (VC) – 2.26% (SW), 2.35 (LOF) – 5.09% (BF), 0.26 (SW) – 13.87% (LOF), 1.75 (PA) –12.40% (FM) and 1.17 (CF) – 1.37% (SW) as compared to control, respectively. The contents of N, P, K, Na, Mg, Ca, Fe, Mn, Zn, Cu and B considerably increased with treatments as compared to the control. It was determined that the organic origin fertilizers used in the experimented could be used as an alternative to chemical fertilizer for kohlrabi cultivation.

Keywords: Kohlrabi, Fertilizer, Plant growth, Yield, Mineral matter.

INTRODUCTION

Kohlrabi (*Brassica oleracea* L. var. gongylodes) is among the vegetables of the Brassiceae group, which has become popular in recent years and it is not economically produced in large quantities in Turkey, so there is no statistical data. Although there is no information about how long kohlrabi has been produced in Turkey, kohlrabi has been widely cultivated in Central and Northern Europe and America [1-4]. The part of kohlrabi that is considered as a vegetable is the stem of the store, and this feature is the most important feature that distinguishes it from other Brassiceae group vegetables [5]. Kohlrabi is rich in carbohydrate and protein, and the B and C vitamins which are important for human health. Kohlrabi has an average of 85% water, 3.74% nitrogenous substances, 6.99% non-nitrogen substances, 0.54% oil, 0.4% sugar, 1.74% crude fiber and 1.78% ash [6, 7]. Although kohlrabi contains trace amounts of vitamin A and vitamin B5, it is also rich in terms of B1 (0.08 mg), B2 (0.04 mg), vitamin C (50 mg) content [7]. Some researchers, on the other hand, recommend kohlrabi in a balanced diet due to its low calorie value (29 cal 100 g^{-1}) and a good source of K (350 mg 100 g^{-1}) and vitamin C (62 mg 100 g^{-1}) [8]. Researchers have suggested consuming kohlrabi's young leaves at the center of the stem, as the mineral content (especially protein and phosphorus) of kohlrabi leaves is higher than that of the stem [3, 9].

Kohlrabi requires a very short cultivation period of 2-3 months, is resistant to cold, and the use of early varieties as a pre-culture in other plant growth in some countries are the most important features that are preferred in production [10]. Kohlrabi can be grown by seed or seedling. Excessive nitrogenous (N) fertilization increases vegetative growth, delays harvest and causes splitting of kohlrabi [5]. For this reason, fertilization should be done carefully in kohlrabi cultivation.

Fertilization is one of the most important inputs in providing yield and quality in agricultural production. With the fertilization, the plant nutrient elements needed by the plant are given to the growing media increase the productivity of the plant [11]. The lack of organic matter and insufficient nutritional elements in the cultivated soil increases the importance of giving farm manure and other organic fertilizers to the soil. It is known that nutrients such as nitrogen, phosphorus and potassium are important for yield and quality in vegetable production and are constantly decreasing in soils. If these decreasing nutrients are not replaced, product productivity decreases in parallel with decreasing soil fertility [12]. Today, there are many commercial fertilizers used in agricultural production on

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the market. The use of chemical fertilizers is especially high in vegetable cultivation. The excessive use of chemical fertilizers causes the organic matter content of the soil to decrease over time and the physical and chemical structure of the soil to deteriorate. However, in recent years, with the increase of environmental protection awareness and the development of production systems that are friendly to nature and human health, many fertilizers with organic origin have been used instead of these chemical fertilizers. With this study, it was determine the effects of different originate fertilizers on the yield, quality and mineral matter content of kohlrabi.

MATERIAL AND METHOD

In the study, Korist F1 (*Brassica oleracea* L. var. gongylodes) kohlrabi variety was used as plant material. The bacterial formulation in the study (*Bacillus subtilis*-TV17C + *Agrobacterium radiobacter* - A16 + *Bacillus megaterium* M3 + *Pseudomonas putida* – RK142) was obtained from Atatürk University Faculty of Agriculture Plant Protection Department, farm manure (2.4% N, 1.8% K_2O, 2.1% P_2O_5 and 6.3 dSm^{-1} EC) was obtained from Atatürk University Livestock Unit. Plant activator (16% Mg and 13% S), chemical fertilizer (Urea, Triple super phosphate and Potassium sulphate mixture), seaweed (10% organic matter, 1% water soluble potassium oxide, 0.5% alginic acid, 5 ppm gibberellic acid and 10.5-12.5 pH), liquid organic fertilizer (35% organic matter, 14% organic C, 4% N, 3% K_2O, 1% P_2O_5 and 4-6 pH) and vermicompost (20% organic matter, 1% P_2O_5 and 10% humic + fulvic acid) were obtained from the market. Farm manure treatment is calculated according to Gunay [7], other treatments were calculated according to the optimum amounts recommended by the producer company.

Kohlrabi seeds were sown in the first week of April in the first year and in the first week of May in the second year on viols with peat + perlite (2:1/v:v) growing medium. The one-month-old seedlings were planted in the plots in the field. The seedlings were planted in 3x3m (9 m^2) plots with 40x30 cm row spacing and row spacing, with 30 plants per plot.

In chemical fertilization, half of the nitrogen, all of the phosphorus and potassium were applied with seedling planting, and the remaining half of the nitrogen was applied 2 weeks later.

Farm manure was applied by mixing it into the soil before planting seedlings. The first part of the bacterial solution was applied by dipping the seedlings into this solution just before planting and the second application was injected into the seedling root area after 2 weeks. After the powder plant activator was dissolved in water, the first application was made after planting the seedling, and the second application was made 2 weeks later. The first application of seaweed, liquid organic fertilizer and vermicompost was applied after the seedling planting and the second application was applied to the plant root zone after 2 weeks.

Kohlrabi plants were harvested 60 days after planting. Chlorophyll (SPAD) measurements were made by a chlorophyll meter (SPAD – 502, Konica Minolta Sensing, Inc., Japan) in the field before harvest on the leaves of the plants that reached the harvest maturity. Plant weight, leaf number, leaf weight per plant, stem weight, yield, stem ratio, stem length, stem diameter, stem index, stem dry weight, root fresh weight, root dry weight, stem dry matter, vitamin C content (with device of reflectometer-RQflex) and total soluble solid (TSS, with device of Atago P-32) were examined. The dry weights were dried at 65±2 °C for 48 hours, were determined in a precision balance (±0.001 g) and stem samples ground for mineral analysis. In addition, analyzes were made on total nitrogen (N), macro and micro (P, K, Na, Ca, Mg, Fe, Cu, Mn, Zn and B) mineral substance contents in the stem samples which were dried and ground after harvesting. The mineral content of the stem were determined in the spectrophotometer (Optima 2100 DV, ICP/OES; Perkin-Elmer, Shelton, CT) [13-15]. The trial was set up with 3 replications according to the randomized blocks experimental design, the data obtained from the study results were subjected to variance analysis with the help of the SPSS 18 package program, and the differences of the means were determined by Duncan multiple comparison test [16].

RESULTS

In the study, the effects of different fertilizer treatments on plant growth and mineral content in kohlrabi were examined, the study was carried out in field conditions between 2014 and 2015, and as a result of the statistical analysis, the results were given over the average of two years since there was no significant difference between years. The effect of different fertilizer treatments on plant growth and mineral matter content of kohlrabi was statistically significant except for stem index, TSS and chlorophyll value (Figure **1**, Figure **2** and Figure **3**). It was determined that total plant weight was the highest (553.35 g and 547.58 g) with CF and FM treatment and

other treatments increased plant weight compared to the control. While the highest number of leaves occurred in the CF treatment followed by FM. Fertilizer treatments increased the weight of leaves compared to the control. The treatments with the highest leaf weight were CF and FM (154.78 g and 149.25 g, respectively) while the lowest was the control.

Stem weight was found to be the highest in CF (401.75 g) and later in FM (385.51 g) fertilizers ($p < 0.001$). When the stem yield was evaluated, it was observed that while the yield increased (32 t ha^{-1}) with CF, fertilizers significantly increased the stem yield compared to the control. The stem yield in PA and LOF treatments was higher (0.79% and 0.81%) than control. In the study, the effect of fertilizers on the stem length is important, the maximum value (80.09 mm) was obtained in CF treatment, while fertilizer treatments increased the stem length compared to the control. Fertilizer treatments increased the stem diameter significantly compared to the control, the highest stem diameter was observed in the CF treatment (101.37 mm) followed by VC treatment (100.08 mm) (Figure **1**).

The effects of the treatments on the stem index were not found to be significant. The stem dry weight with CF was the most (49.00 g) followed by PA treatment (45.84 g). While CF fertilizer provided the highest increase on root fresh weight (13.91 g), other fertilizer treatments also increased root fresh weight significantly compared to the control. Fertilizer treatments significantly increased root dry weight compared to the control. Root dry weight was higher in CF treatment than the other treatment.

Vitamin C was found to be increased with treatments compared to the control. It was determined that fertilizers (especially PA, FM, SW and VC) increased the TSS compared to the control. There were no statistically significant differences in the effects of the treatments on TSS and chlorophyll content (Figure **2**).

Kohlrabi N content was the most in VC treatment (2.06%), while the lowest was obtained from control (1.44%). BF (1850.08 mg kg^{-1}), FM (1865.48 mg kg^{-1}) and VC (1908.34 mg kg^{-1}) treatments were the treatments with the highest P content. The lowest P content in kohlrabi was obtained from the control plants. While the content of K was the most in the FM treatment (16512.52 mg kg^{-1}), the lowest amount of K was obtained from the control (13677.65 mg kg^{-1}). BF (1057.03 mg kg^{-1}) treatment gave the highest Na content, while the lowest Na amount in kohlrabi was obtained from the CF. Kohlrabi had the highest Ca content (13616.70 mg kg^{-1}) in VC treatment. The lowest Ca content was obtained from control plants. The maximum Mg content (584.69 mg kg^{-1}) was occurred in the CF treatment, and the lowest in the SW treatment. Kohlrabi Fe content was the most (148.72 mg kg^{-1}) in BF treatment, while the lowest Fe content (119.58 mg kg^{-1}) was in control. While the most Cu amount was in BF treatment (23.25 mg kg^{-1}), the lowest Cu amount occurred in SW treatment. The highest amount of Mn was found in VC treatment (44.93 mg kg^{-1}). While the highest Zn amount was in the VC treatment (40.29 mg kg^{-1}), the lowest Zn amount was obtained from the control group. The highest amount of kohlrabi B was obtained from the VC treatment (13.23 mg kg^{-1}) and the lowest amount of B was obtained from the control group (Figure **3**).

DISCUSSION AND CONCLUSION

In this study we conducted in Erzurum (Eastern of Anatolia) conditions based on previous studies [17]. The effects of different fertilizers on the yield, quality and mineral content of the Korist F1 kohlrabi variety as one of the varieties with high adaptability to the regional conditions were investigated. In the study, it was determined that the effects of fertilizers on kohlrabi plant weight, leaf number, leaf weight, stem yield, stem length, stem diameter, stem ratio, stem index, stem dry weight, root fresh weight, root dry weight, TSS, vitamin C and chlorophyll value to be statistically significant at different levels. The highest increases in terms of plant weight, leaf number, leaf weight, stem yield, stem length, stem diameter, stem dry weight, root fresh weight, root dry weight and vitamin C were obtained from the CF treatment. Considering the average data in terms of these parameters, the highest and lowest increases compared to the control are respectively: 4.16% (PA) - 43.46 (FM), 0.77% (VC) - 6.54 (FM), 3.94% (SW) - 31.27 (FM), 25.66% (PA) - 54.64 (FM), 3.96% (LOF) - 7.87 (FM), 4.42% (LOF) - 9.60 (VC), 4.16% (LOF) - 22.24 (PA), 9.03% (SW) - 17.16 (VC), 11.86% (SW) - 24.51 (BF) and 3.37% (VC) - 12.45 (SW). It has been determined by many researches that there has been a significant increase in yield with chemical fertilization. However, the damage caused by the chemical and synthetic fertilizers used is now well known. Studies are intensively carried out on many alternative fertilizers that can be used instead of chemicals in agricultural production. As a matter of fact, in this study, it was determined that the organic origin fertilizers we used had effects close to chemical fertilizers, and significant increases were obtained especially with farm manure. Similarly, in a study conducted on lettuce, it was determined that organic

fertilizers such as farm manure and poultry manure, significantly affected plant growth and yield, and the highest number of leaves, plant height and total yield were obtained from the treatment of 10t ha^{-1} poultry manure [18].

In a study, the effects of fertilization on yield and quality parameters of kohlrabi were investigated, and it was determined that the stem weight of kohlrabi was 39.2% lower than urea and other treatments in control. In addition, the researchers found that there was no significant difference (274–291 mg kg^{-1}) between treatments in terms of kohlrabi ascorbic acid content [19]. Lošák *et al*. [20] determined that the stem weight of kohlrabi was lower in digestate fertilization compared to the control. In addition, it was stated that digestate treatment used with P increased the stem yield by 11.0-14.3% compared to only digestate treatment. Ahmed *et al*. [21] reported that the highest stem weight (430.80 g), stem diameter (10.23 cm), number of leaves per plant (14.38) and stem yield (25850 kg ha^{-1}) have obtained from 160-120-160 kg ha^{-1} NPK. Uddin *et al*. [22] determined that plant height, leaf length, leaf width, fresh leaf weight per plant, stem diameter, stem

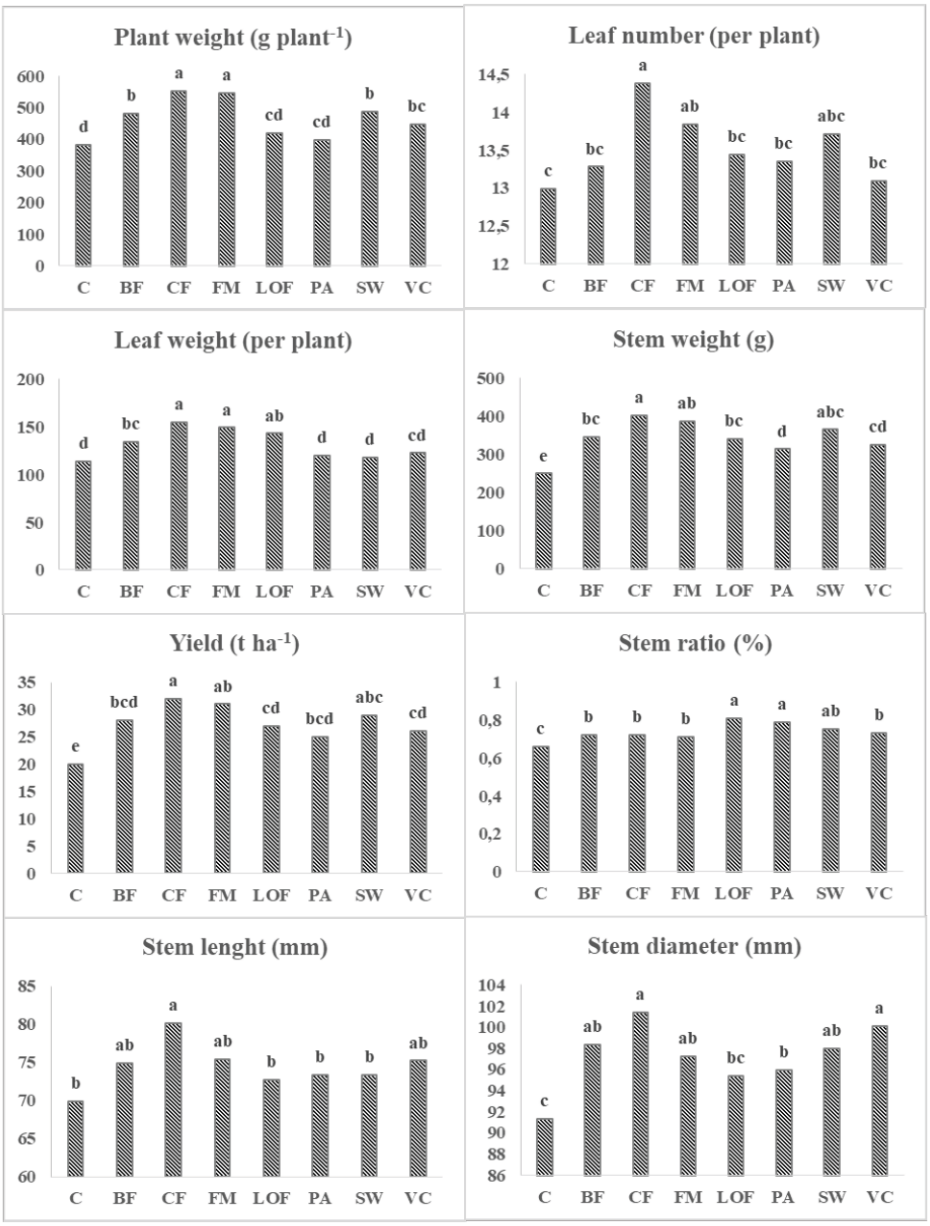

Figure 1: The effects of different fertilizer treatments on kohlrabi plant weight, leaf number, leaf weight, stem weight, yield, stem ratio, stem length and stem diameter. There is no statistical difference between the means shown with the same letter on the columns.

C: control, CF: chemical fertilizer, BF: bacterial formulation, PA: plant activator, FM: farm manure, SW: seaweed, LOF: liquid organic fertilizer, VC: vermicompost.

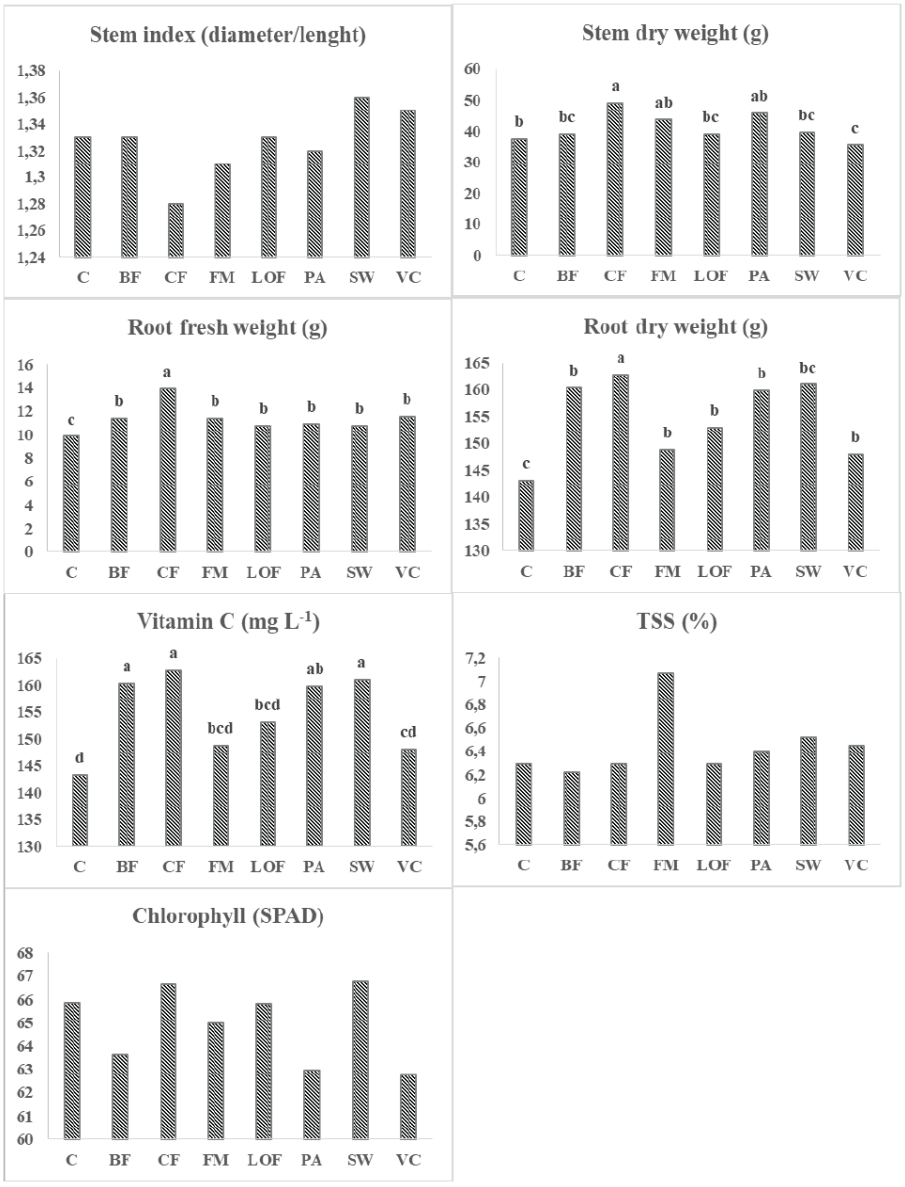

Figure 2: The effects of different fertilizer treatments on kohlrabi stem index, stem dry weight, root wet weight, root dry weight, vitamin C, TSS and chlorophyll value. There is no statistical difference between the means shown with the same letter on the columns. There is not statistical difference between treatments in the means without lettering.

C: control, CF: chemical fertilizer, BF: bacterial formulation, PA: plant activator, FM: farm manure, SW: seaweed, LOF: liquid organic fertilizer, VC: vermicompost.

weight and yield per hectare of kohlrabi increased with different organic fertilizers, especially poultry manure. In addition, it was determined in a different study that farm manure also increases plant growth and yield in kohlrabi [23]. It has been concluded that organic fertilizers, which are considered as an alternative to chemical fertilizers can be beneficial for producers in terms of efficient and quality production. In this study, besides the effects of different fertilizer treatments on vegetative growth parameters in kohlrabi cultivation in Erzurum conditions, the effects on the mineral substance content of kohlrabi were also examined. In our study, the mineral element contents of kohlrabi differed with fertilizer treatments, the highest results were obtained with vermicompost treatments for kohlrabi in terms of N, P, Ca, Mn, Zn and B. Vermicompost has humic and fulvic acid, which can cause top increase uptake of plant nutrient elements [24]. These effects may also vary depending on the plant species. As a matter of fact, it was determined that the N, P, K, Ca and Mg content of lettuce were not statistically affected with vermicompost treatments [25].

The effects of the fertilizers used in our study on the plant mineral element contents differed according to the treatments, and this situation is thought to occur

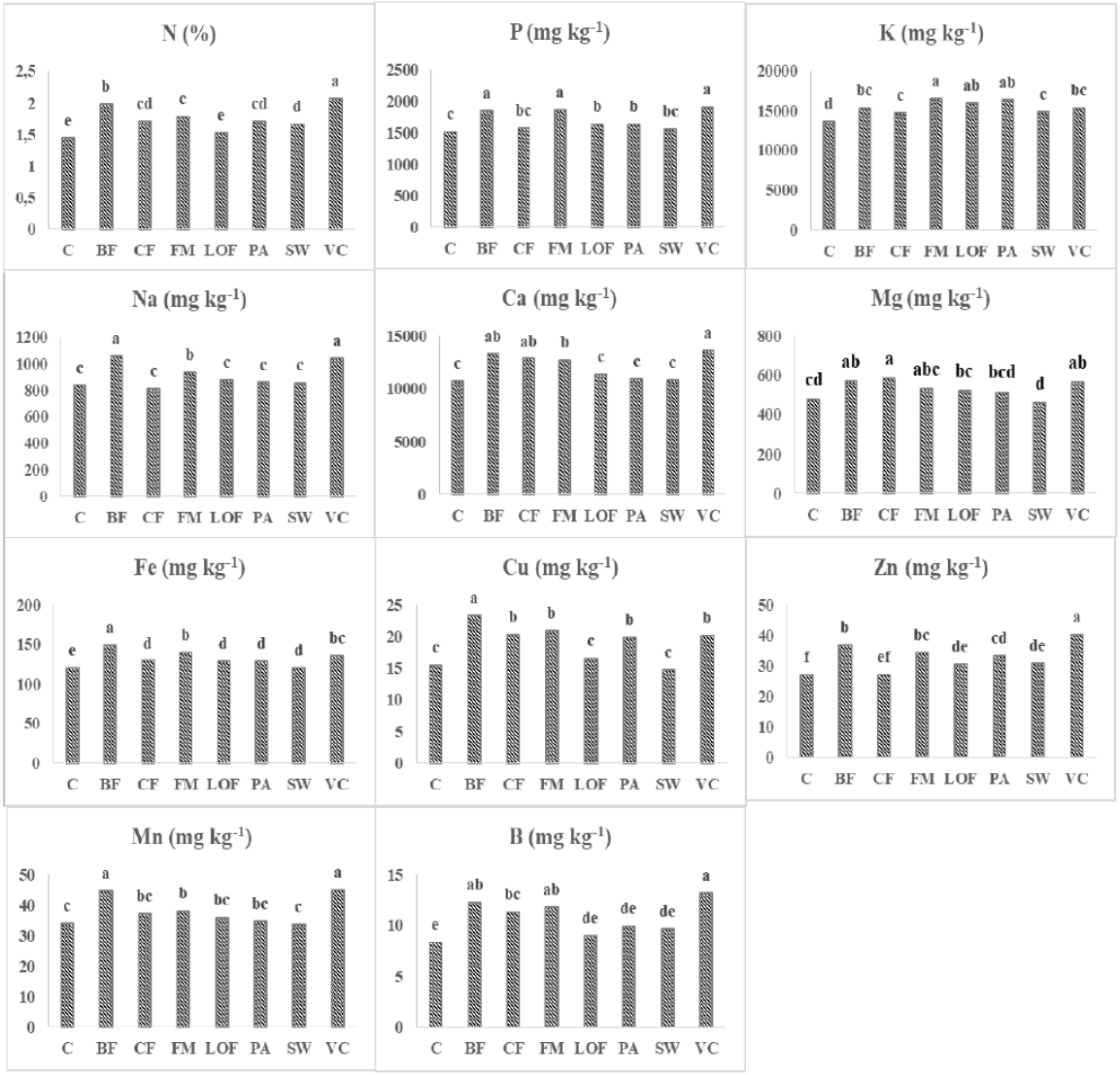

Figure 3: Effects of different fertilizer treatments on mineral substance content of kohlrabi. There is no statistical difference between the means shown with the same letter on the columns.

C: control, CF: chemical fertilizer, BF: bacterial formulation, PA: plant activator, FM: farm manure, SW: seaweed, LOF: liquid organic fertilizer, VC: vermicompost.

according to the content of the fertilizer and ecological conditions. Hossain and Ryu [26] determined that 13t ha^{-1} of organic fertilizer treatment in lettuce provides an increase in N, P, K, Ca, Mg and Na intake compared to the control. It was determined that N content of rocket was increased by biofarm humus and palm organic fertilizers, P amount by biofarm humus manure and K by biofarm humus and cattle manure [27]. With the treatment of bacteria, an increase in the mineral content of kohlrabi was obtained. Similarly, Khosravi *et al*. [28] investigated the effects of PGPR (plant growth promoting rhizobacteria), vermicompost and phosphate fertilizers in lettuce in their study. Researchers have determined that the treatments increase the dry matter content of the plant and the intake of some elements. They also reported that the combination of PGPR and phosphate significantly increased the amount of plant dry matter and the uptake of N, K, P, Mn and Zn. The effects of fertilizers on the plant mineral substance content are due to the fertilizer type and content. It has created significant differences in mineral contents according to the properties of the fertilizer used in previous studies. In a study conducted with fish manure in lettuce, it was determined that the highest amount of K, Ca, Mn, Fe and Si was obtained at a dose of 200 kg ha^{-1} of fish manure, while the highest P, Mg and Zn content was obtained from fish manure alone and in combination with mineral fertilizers [29].

As a result, the effects of different fertilizers on yield and quality of kohlrabi were studied. It can be suggested that especially the use of farm manure,

bacterial formulation, seaweed and vermicompost provide significant benefits in kohlrabi cultivation. They can be used very easily in kohlrabi production, since yield and quality are obtained close to chemical fertilization. These organic origin fertilizers can reduce environmental and health risk caused by chemical fertilizers.

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