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Effects of Organic Fertilizers on Plant Growth, Yield and Mineral Content of Lettuce (Lactuca sativa L.)

Araştırma Makalesi

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Lettuce, plant growth, mineral content, nitrate

Abstract

The effects of two different organic fertilizers, which differ ratio according to the NPK content, on plant growth, yield and mineral content in lettuce (Lactuca sativa L. cv. Yedikule) were examined in this study. In addition, nitrate contents were determined. The study was conducted as a pot experiment in the greenhouse conditions, and two organic fertilizers named CombiPower® (8-8-8) and SuperPower® (10-25-0) were used. Chlorophyll reading value, stem diameter, plant height, number of leaves, vitamin C, root and plant fresh and dry weights and mineral contents of leaf and roots were examined in lettuce. Organic fertilizers used in the study increased chlorophyll reading value, stem diameter, plant height, leaf number, vitamin C, plant fresh weight, plant dry weight, root fresh weight and root dry weight compared to the control with ratio of 43-69%, 71-75%, 79-85%, 41-46%, 136-165%, 261-412%, 147-185%, 64-100% and 33-67%, respectively. In addition, it was determined that the mineral contents increased with fertilizers in plant leaves and roots. With applications, an increase in root and leaf nitrate content has also occurred compared to control, but this increase was not at critic levels. It is thought that the fertilizers used in this study may have important benefits in terms of plant growth and yield in lettuce cultivation.

Anahtar Kelimeler
Marul, bitki gelişimi, mineral içerik, nitrat

Marulda organik gübre kullanımı: bitki gelişimi ve mineral madde içeriği üzerine etkisi

Özet

Bu çalışmada, NPK içeriğine göre oran farklılığı gösteren iki farklı organik gübrenin marulda (Lactuca sativa L. cv. Yedikule) bitki gelişimi ve mineral madde ve nitrat içeriği üzerine etkileri incelenmiştir. Sera koşullarında saksı denemesi olarak yürütülen çalışmada, CombiPower® (8-8-8) ve SuperPower® (10-25-0) isimli iki organik gübre kullanılmıştır. Marulda yaprak klorofil okuma değeri, gövde çapı, bitki boyu, yaprak sayısı, C vitamini, kök ve bitki taze ve kuru ağırlıkları ile yaprak ve köklerin mineral içerikleri incelenmiştir. Çalışmada kullanılan organik gübreler, kontrole göre klorofil okuma değeri, gövde çapı, bitki boyu, yaprak sayısı, C vitamini, bitki taze ağırlığı, bitki kuru ağırlığı, kök taze ağırlığı ve kuru kök ağırlığını sırasıyla % 43-69, % 71-75,% 79-85,% 41-46,% 136-165,% 261-412,% 147-185,% 64-100 ve % 33-67 oranında artırdı. Ayrıca, bitki yaprak ve köklerinde gübreler ile mineral içeriklerinin arttığı tespit edilmiştir. Uygulamalar ile kontrole göre kök ve yaprak nitrat içeriğinde de artış meydana gelmiş ancak bu artış kritik düzeyde olmamıştır. Bu çalışmada kullanılan gübrelerin marul yetiştiriciliğinde bitki gelişimi ve verimi açısından önemli faydaları olabileceği düşünülmektedir.

1. INTRODUCTION

The fertilizers used in vegetable growing increase yield and production in important levels. However, the use of excess fertilizer in agriculture, especially chemical fertilizers, causes the increase in the level of pollutants, the decrease in soil fertility, the increase in soil and groundwater pollution and increase in nitrate concentration of vegetable leaves (Parante et al., 2006; Hernandez et al., 2010: Saleh et al., 2010). However, today, organic farming and the use of fertilizers according to the crop needs in agriculture can cause these problems to be alleviated.

Vegetables occupy an important place in human nutrition especially in terms of mineral substances and vitamins they contain. It is stated that vegetables can provide more than 70-85% of daily nitrate intake (Premuzic et al., 2004; Gangolli et al., 1994). Especially leafy vegetables as lettuce are known to accumulate more nitrates. Although it has a short growing period, high nitrate intake occurs due to the need for high doses of N in lettuce (Pôrto et al., 2008; Chiesa et al., 2009; Saleh et al., 2010; Parente et al., 2006).

In the other hand, excessive nitrate has harmful effects for human health and environment. Increasing demand for agricultural products that do not contain chemical residues enabled production models to reduce this problem in production. N doses suitable for lettuce cultivation or organic production systems should be preferred to prevent nitrate accumulation (Pôrto et al., 2008).

Optimal fertilization application and use of N, P and K have important to increase yield and quality of agriculture crops, and decreased production costs (Zandvakili et al., 2019a). Lettuce positively responses to organic matter in soil. Lettuce grows fast in soils rich in organic matter and reaches harvest maturity in a short time (Vural et al., 2000). It has been reported that inorganic fertilization causes three times more nitrate accumulation in lettuce and salads than organic fertilization (Özgen et al., 2011). In addition, the physical and chemical structure of the soil can be improved by increasing microorganism activities with the use of organic fertilizers (Özer 2016). Therefore, the use of organic fertilizers besides chemical fertilizers in lettuce cultivation should be expanded (Kibar, 2018). In this study, the effects of two different organic fertilizers according to the amount of NPK in their content on the plant growth and the mineral content in lettuce were investigated, and the effects of these fertilizers in terms of nitrate content of plant were examined.

2. MATERIALS AND METHODS

The study was carried out as a pot study in the greenhouse. The study was conducted under controlled greenhouse conditions (natural light conditions, approximate day/night temperatures of 32/19ºC, and 45% relative humidity) during the spring of 2019. In the study, lettuce (Lactuca sativa L. cv. Yedikule) was used as plant material. The effects of two different organic fertilizers [CombiPower® -CP (total N: 8%, urea N: 5%, soluble P2O5 in water: 8% and soluble K2O in water: 8%) and SuperPower®-SP (total N: 10%, urea N: 10%, soluble P2O5 in water: 25%)] were examined.

Seeds were sown in multiple seedling pots with peat, then three true leaf seedlings were transplanted to 9 L plastic pots filled with mixture of soil:sand (2:1, v:v). The pots were placed randomly in the greenhouse. The study was done using a factorial experiment in a randomized plot design with three replications and 4 plants each in pots.

Fertilizer applications were started after planting seedlings. Applications were made in irrigation with prepared solutions (5 ml L-1) every two weeks. Chlorophyll reading value (SPAD) was measured before the plants were harvested, then various measurements (stem diameter, plant height, leaf number, vitamin C, plant fresh and dry weight, root fresh and dry weight) were made during harvest.

The leaf greenness of the tomato plants for chlorophyll reading value (CRV) was determined by a portable chlorophyll meter (SPAD-502; Konica Minolta Sensing, Inc., Japan).

Ascorbic acid (Vitamin C) content in samples was quantified with a Merck reflectometer set (Merck RQflex).After the plant leaf and root samples were dried at 65°C, they were used for mineral analysis. To determine the total N, Kjeldahl method was used with a Vapodest 10 Rapid Kjeldahl Distillation Unit (Gerhardt, Konigswinter, Germany). To determine the mineral (P, K, Ca, Mg, S, Na, Mn, Fe, Cu, Cl and B) concentrations of leaves and roots was used an inductively coupled plasma spectrophotometer (Optima 2100 DV; Perkin-Elmer, Shelton, CT) and were done according to methods of Bremner (1996), Mertens, (2005a; 2005b). The nitrate content of leaf and root of plant were determined to methods of AOAC (2005). The SPSS program was used to evaluate the measured data (SPSS, 2010). The differences among the means were compared using the Duncan multiple tests (DMRT).

3. RESULTS AND DISCUSSION

In the study, the effects of treatments on plant growth in lettuce were statistically significant (Table 1). Applications increased chlorophyll reading value (SPAD) compared to control, the highest SPAD was obtained from CP. While the highest stem diameter and vitamin C were in CP application, the highest plant fresh and dry weight and root fresh and dry weight was obtained in SP application. Also plant height and leaf number increased with fertilizers. All fertilizers increased chlorophyll reading value, stem diameter, plant height, leaf number, vitamin C, plant fresh weight, plant dry weight, root fresh weight and root dry weight compared to the control with ratio of 43-69%, 71-75%, 79-85%, 41-46%, 136-165%, 261-412%, 147-185%, 64-100% and 33-67%, respectively. Organic fertilizer has important effects on plant growth and production. CP and SP with organic characters increased plant growth of lettuce.

Table 1. Effects of fertilizer on some plant growth parameters of lettuce

Fertilizer	Chlorophyll reading value (SPAD)	Stem diameter (mm)	Plant Height (cm)
Control	19,53 c*	6,56 b	10,33 b
CP	33,10 a	11,50 a	18,54 a
SP	27,97 b	11,20 a	19,15 a
	P<0,001	P<0,01	P<0,001
	Leaf number	Vitamin C (mg/100g)	Shoot fresh weight (g/plant)
Control	14,43 b	156,67 c	16,46 c
CP	20,28 a	415,00 a	59,41 b
SP	21,00 a	370,00 b	84,25 a
	P<0,01	P<0,001	P<0,001
	Shoot dry weight (g/plant)	Root fresh weight (g/plant)	Root dry weight (g/plant)
Control	1,56 c	2,89 c	0,33 c
CP	3,85 b	4,75 b	0,44 b
SP	4,44 a	5,79 a	0,55 a
	P<0,001	P<0,001	P<0,001

*Data fallowed by a different letter in column were different according to DMRT (P<0,001).

Table 2. Effects of fertilizer on mineral content of lettuce

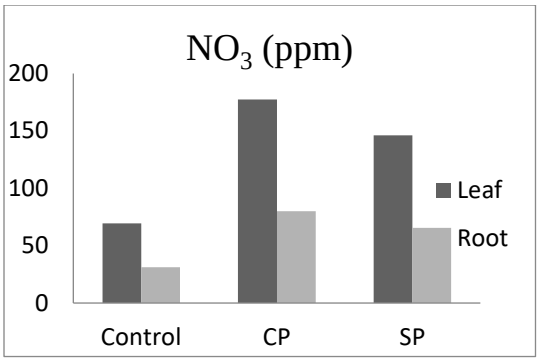
Fertilizer	Leaf	Root	Leaf	Root	Leaf	Root
		N (%)		P (%)		K (%)
Control	2,44 b*	1,16 b	0,25 b	0,11 b	1,14 b	0,51 c
CP	3,78 a	1,69 a	0,38 a	0,18 a	2,38 a	1,00 a
SP	3,54 a	1,59 a	0,36 a	0,16 a	1,95 a	0,88 b
	P<0,001	P<0,001	P<0,01	P<0,001	P<0,01	P<0,001
		Mg (%)		S (%)		Ca (%)
Control	0,88 b	0,40 b	0,84 b	0,38 b	1,08 c	0,49 c
CP	1,17 a	0,52 a	1,23 a	0,55 a	1,42 a	0,65 a
SP	1,11 a	0,50 a	1,25 a	0,56 a	1,31 b	0,59 b
	P<0,001	P<0,001	P<0,001	P<0,001	P<0,001	P<0,001
		Mn (ppm)		Fe (ppm)		Cu (ppm)
Control	16,67 b	7,33 b	35,00 c	15,70 b	9,00	4,04 b
CP	21,67 a	10,60 a	41,67 b	18,69 b	11,33	4,65 b
SP	24,33 a	11,25 a	49,00 a	22,28 a	12,00	5,72 a
	P<0,01	P<0,01	P<0,001	P<0,01	P>0,05	P<0,01
		Cl (ppm)		B (ppm)		Na (ppm)
Control	137,67 b	61,75 b	17,00 b	7,29 b	146,00 b	65,49 b
CP	165,67 ab	70,98 b	35,00 a	16,03 a	230,00 a	103,16 a
SP	185,67 a	83,28 a	39,00 a	17,49 a	248,33 a	111,39 a
	P<0,05	P<0,01	P<0,001	P<0,001	P<0,05	P<0,001

Similarly, Smith and Hadley (1989), Mohammed et al. (2019), Zandvakili et al. (2019a; 2019b) and Manojlovic et al. (2010) reported that organic fertilizer increased vegetative growth of lettuce in their study.

There were statistically significant increases in mineral matter content in lettuce leaves and roots (Table 2). In addition, leaf mineral content is higher than in roots. Increases in leaf N, P, K, Ca, Mg, S, Na, Mn, Fe, Cu, Cl and B content with applications were 45-55 %, 44-52 %, 71-109 %, 21-31 %, 26-33 %, 46-49 %, 58-70 %, 30-46 %, 19-40 %, 26-33 %, 20-35 % and 106-129 % respectively, compared to control. On the other hand, root N, P, K, Ca, Mg, S, Na, Mn, Fe, Cu, Cl and B increased ratio of 37-46 %, 45-64 %, 73-96 %, 20-33 %, 25-30 %, 45-47 %, 57-71 %, 45-53 %, 19-42 %, 15-42 %, 15-35 % and 120-140 % respectively, compared to control. Leaf and root nitrate contents were also higher with fertilizer applications with 111-156 % and 109-155 % ratios compared to control (Figure 1). N, P, K, Ca and Mg content of leaf and root were high in CP, while S, Na, Mn, Fe, Cu, Cl and B were in SP fertilizer. But both fertilizers were in same statistically group according to

statistically analysis. Zandvakili et al. (2019a; 2019b) reported that organic fertilizer increased in total N of lettuce and gave the height P accumulation and increase the other mineral matter in leaf of lettuce.

Figure 1. Effects of fertilizer on NO_3 content of lettuce



It is a fact that fertilizers have an important effect on vegetable cultivation. Today, many chemical and organic fertilizers obtained from many different sources on the market are used for this purpose. However, it is well known that chemicals especially used in agriculture as the cause of increasing environmental pollution and some diseases in recent years. Therefore, fertilizers used in agricultural production are also desired to be effective and most importantly reliable. In addition, instead of unconscious fertilizing, fertilization applications should be provided according to the plant need. It is aimed to give sufficient amount of mineral substances needed by the plant and to prevent excessive use of mineral substances and fertilizers. There are two different organic fertilizers used in this study, both of which have had a positive effect on lettuce. Of these, CP that has a lower rate of NPK content showed a similar effect with another fertilizer, SP.

Similarly, it has been determined that lettuce plant growth and yield were higher in different fertilizers especially with high N content (Smith and Hadley, 1989; Parente et al., 2006; Pavlou et al., 2007; Chiesa et al., 2009; Oliveira et al., 2009; Hernandez et al., 2010; Barros Júnior et al., 2011; Zandvakili et al., 2019a). The content of vitamin C (ascorbic acid) was higher with fertilizers compared to the control. Similarly, Chiesa et al. (2009) determined that ascorbic acid content of lettuce grown in fall-winter season increased with vermicompost and urea fertilizers, which have the highest N level especially. On the other hand, the researchers stated that chemical fertilizer decreased ascorbic acid content of lettuce independently of the N level in spring season.

Nitrate content of lettuce leaf and root increased with fertilizers, but this increase was below the upper limits stated by the European Commission (3000-5000 mg NO3 kg-1 for protected and open-grown Lactuca sativa L. (European Union, 2011). It can be said that the fertilizers used in this study do not cause excessive nitrate accumulation. Similarly, Parente et al. (2006) reported that nitrogen fertilization increased the nitrate content in leaves of lettuce but this nitrate levels were below the limits. It was determined that nitrate content on leaf, stem and root of lettuce increased linearly with nitrogen and manure fertilization in other study (Pôrto et al., 2008). As a matter of fact, it is known that the fertilizers used can affect the nitrate content of the crop. Pavlou et al. (2007) and Chiesa et al. (2009) stated that nitrate concentration in lettuce leaves depends on fertilizer type and dose and growing season. It was expressed that organic fertilizers regulate the nitrate content of lettuce (Manjlovic et al., 2010).

With the fertilizers used in the study, significant increases have occurred in both leaf and root mineral material content. In parallel with these increases, plant development has also increased. Similarly, Hernandez et al. (2010) determined that the content of lettuce leaf N and K varies with the application of urea, and that the content of leaf Ca, Mg and Mn increases with organic fertilizers. In addition, researchers determined that high Mg, Fe, Zn and Cu occur in lettuce leaves with vermicompost application and lower Na content compared to compost. As a result, organic fertilizers used in the study increased the growth of seedlings in lettuce with the increase in plant mineral matter content.

4. CONCLUSION

In the study, two organic fertilizers that differ in NPK content were used, and the increasing effects of fertilizers on lettuce in terms of plant growth and mineral content were determined. The increase in nitrate caused by N fertilization in lettuce has also occurred with these fertilizers, but this increase has been very below the critical limit. In order to prevent excessive use of fertilizers (especially chemical fertilizer) in agricultural production, it is useful to apply the nutrients needed by the plant in the required amount. Therefore, more care should be taken in the use of organic or inorganic fertilizers. It is thought that the fertilizers used in this study may be beneficial in terms of yield and quality in lettuce production. It can also be preferred as a good nutrient source in organic production of lettuce.

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