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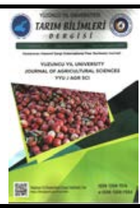

Araştırma Makalesi (Research Article)

Nitrogen Fertilization Affects Growth, Yield, Nitrate and Mineral Content of Garden Cress (*Lepidium sativum* L.)

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Keywords

Garden cress,
Growth,
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Abstract: Garden cress is rich in carotenoids, vitamin C, fiber, flavonoids, selenium, s-methyl cysteine, sulfoxide and glucosinolates. Nitrogen deficiency is a limiting factor for plant growth. The study was conducted in Atatürk University, in Erzurum under field conditions in 2013 and 2014. The aim of the present study was to evaluate effects of the different ratios of nitrogen on growth, yield and some quality properties of garden cress (cv. Dadaş). Treatments consisted of Nmin (mineral nitrogen in the soil layer 0–30 cm at planting; i.e. no basal nitrogen fertilization) (Control), 50, 100 and 150 kg N ha^{-1} doses as ammonium nitrate. The effect of different nitrogen doses on the plant height and yield in the cress was statistically significant. The highest plant height and yield was observed in 100 kg N ha^{-1}. Generally, NO_3 and the other elements in garden cress increased with increasing nitrogen doses. In conclude 82.17 kg N ha^{-1} can be suggested for higher yield and quality for Dadaş garden cress variety in sand soil conditions according to the regression analysis.

Azot Gübrelemesinin Terede (*Lepidium sativum* L.) Büyüme, Verim, Nitrat ve Mineral İçeriğine Etkileri

Makale Bilgileri

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Anahtar kelimeler

Tere,
Bitki gelişimi,
Azot,
Kalite,
Verim.

Öz: Tere, karotenoidler, C vitamini, lif, flavonoidler, selenyum, s-metil sistein, sülfoksit ve glukozinolatlar bakımından zengindir. Azot eksikliği, bitki büyümesi için sınırlayıcı bir faktördür. Bu çalışma 2013 ve 2014 yıllarında Erzurum Atatürk Üniversitesi'nde tarla koşullarında yürütülmüştür. Çalışmanın amacı, farklı azot oranlarının terede (Dadaş çeşidi) bitki gelişimi, verim ve bazı kalite özellikleri üzerindeki etkilerini değerlendirmektir. Azot uygulamaları, Nmin (ekim öncesi 0–30 cm toprak tabakasındaki mineral azot dikkate alınarak; bazal azot gübrelemesi yok) (Kontrol), 50 kg N ha^{-1}, 100 kg N ha^{-1}ve 150 kg N ha^{-1} dozlarında amonyum nitrat olarak uygulanmıştır. Farklı azot dozlarının terede bitki boyu ve verimi üzerine etkisi istatistiksel olarak önemli bulunmuştur. En yüksek bitki boyu ve verimi 100 kg N ha^{-1} dozu verilen uygulamada tespit edilmiştir. Artan azot dozları ile genellikle tere içerisindeki NO_3 ve diğer elementler artmıştır. Yapılan regresyon analizi sonucunda kumlu topraklarda 82.17 kg ha^{-1} azot uygulamalarının Dadaş bahçe teresinde uygulanalabilirliği ortaya konmuştur.

1. Introduction

Garden cress belongs to the Brassicaceae family. The plant, native to Asia and North Africa, is a one-year herbaceous plant. It is used as an appetizer in the form of a salad or garnish vegetable due to its pleasant smell and light spicy structure. Garden cress has been used in the treatment of liver diseases and infections in addition to its use as an immune system enhancer, diuretic (Nadkarni, 1954) and antibacterial (Amin, 2005).

Fertilizer is one of the most important inputs in agricultural production. When it is not applied adequately, it causes significant losses in efficiency and quality, whereas in case of excessive application, it causes pollution of water sources, especially with the washing of nitrogen fertilizers, and the production of greenhouse gases with the emission of nitrogen oxides (NO, N_2O and NO_2) (Güler, 2004).

Nitrogen is an important nutrient element in plant cells found in many structural compounds such as chlorophyll and amino acids. Nitrogen deficiency is one of the most important factors in plant growth and development (Tuncay et al., 2011). In addition, if nitrogenous fertilizers are used excessively, the amount of nitrate in the leaf reaches a level that threatens human health, especially in leaf-edible vegetables (Roorda van Eysinga, 1984). The use of unbalanced nitrogen fertilizers causes nitrogen accumulation within the plant and nitrate accumulation if nitrogen is taken in the form of nitrate. Nitrate concentrations can reach high levels in some leafy vegetables such as lettuce and spinach. Nitrate can turn into harmful substances that can cause cancer in humans and animals (Ziarati et al., 2018).

Soil and climatic conditions have an important effect on the nitrogen content of plants. Plants grown in soils rich in absorbable nitrogen contain more nitrate than those grown in soils poor in nitrogen. As a result of the research conducted on the effects of different soils on the nitrate levels of vegetables, it is reported that the amount of nitrate in lettuce, carrot and white cabbage grown in sandy soil with less organic matter is found to be less than those grown in other soils (Geyer, 1978). The nitrate content of vegetables also varies according to species and varieties. In addition to varieties, maturity and leaf types of plants during the harvest period also affect nitrate content (Corre and Breimer, 1979). When producing leafy vegetables, one important aspect is the final plant nitrate content, with its indirect negative effects on human health. Garden cress can be considered as a species of high nitrate accumulating (Cavarianni et al., 2008). Since the vegetation period of leafy vegetables is short, they require high amounts of nutrients, especially nitrogen, in their growth period, making fertilization inevitable. Excessive nitrogen uptake in plant nutrients or inhibition of nitrogen conversion to protein causes nitrogen accumulation in the plant (Maynard et al., 1976).

Garden cress is classified into 2 types according to their leaf shapes, namely flat and segmented leafed cress. The cress grown in our country is mostly in the flat leaf group. On the other hand, in eastern regions of Turkey, garden cress with leaves like parsley is mostly consumed (Yanmaz et al., 2010). As a result of the studies we conducted in Ankara and Erzurum conditions, it was determined that parsley-leaved garden cress was different from the existing cress varieties and it was registered with the name Dadaş. The aim of the present study was to evaluate effects of the different ratios of nitrogen on growth, yield and some quality properties of garden cress (Dadaş cultivar).

2. Materials and Methods

The study was carried out in the experimental fields of Atatürk University, Erzurum, Turkey (39º91’ N; 41º36’E; 1900 m above sea level). Climatic conditions during the experiment are given in Figures 1a and b. The average temperature ranged between 19.7 ºC (July) and 7.0 ºC (October) in 2013, 21.2 ºC (July) and 8.8 ºC (October) in 2014. Total rainfall was 15.2 mm in July and 32.7 mm in October in 2013, and 34.9 mm in July and 43.4 mm in October in 2014. Soil properties of the experimental area are given in Table 1. Manure (30 t ha^{-1}) was applied to plots. Treatments consisted of Nmin (mineral nitrogen in the soil layer 0–30 cm at planting; i.e. no basal nitrogen fertilization) (Control), 50 kg N ha^{-1}, 100 kg N ha^{-1} and 150 kg N ha^{-1} as Ammonium Nitrate. A basal dressing of 100 kg P ha^{-1} as triple superphosphate was applied before planting. Garden cress (*L. sativum* L.) cv. Dadaş was used as plant material. This cultivar “Dadaş” was parsley-leaved garden cress.

Garden cress (*L. sativum* L.) seeds (2 g m^{-2}) were sown to 2 m^2 plots with a 10 cm space between rows in 22.08.2013 and 19.08.2014. Irrigation was done when needed. Weeding was done by hand. Garden cress plants were harvested by cutting when they have 7-10 leaf in 30.09.2013 and 28.09.2014. At harvesting, plant height, plant fresh weights (FW) and plant dry weights (DW) were calculated. Leaf NO_3 content was measured using ion chromatography (Dionex® DX 500; Dionex Corp., Milan, Italy) on a sample of 20 g.

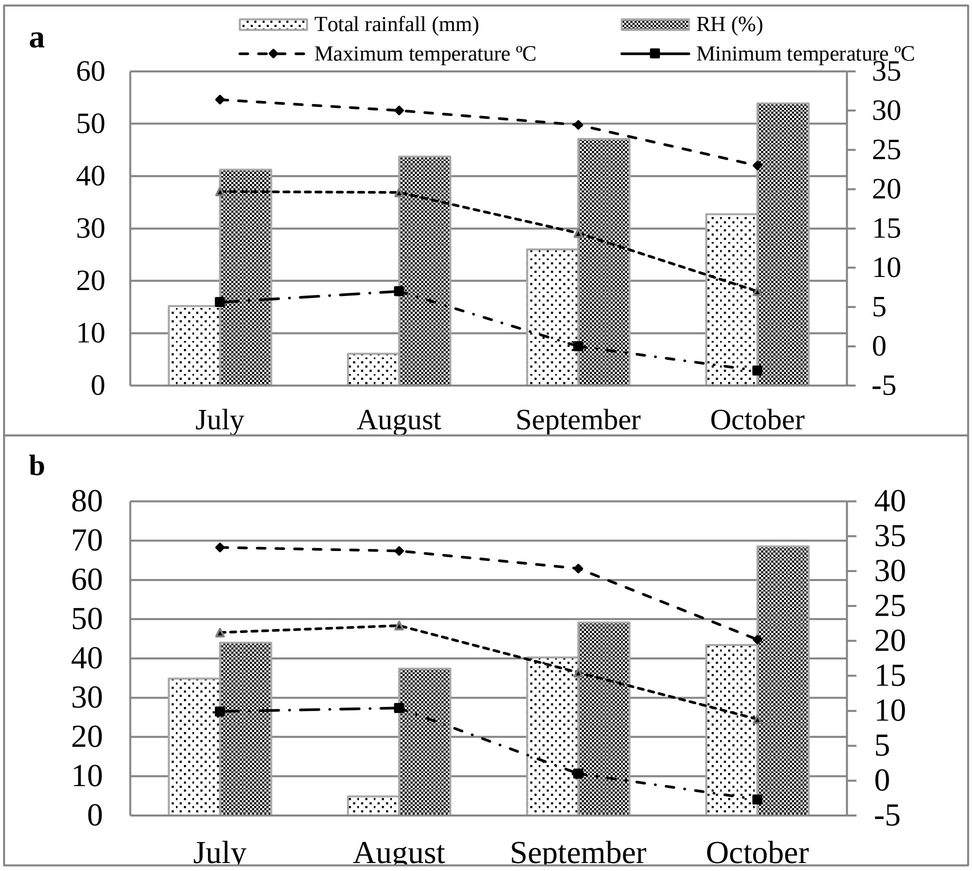

Figure 1. Some meteorological parameters of experimental area in 2013 (a) and 2014 (b).

Table 1. Physical and chemical characteristics of the soil before the experiment (mean ± standard deviation, n = 10)

Soil Properties	Units	Means
N	(mg kg^{-1})	8.16±0.75
P	(me 100 g^{-1})	12.36±1.04
K	(me 100 g^{-1})	2.34±0.16
Ca	(me 100 g^{-1})	16.75±2.13
Mg	(mg kg^{-1})	1.44±0.04
Na	(mg kg^{-1})	0.35±0.03
Fe	(mg kg^{-1})	4.54±0.24
Cu	(mg kg^{-1})	5.44±0.74
Mn	(mg kg^{-1})	6.45±0.95
Zn	(mg kg^{-1})	3.65±0.15
B	(mg kg^{-1})	0.24±0.01
Organic matter	(%)	0.76±0.09
Sand	(%)	38.4±2.48
Silt	(%)	34.1±3.04
Clay	(%)	27.5±1.19

Ascorbic acid (Vitamin C) was determined with a Merck reflectometer set (Merck RQflex). To determine the mineral concentrations of garden cress leaves was used an inductively coupled plasma spectrophotometer (Optima 2100 DV; Perkin-Elmer, Shelton, CT) (Bremner, 1996). The experimental design was a randomized complete block design with three replications. Data were subjected to the analysis of variance (ANOVA) to compare the effects of treatments. When significant differences occurred, the differences of means were determined using Duncan. Regression analysis was made on the effect of nitrogen applications on yield.

3. Results

In the study, it was determined that the effect of different nitrogen doses on the plant height and yield in the garden cress was statistically significant ($p<0.001$) in both years. However, nitrogen treatments did not affect significantly branch number of garden cress (Table 2). The highest plant height and yield were observed in 100 kg N ha^{-1} while the lowest were determined in the control. Similarly, the FW and DW were the highest in 100 kg N ha^{-1} treatment. Further nitrogen increase caused reduced FW and DW of garden cress. The lowest FW and DW occurred in the control. The results of the study increasing N doses reduced Vitamin C. The lowest Vitamin C content was determined in 100 kg N ha^{-1} while the highest was in the control (Table 3).

Table 2. Plant height, branch number and yield response of garden cress to N fertilization

N	Plant height (cm)			Branches number/plant			Yield g/m^2		
(kg ha^{-1})	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean
0	23.71 b	23.27 b	23.49 B	11.60	8.43	10.02	2315.95 c	4730.00 c	3522.98 D
50	25.43 a	26.20 a	25.81 A	10.83	8.30	9.57	2995.07 ab	5240.00 b	4117.53 B
100	26.93 a	26.34 a	26.63 A	10.70	8.23	9.47	3193.87 a	5530.00 a	4361.93 A
150	26.70 a	26.53 a	26.62 A	10.90	8.13	9.52	2846.55 b	4620.00 c	3733.28 C
P	<0.01	<0.001	<0.001	>0.05	>0.05	>0.05	<0.001	<0.001	<0.001

The difference between the means indicated with the same letter is not statistically significant.

Table 3. Fresh weight (FW), dry weight (DW) and Vitamin C content response of garden cress to N fertilization

N	FW (g)			DW (g)			Vitamin C		
(kg ha^{-1})	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean
0	66.17 c	157.67 c	111.92 D	7.64 b	10.71 c	9.18 C	135.33 a	146.67 a	141.00 A
50	85.57 ab	174.67 b	130.12 B	8.79 b	12.58 b	10.69 B	137.33 a	138.00 ab	137.67 A
100	91.25 a	184.33 a	137.79 A	10.71 a	11.58 b	11.15 A	115.33 c	130.00 b	122.67 C
150	81.33 b	154.00 c	117.67 C	8.22 b	11.95 a	10.09 B	125.00 b	136.00 ab	130.50 B
P	<0.001	<0.001	<0.001	<0.01	<0.01	>0.05	<0.001	<0.05	<0.001

The difference between the means indicated with the same letter is not statistically significant.

The nitrate and plant nutrient content of garden cress grown under different nitrogen doses are given in Tables 4, 5, 6 and 7. Nitrogen treatments affected significantly NO_3 and the other elements except for B content of garden cress. Generally, NO_3 and the other elements in garden cress increased with increasing nitrogen doses. The highest values of NO_3, N, P, K, Ca, Mg, Fe and Cu were obtained from 150 kg N ha^{-1} treatment while the lowest ones generally were in the control. Na, Mn and Zn content changed depending on nitrogen doses.

Table 4. Nitrate (NO_3), nitrogen (N) and phosphorus (P) content response of garden cress to N fertilization

N	NO_3 (mg kg^{-1})			N (%)			P (mg kg^{-1})		
(kg ha^{-1})	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean
0	385.72 d	424.97 c	405.35 D	2.50 d	2.63 d	2.57 D	2660.51 b	2883.93 b	2772.22 C
50	415.00 c	453.00 b	434.00 C	2.63 c	2.85 c	2.74 C	2702.65 b	3144.42 a	2923.53 B
100	486.07 b	461.78 b	473.92 B	2.89 b	2.99 b	2.95 B	2804.23 b	3230.49 a	3017.36 B
150	505.23 a	508.24 a	506.74 A	3.01 a	3.18 a	3.10 A	3083.88 a	3195.06 a	3139.47 A
P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001

The difference between the means indicated with the same letter is not statistically significant.

Table 5. Potassium (K), calcium (Ca) and magnesium (Mg) content response of garden cress to N fertilization

N (kg ha^{-1})	K (mg kg^{-1})			Ca (mg kg^{-1})			Mg (mg kg^{-1})		
	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean
0	16406.77b	16003.02a	16204.90 B	5049.61a	4281.01a	4665.31AB	1840.80c	1891.65a	1866.23B
50	16673.12b	16415.20a	16544.16 B	4717.22b	4369.04a	4543.13 B	1971.82b	1943.79a	1957.81A
100	16501.12b	16831.60a	16666.36 B	4782.08b	4507.57a	4644.83AB	2017.15b	1939.57a	1978.36A
150	17918.92 a	16585.01a	17251.97A	5046.17a	4403.48a	4724.83 A	2108.52a	1851.98a	1980.25A
P	<0.01	>0.05	<0.01	<0.05	>0.05	>0.05	<0.001	>0.05	<0.01

The difference between the means indicated with the same letter is not statistically significant.

Table 6. Sodium (Na), iron (Fe) and copper (Cu) content response of garden cress to N fertilization

N (kg ha^{-1})	Na (mg kg^{-1})			Fe (mg kg^{-1})			Cu (mg kg^{-1})		
	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean
0	616.45 a	549.63 a	563.04 AB	136.85 b	145.15 b	140.99 B	32.26 ab	31.10 c	31.68 B
50	598.72 a	555.75 a	577.23 A	131.88 d	154.29 a	143.08 B	34.33 a	33.28 b	33.83 A
100	556.74 a	544.22 a	550.48 AB	141.19 b	155.50 a	148.35 A	30.62 b	36.27 a	33.45 A
150	554.51 a	504.11 a	529.31 B	147.54 a	154.00 a	150.77 A	33.82 a	34.57 ab	34.20 A
P	>0.05	>0.05	<0.05	<0.001	<0.05	<0.001	<0.01	<0.01	<0.01

The difference between the means indicated with the same letter is not statistically significant.

Table 7. Manganese (Mn), zinc (Zn) and boron (B) content response of garden cress to N fertilization.

N (kg ha^{-1})	Mn (mg kg^{-1})			Zn (mg kg^{-1})			B (mg kg^{-1})		
	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean
0	47.37 c	40.60 c	43.98 D	37.72 a	41.12 c	39.42 B	26.92 a	25.76 b	26.34 A
50	48.61 bc	43.36 b	45.98 C	41.25 a	41.89 bc	41.57 A	26.27 a	27.54 a	26.90 A
100	54.07 a	44.27 b	49.17 A	37.85 a	45.45 a	41.65 A	26.91 a	24.74 b	25.82 A
150	49.03 b	46.27 a	47.65 B	38.22 a	43.91 ab	41.07 AB	26.38 a	25.70 b	26.04 A
P	<0.001	<0.001	<0.001	>0.05	<0.01	<0.05	>0.05	<0.05	>0.05

The difference between the means indicated with the same letter is not statistically significant.

According to the regression analysis for an average of 2 years, the highest yield of garden cress was recorded at 82.17 kg N ha^{-1}, while saving approximately 45% of nitrogen fertilizer yet giving 15% more yield compared with 150 kg N ha^{-1} (Figure 2).

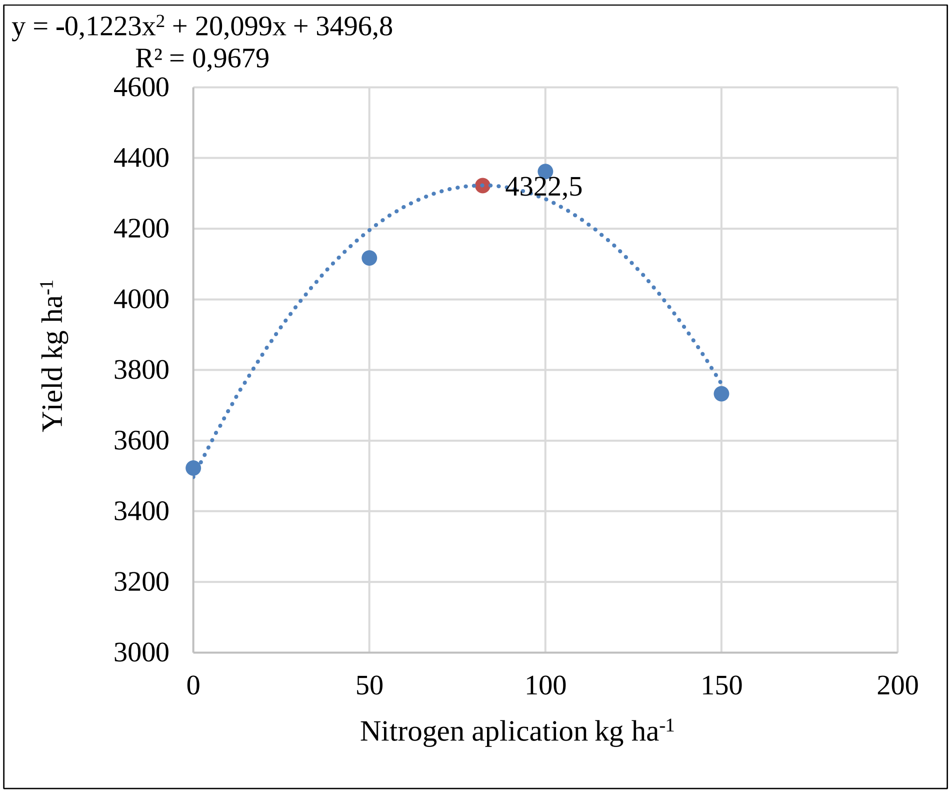

Figure 2. Effects of N fertilizer applied at different levels on yield of garden cress.

4. Discussion and Conclusion

In the study, it was determined that nitrogen fertilization significantly increased plant growth in garden cress. According to the results of the research; it has been observed that all fertilizer applications increase plant growth in garden cress compared to plants under control. In the light of the parameters examined, when nitrogen doses are compared among themselves, 100 kg ha^{-1} nitrogen dose was found to be the most effective dose. Many studies pointed out that nitrogen fertilization increases plant growth and yield of several crops (Turan, 2002; Albayrak et al., 2006; Tekeli and Daşgan, 2013).

It is inevitable to use inorganic fertilizers, especially nitrogen fertilization, to increase the vegetative growth of plants. Nitrogen, which forms the main part of protein and nucleic acids, which are the basis of all living forms, is the most used nutrient element in vegetable cultivation, and product amount and quality losses occur in its deficiency (Mengel, 1991). In addition, nitrogen is a structural part of chlorophyll, phospholipids, alkaloids, enzymes, coenzymes, hormones and vitamins (Castellanos et al., 2000). Studies have reported that nitrogen applications significantly affect the yield and quality of lettuce and spinach and generally increase the plant growth and yield in parallel with the increase in nitrogen dose up to a certain level (Topçuoğlu and Yalçin, 1996; Mordoğan et al., 2001). Yadav et al. (2013) planted garden cress in two seasons to examine the effect of planting date, row spacing and nitrogen doses in an experiment they conducted. On the yield of *L. sativum* L. grown in irrigated loamy sandy soils, 40 and 60 kg ha^{-1} nitrogen application was found to be the most effective dose. Boroujerdnia and Ansari (2007) reported in their study that plant growth and yield in lettuce increased up to a certain level in parallel with increasing nitrogen dose. Our study results showed that nitrogen fertilization negatively affected Vitamin C content of garden cress. A high dose of N treatments has been reported to decrease vitamin C content in vegetable crops (Miceli and Miceli, 2014). Previous reports confirm that increasing nitrogen fertilization rates caused reduced vitamin C content in some vegetables (Mozafar, 1993; Lee and Kader, 2000; Yildirim et al., 2007; Yildirim et al., 2020).

According to the macro and micronutrient element analysis results, it was determined that there were important differences between the different nitrogen doses. The highest plant N, P, K, Ca, Mg, Fe and Cu content were determined in 150 kg ha^{-1}. In parallel with the findings obtained from the study, it has been reported that with nitrogen fertilizers applied to the soil in increasing amounts, the N content of spinach plant increased, but contrary to our findings, other element contents decreased (Topçuoğlu and Yalçin, 1996). In a study conducted to determine the effect of the use of organic and chemical fertilizers on the nutritional status of the plant in peppers, N, P, K, Ca, Mg, Fe and Mn concentrations have been reported to increase significantly with the effect of different fertilizer applications (Özkan et al., 2013). In a study conducted in pots under greenhouse conditions, it was found that four different doses of nitrogen application (0, 200, 400, and 600 mg N kg^{-1}) increased the nitrogen content in the leaf and root of lettuce, but decreased the phosphorus and potassium content (Petridis et al., 2013).

The results obtained from the study showed that the highest NO_3 content in garden cress was determined in the highest application (150 kg ha^{-1}) of the commercial form of nitrogen fertilizer (Table 2). In parallel with the findings obtained from our study, studies have been conducted showing that the NO_3 content in the leaf increases with the increase of the nitrogen dose applied in spinach and lettuce (Smatanova et al., 2004; Liu et al., 2014). In a study conducted under greenhouse conditions, the effect on plant growth and nitrate content in the leaf was investigated in two lettuce varieties grown at two nitrogen levels. At the end of the study, it was determined that high nitrogen dose increased NO_3 accumulation in leaves (Balanza et al., 2011). Yağmur et al. (2019) determined that the highest nitrate, nitrite and total nitrogen values of flat leaved garden cress occurred in nitrate fertilizer application.

In case of high NO_3 concentration taken through the diet, it can either directly cause the intestinal membranes to break down or it can turn into nitrite and prevent oxygen transport in the blood. In addition, it can transform into nitrosamines in the body and have a carcinogenic effect. This is especially important for vegetables whose leaves are eaten, as nitrate accumulates in the leaves. According to Venter (1978), nitrate value in lettuce leaves varies as 282-3520 mg NO_3 kg^{-1} fresh weight (ppm) (Ceylan et al., 2001). The maximum nitrate limit in the leaves of lettuce grown in the open field by the European Union has been determined as 3500-4000 ppm (Özgen, 2009). The values obtained in the study were found to be far below the given values.

In order to ensure high efficiency in agricultural production, large amounts of chemical fertilizers are used, which causes human health, environmental and economic problems. Studies have started to intensify in recent years to reduce or eliminate the negative effects of such practices. Garden cress is very sensitive to fertilization, especially nitrogen fertilization, and fertilization is the most important factor affecting yield and quality when other conditions are equal. However, in case of excessive nitrogen use, nitrogen may accumulate in the leaves of the plant as nitrite, which may be harmful to human health. For this reason, N should not be given to the soil more than enough for the development of the plant (Şalk et al., 2008). Excessive nitrogen applications cause deterioration of the quality of vegetables and some physiological disorders such as tip burn (McCollum, 1992). To conclude 82.17 N ha^{-1} can be suggested for higher yield and quality for Dadaş garden cress variety in sand soil conditions according to the regression analysis.

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