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The impact of various nitrogen sources and levels on the quantitative and qualitative characteristics of parsley

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Original Article

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ABSTRACT

Parsley possesses a high nutritional content, which includes vitamins A, B, and C, as well as essential mineral nutrients. The purity and chemical composition of fertilizers containing the same element can vary significantly. This difference has an important effect related to the method of usage, time of application, and the effectivity of fertilizers. Nitrate, ammonium, and urea are the primary sources of mineral nitrogen for higher plants, each with distinct chemical properties and varying impacts on plant growth. Hence, to examine the impact of various nitrogen sources on parsley, a study was carried out using a factorial combination of three nitrogen forms (calcium nitrate, ammonium sulfate, and urea) and four nitrogen levels (0, 100, 125, and 150 Kg/ha). The study employed a completely randomized basic design with three replications. The findings indicated that all measured parameters were significantly influenced by the nitrogen (N) sources. The greatest fresh weight of shoots, fresh weight of roots, vitamin C concentration in the leaves, and concentration of calcium (Ca) in the leaves were achieved with an application of 150 kg/ha of calcium nitrate. The highest dry weight of shoots, plant height, length of leaves, and iron (Fe) concentration in the leaves were observed with an application of 150 kg/ha of ammonium sulfate. The highest levels of total chlorophyll (a+b) were recorded with an application of 150 kg/ha of urea.

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1. Introduction

Parsley (*Petroselinum crispum* Mill) belongs to the Apiaceae family, which contains high amounts of volatile essential oils such as apiol and myristicin, used to flavor foods (Peyvast, 1998). Due to having significant amounts of antioxidant compounds, parsley reduces the incidence of diseases. Due to having substantial quantities of antioxidant compounds, parsley minimizes the incidence of diseases (Pasikowska *et al*., 2002). Many factors influence the quality of vegetables, but one of the most important factors is nutrition. The widespread use of chemical fertilizers in crop cultivation, which leads to environmental problems and negative impacts on the health of living organisms, is a consequence of population growth and growing demand for agricultural products (Weitzberg and Lundberg, 2013).

Nitrogen (N) is involved in vegetative growth, chlorophyll, plant proteins, and fruit and seed production. Also, as one of the most important components of cell walls, cytoplasmic proteins, and nucleic acids, and as an important part of other cellular components, it plays an important role in plant life biochemistry. Research shows N is one of the important elements in increasing plant performance and is the element that deficiency limits crop yields more than other elements. (Susin *et al*., 2006). Different plants have different nitrogen requirements during the growing season, and plants with vigorous vegetative growth tend to accumulate more nitrogen in their bodies (Susin *et al*., 2006). It is a crucial part of nitrogen fertilizer management to use the correct amount and source of nitrogen to maximize plant consumption efficiency (Malakouti *et al*., 2013). Soil organic matter is the main source of nitrogen for plants, which either naturally enters the soil or arises from human activities, but cannot meet the nutritional needs of plants by itself (Correia *et al*., 2010). Therefore, it has been suggested that the combined use of organic and chemical fertilizers reduces environmental pollution, improves soil condition, and improves nutrient uptake (Correia *et al*., 2010). However, before choosing or consuming chemical fertilizers, it is necessary to know a sufficient amount of information about their types and in particular nitrogen. Nitrate (NO3) and ammonium (NH4) are the main sources of inorganic nitrogen absorbed by the roots of higher plants. Although plants can absorb nitrate and ammonium ions, many species do not grow optimally on ammonium ions (Roosta and Schjoerring. 2007). During the process of glutamate biosynthesis, the amount of nitrate in the cytosol and chloroplasts of leaves undergoes conversion into ammonium. This conversion occurs in two consecutive steps facilitated by enzymes called nitrate reductase and nitrite reductase. Subsequently, the ammonium is transformed into various secondary metabolites, acid amine, and prophins (Leszczynska *et al*., 2009). On the other hand, nitrates have negative effects on human health and the accumulation of nitrates in vegetables is currently attracting great attention that considered one of the physiological and quality indicators of vegetables (Leszczynska *et al*., 2009). Under conditions where a large amount of nitrogen fertilizer is consumed, the capacity of nitrate regeneration decreases and finally, excess amounts of nitrate are transferred to the leaves (Malakouti *et al*., 2013).

Among vegetables, leafy types have the greatest response to nitrogen fertilizers and can accumulate large amounts of nitrate (Colla *et al*., 2018). The results show that the concentration of nitrates in the environment is directly related to plant accumulation, while the most important factor influencing it is the number of ions available for plants (Colla *et al*., 2018). The researchers showed that with the increase in the use of urea fertilizer, the remaining amount of nitrate in plants showed an increasing trend (Colla *et al*., 2018). In the study of nitrate concentration in plants such as cabbage, spinach, and turnip, the researchers showed that the amount of nitrate accumulation was influenced by the amount of external nitrate and the role of genetic factors in nitrate accumulation at low concentrations can be neglected (Colla *et al*., 2018).

Several studies have been conducted on the impact of various nitrogen fertilizer sources on the growth of plants. Nitrogen fertilizers are used in different forms, including urea (NH2CONH2), ammonium nitrate (NH4NO3), ammonium sulfate ((NH4)2SO4), and anhydrous ammonia (NH3) (Stecker *et al*., 1993). The researcher noted that nitrogen had a considerable impact on the development of select vegetables, with the greatest performance achieved through the application of 150 kilograms of pure nitrogen per hectare (Sadeghi and Critical, 2000). Robinson (1978) investigated the potential benefits of utilizing 200 kg of nitrogen fertilizer to improve the harvest of parsley. The growth of strawberry plants in an experiment was found to be significantly enhanced when a combination of nitrate and ammonium sources was used, as opposed to using fertilizers alone (Darnell and Stutte, 2001). Researchers have found that the performance of grain in corn is greatly influenced by different nitrogen sources, such as ammonium nitrate, urea, and a combination of ammonium nitrate and ammonium thiosulfate. Interestingly, the study revealed that ammonium nitrate exhibited superior results when compared to urea and other nitrogen sources that contained urea (Stecker *et al*., 1993; Kumar and Prasad, 2004). A study was conducted to test the impact of four different nitrogen fertilizers (calcium nitrate, ammonium nitrate, urea, and a combination of urea and ammonium nitrate) at four levels on corn. According to the results of this experiment, there was no difference between the four types of fertilizers in terms of grain yield (Below *et al*., 1995). In another experiment, the effects of two sources of urea - ammonium nitrate and anhydrous ammonia at different nitrogen levels on corn plants were investigated. The findings indicated that there was no significant difference between the two sources in terms of their impact on the fresh weight of plants (Barge, 2002). It has been reported by researchers that an increase in nitrogen levels up to 400 kg per hectare can promote the growth and development of parsley, although excessive consumption may lead to ammonium toxicity (Malkuti and Riyazi Hamadani, 1991). To achieve the highest possible yield in parsley production, researchers have advised applying 150 to 170 kg/h of nitrogen (Colla *et al*., 2018). The correct application of nitrogen is essential for managing nitrogen fertilizer effectively (Lany *et al*., 1999). This research focuses on examining different nitrogen amounts and sources to enhance consumption efficiency for parsley plants.

2. Materials and Methods

The study was conducted at the Islamic Azad University of Kerman on a 700-square-meter plot of land during the 2011 crop year. The soil texture at the test site was determined to be sandy loam, with no constraints related to salts and salinity, and the pH level was at 7/5. This experiment was based on a factorial in a randomized complete block design with 3 replications. The first factor is the type of fertilizer at 3 levels of calcium nitrate, ammonium sulfate, and urea, the second factor is the amount of fertilizer at 4 levels of 0, 100, 125, and 150 kg/ha. The field was initially plowed thoroughly, and then areas of 2 m2 were designated for plots. All phosphorus and potassium and one-third of nitrogen during planting and the rest of the nitrogen fertilizer were used five times after each harvest (5 harvests in total) by spreading on the surface of the plot. Irrigation of the field was carried out by flooding and very carefully. The seeds were sown in the field at a rate of 40 plants per square meter (equivalent to 1.2 gr of seeds per plot) and a depth ranging from 2 to 3 centimeters. Nitrogen treatment was done after calculating the desired amount for each plot. Weeding was done by hand in several stages (4 stages). For each harvest, 6 plants were randomly selected to determine plant height, stem fresh and dry weight, root fresh weight, leaf length, total chlorophyll content, calcium concentration, iron concentration, nitrogen content, and vitamin C concentration.

The wet and dry weight of stems and roots were measured using a precise digital scale. After drying the stems for 20 days in the shade, we weighed them to determine the dry weight of the shoot. The total chlorophyll content was determined using the Lichtenthaler method (1987). Leaf elements were measured by cutting the shoots of the plants and transferring them into paper envelopes. Subsequently, all envelopes were subjected to a temperature of 65-70 degrees centigrade for 48 hours. After the dry weight of the plant shoots was measured, the extracts were prepared by utilizing powdered samples. The concentration of iron and calcium was analyzed using atomic absorption in the obtained samples. The total nitrogen content was quantified through the application of the Kjeldahl method (1883). Vitamin C was measured using the method of Khan et al. (2006). Statistical analysis was conducted on the data utilizing SAS software, and the comparison of averages was performed using Duncan's test.

3. Results

3.1. Fresh weight of shoot

The analysis of data variance showed that the effect of nitrogen source, fertilizer amount, and their interaction was significant at the level of 1% probability level on the fresh weight of the shoot (Table 1). The treatment with a fertilizer level of 150 kg/ha of calcium nitrate was the most effective of all, resulting in over two times the fresh weight of the shoot when compared to the control treatment. However, there was no significant difference between the levels of 100, 125, and 150 kg/ha of calcium nitrate. After the mentioned treatments, the fertilizer level of 150 kg/ha of ammonium sulfate was more effective than other treatments and urea fertilizer levels caused a smaller increase among all the fertilizer sources (Fig. 1). Because nitrogen has a direct influence on vegetative growth, it is to be expected that it would positively affect and enhance the fresh weight of the plant. The analysis conducted on the traits indicated a strong and statistically significant correlation between the fresh weight of the shoot and the concentration of nitrogen, calcium, and iron elements in the leaves (Table 2). Therefore, better absorption of these elements, especially nitrogen, can play a role in increasing the growth of the fresh weight of the shoot.

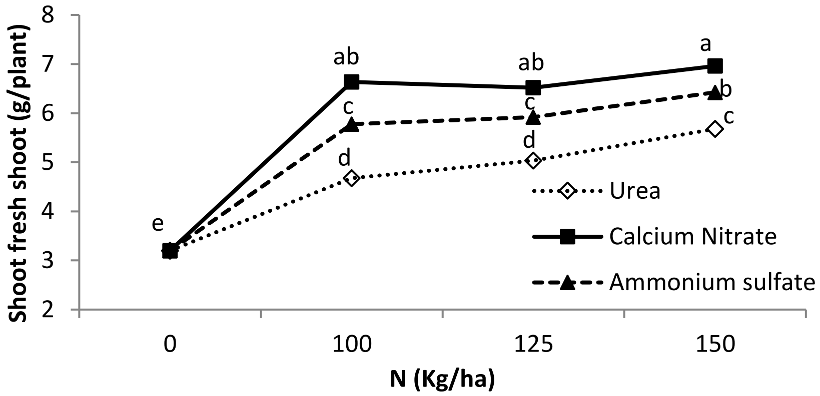

Figure 1. The effect of different nitrogen sources on the average fresh weight of parsley shoot.

3.2. Dry weight of shoot

The analysis of data variance revealed that the influence of nitrogen source, fertilizer amount, and their interaction effect on the dry weight of the shoot was statistically significant at the level of 1% significance level (Table 1). Among all the treatments, the fertilizer amount of 150 kg/ha of ammonium sulfate was more effective on the dry weight of the plant. The fertilizer amount of 125 kg/ha of ammonium sulfate was the next most important and caused a greater increase than other sources of fertilizer (Fig. 2). As nitrogen enhances vegetative growth, consequently, the plant's dry weight also increases. It seems that one of the reasons for increasing the dry weight of the plant after the use of ammonium sulfate is the effect of sulfate. Correlation analysis demonstrated a strong and positive connection between the dry weight of the plant and the levels of nitrogen, calcium, and iron elements present in the leaves (Table 2). Enhanced absorption of these nutrients, particularly nitrogen, can contribute to the enhancement of photosynthesis, leading to an increase in dry weight.

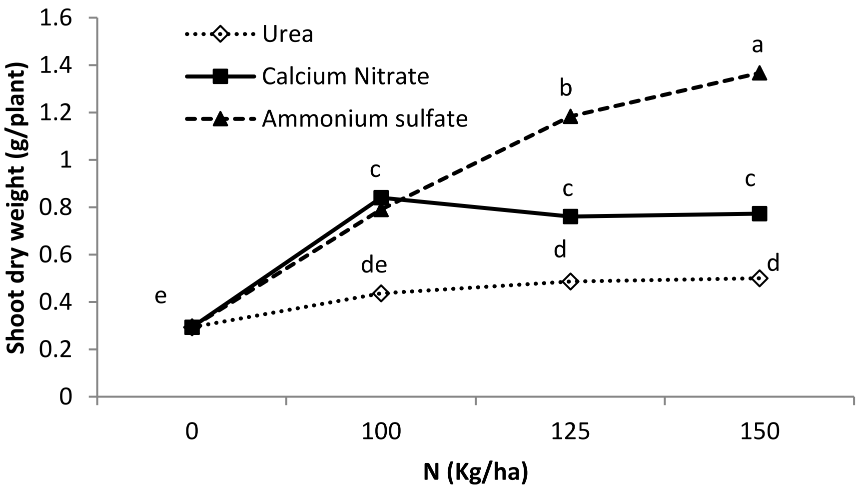

Figure 2. The effect of different nitrogen sources on the average dry weight of parsley shoot.

3.3. Fresh weight of root

The analysis of data variance showed that the effect of nitrogen source, fertilizer amount, and their interaction effect on root fresh weight was significant at the level of 1% level (Table 1). Among all the treatments, the fertilizer amount of 150 kg/ha of calcium nitrate and 150 kg/ha of ammonium sulfate was more effective, and compared to the control, it resulted in more than two times increase in root fresh weight. After these treatments, the fertilizer amount of 125 kg/ha of calcium nitrate was more effective than the other treatments (Fig. 3). Urea fertilizer levels had the least effect among all the fertilizer sources. A positive and significant relationship was observed between the fresh weight of the root and the concentration of nitrogen, calcium, and iron elements in the leaves, indicating a correlation between these traits (Table 2). Therefore, better absorption of these elements can also play a role in increasing root growth.

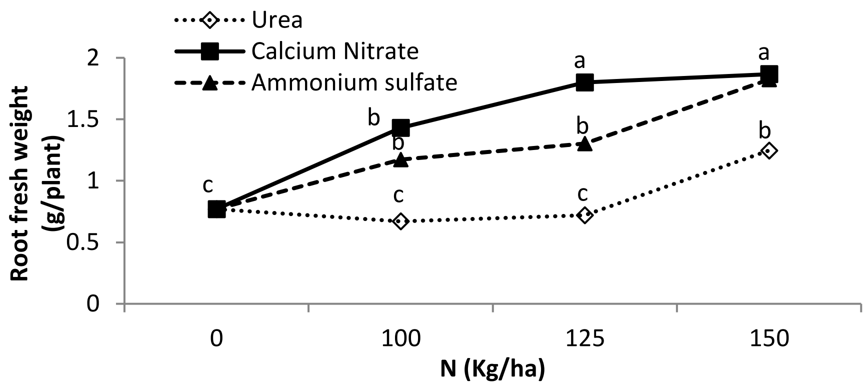

Figure 3. The effect of different nitrogen sources on the average fresh weight of parsley root.

3.4. Plant height

The analysis of data variance showed that the effect of nitrogen source and fertilizer amount on plant height was significant at the level of 1% and their interaction effect was significant at the level of 5% (Table 1). Among all the treatments, the fertilizer amount of 150 kg/ha of ammonium sulfate was more effective, and compared to the control, it caused more than a 20% increase in plant height. After this treatment, the fertilizer amount of 150 kg/ha of calcium nitrate was more effective than other treatments. Urea fertilizer levels had the least effect among all the fertilizer sources (Fig. 4). Correlation between traits showed that there is a positive and significant relationship between height and leaf nitrogen concentration (Table 2). Therefore, better absorption of this element can play a role in increasing plant height.

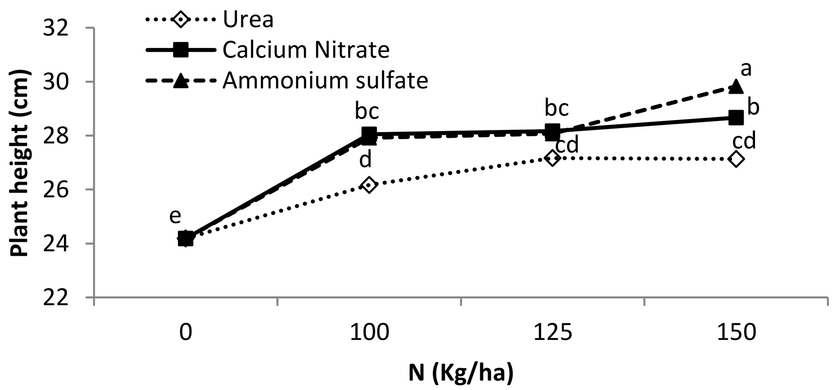

Figure 4. The effect of different nitrogen sources on the average plant height of parsley.

3.5. Leaf length

The analysis of data variance showed that the effect of fertilizer amount on parsley leaf length was significant at the level of 1%, but the effect of nitrogen source and the interaction effect of nitrogen source and fertilizer amount was not significant (Table 1). Among all the treatments, the fertilizer amount of 150 kg/ha of ammonium sulfate was more effective, and compared to the control, it caused more than a 34% increase in leaf length (Fig. 5). Correlation between traits showed that there is a positive and significant relationship between leaf length and leaf nitrogen concentration (Table 2).

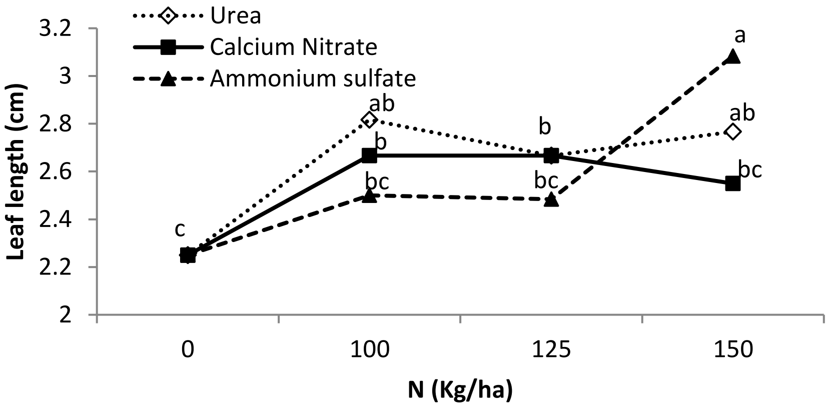

Figure 5. The effect of different nitrogen sources on the average leaf length of parsley.

3.6. Total chlorophyll content (a+b)

The analysis of data variance showed that the effect of nitrogen source, fertilizer amount, and their interaction effect on total chlorophyll content was significant at the level of 1% (Table 1). Among all the fertilizer sources, the urea fertilizer amount was more effective, so the 150 kg/ha urea fertilizer resulted in a more than 200% increase in total chlorophyll content compared to the control. The amount of ammonium sulfate fertilizer did not lead to an increase in total chlorophyll content compared to the control (Fig. 6). Fertilizer amounts of 125 and 150 kg/ha of calcium nitrate significantly increased the total chlorophyll content compared to the control. Correlation between the traits showed that there is a positive and significant relationship between the total chlorophyll and the concentration of leaf nitrogen element (Table 2). Therefore, due to the presence of nitrogen in the structure of chlorophyll, better absorption of this element can contribute to the increase of leaf total chlorophyll.

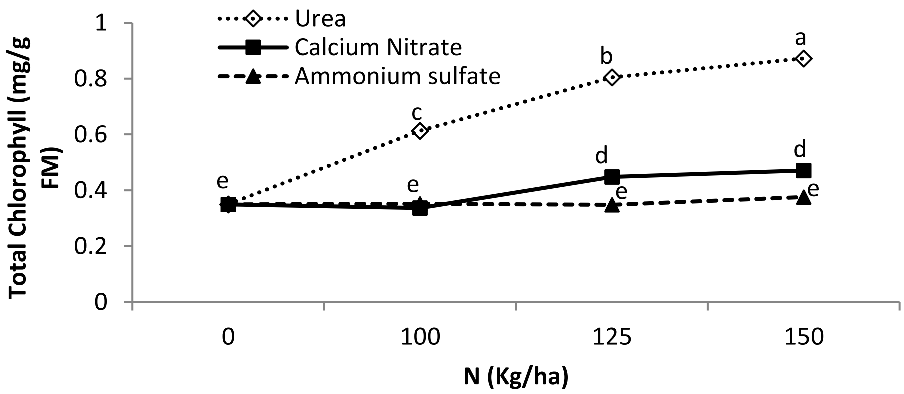

Figure 6. The effect of different nitrogen sources on the total chlorophyll of parsley.

3.7. Vitamin C concentration

The analysis of data variance showed that the effect of the amount of fertilizer on the concentration of vitamin C in parsley was significant at the level of 1%, but the effect of the nitrogen source and the interaction between the nitrogen source and the amount of fertilizer was not significant (Table 1). Among all the fertilizer sources, the amount of calcium nitrate was more effective, so the amount of 150 kg/ha of calcium nitrate increased the concentration of vitamin C by 10% compared to the control. The sources of ammonium sulfate and urea also caused a significant increase in vitamin C in parsley (Fig. 7). Correlation between traits showed that there is a positive and significant relationship between the concentration of vitamin C and the concentration of nitrogen, calcium, and iron elements in leaves and vegetative traits (Table 2).

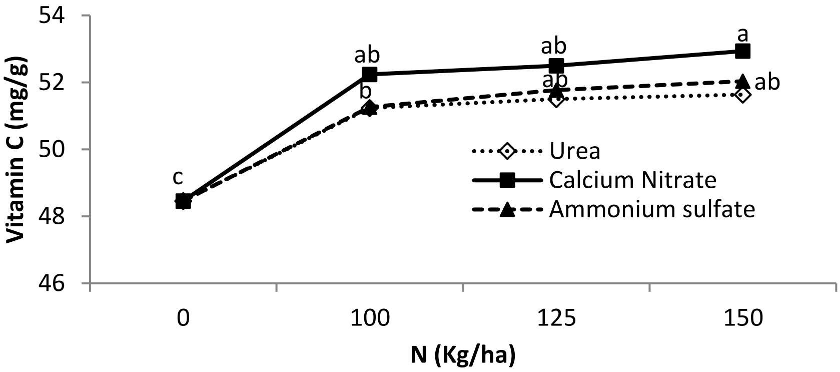

Figure 7. The effect of different nitrogen sources on vitamin C concentration of parsley.

3.8. Nitrogen concentration (N)

The analysis of data variance showed that the effect of the amount of fertilizer on the nitrogen concentration of parsley shoots was significant at the level of 1%, but the effect of the nitrogen source and the interaction between the nitrogen source and the amount of fertilizer was not significant (Table 1). All sources and levels of fertilizers led to a significant increase in nitrogen concentration compared to the control, but no significant difference was observed between them (Fig. 8).

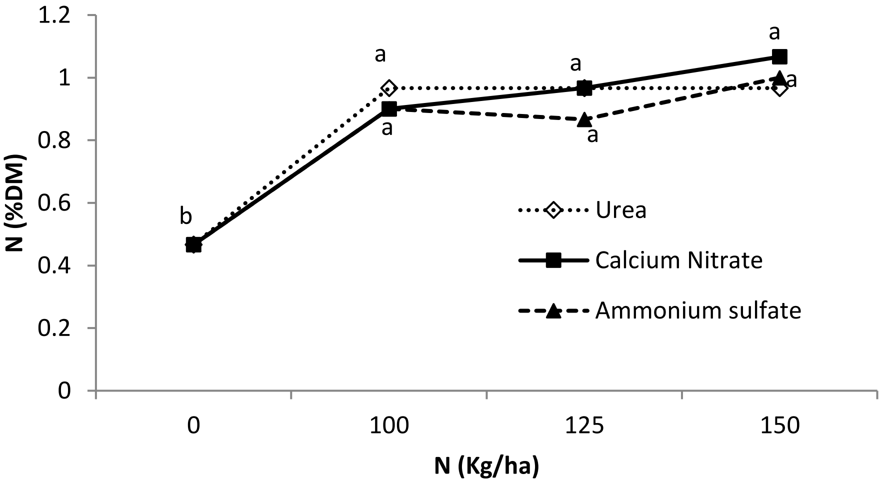

Figure 8. The effect of different nitrogen sources on the nitrogen concentration of parsley.

3.9. Calcium concentration (Ca)

The analysis of data variance showed that the effect of nitrogen source and fertilizer amount on calcium concentration in parsley was significant at the level of 1% (Table 1). Among all the fertilizer sources, the amount of calcium nitrate fertilizers was more effective, so the amount of 150 kg/ha of this fertilizer increased the calcium concentration in leaves by 50% compared to the control. The results of this research showed that the sources of ammonium sulfate and urea fertilizers did not affect leaf calcium concentration (Fig. 9).

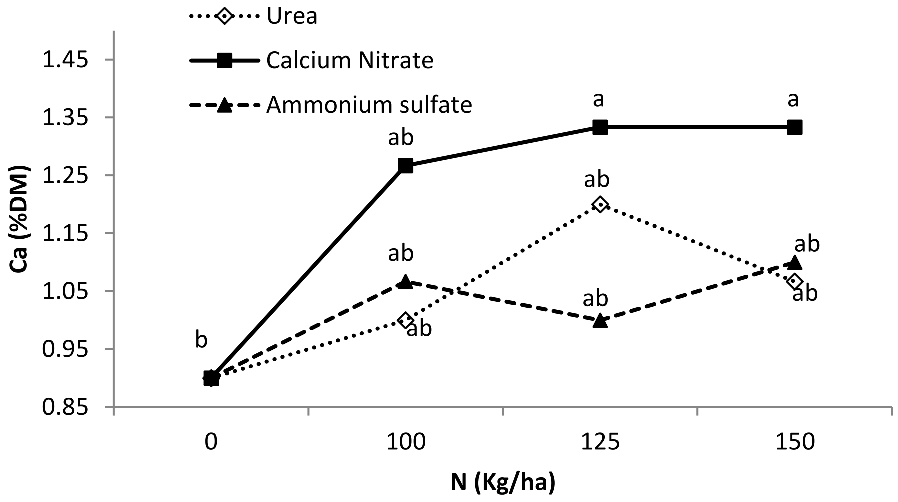

Figure 9. The effect of different nitrogen sources on the calcium concentration of parsley.

3.10. Iron concentration (Fe)

The analysis of data variance showed that the effect of the amount of fertilizer on the iron concentration of parsley leaves was significant at the level of 1%, but the effect of the nitrogen source and the interaction between the nitrogen source and the amount of fertilizer was not significant (Table 1). All the sources and levels of fertilizers significantly increased the Fe concentration in the plant compared to the control, but no significant difference was seen between them (Fig. 10).

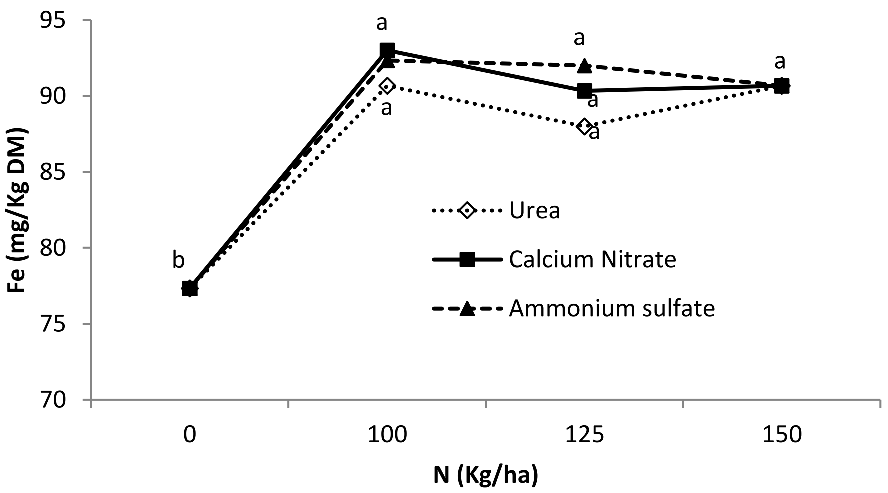

Figure 10. The effect of different nitrogen sources on the iron concentration of parsley.

4. Discussion

Nitrogen fertilizer plays a crucial role in influencing the production of stems and leaves, thereby accelerating the vegetative growth of the plant. Consequently, this acceleration in growth leads to an increase in the fresh weight of plants (Sheikh Babaei et al., 2009). Calcium is believed to play a role in increasing fresh weight in the parsley plant, as it enhances plant growth and strengthens the cell wall. The results of this experiment are consistent with the findings of other researchers. In this regard, Yıldırım et al. (2007) stated that foliar spraying with urea increased fresh weight in broccoli. Also, increasing the yield of plant fresh weight (leaf yield) in parsley with the use of nitrogen has been reported by Pasikoska et al. (2002). Another study revealed that the use of calcium nitrate led to a greater increase in the fresh weight of fenugreek plants than urea (Sheikh Babaei et al., 2009). The application of urea in field conditions is influenced by the efficiency of nitrogen, the ability to provide nitrogen fertilizer, and the potential reaction of urea to the anticipated crop yield. The findings indicated that while the application of urea increased the plant's dry weight compared to the control, its effectiveness was comparatively lower than that of other fertilizer sources due to a reduction in the nitrogen effect ratio of this fertilizer (Kunelius *et al*., 1987). A study conducted in India showed that the greatest plant dry weight among various fertilizer sources was achieved by using 175 kg/ha of ammonium sulfate, consistent with the findings of this research (Kumar and Prasad, 2004). This experiment also revealed that the use of nitrate and ammonium sources caused an increase in dry weight in parsley. The dry weight of the shoot is not greatly affected by urea, as observed in the case of broccoli plants (Yildirim *et al*., 2007). The fresh weight of the parsley root may have increased due to the impact of calcium nitrate, as calcium is known to enhance cell wall strength, promote plant growth, and contribute significantly to root development (Sheikh Babaei *et al*., 2009). Some sources also showed that nitrates are a more suitable source than other nitrogen fertilizer sources for plant growth. In an experiment, it was stated that the highest root weight and plant growth were obtained from nitrate fertilizer treatment, and then the highest growth was obtained from ammonium fertilizers (Richardson and Mckell, 1981), which is consistent with the results of the present research on parsley. It was also reported in fenugreek that calcium nitrate caused a significant increase in root weight, while urea did not show a significant effect in this regard (Sheikh Babaei *et al*., 2009). Regarding the negative effect of urea on root weight, it has also been stated that urea reduces the fresh and dry weight of roots in beans, which also confirms the validity of the findings of this research (Busada *et al*., 1984). Due to its participation in the structure of proteins, nitrogen causes an increase in the growth and length of internodes in plants and thus improves plant growth. Another reason for the increase in the height of parsley can be the presence of sulfur in ammonium sulfate as a necessary element in plant nutrition. Taghavi et al. (2004) showed that the maximum growth and height of strawberry plants was obtained from treatment with ammonium fertilizer source compared to other nitrogen sources. The researchers reported that plant height in corn was significantly affected by nitrogen sources (ammonium nitrate, urea, ammonium nitrate + ammonium thiosulfate), and ammonium nitrate showed superiority compared to urea and urea nitrogen sources (Stecker *et al*., 1993). Nitrogen fertilizer has a major effect on the production of stems and leaves, plant germination and generally accelerates the vegetative growth of the plant. Also, the role of sulfate in increasing the leaf surface has been identified in some sources. An important parameter for measuring vegetative growth in parsley is the increase in leaf length and leaf area, with sulfate playing a significant role in promoting this growth. The reason for the increase in the length of parsley leaves after the application of urea may be due to the high solubility and small molecular size of urea, which is quickly available to the plant (Padem and Alan, 1995).

Nitrogen is involved in the formation of chlorophyll, vegetative growth, and plant protein, and along with magnesium, it is one of the main components of chlorophyll structure (Malkuti and Riyazi Hamadani, 1991). The researchers reported that among several different sources of nitrogen fertilizers, the highest amount of chlorophyll in the ornamental plants was obtained from the source of urea, which is the result of the present study (Bani Jamali and Ziai, 2015). There are similar results regarding the increase in the amount of total chlorophyll after the application of nitrogen fertilizers in the cabbage plants (Villeneuve *et al*., 2002; Westerveld *et al*., 2003). Although some studies have mentioned the negative effect of urea and other nitrogen fertilizers on the concentration of vitamin C (Babik and Elkner. 2002; Yildirim *et al*., 2007), however, Abdala et al. (2000) stated that the use of urea fertilizer in citrus fruits led to a significant increase of vitamin C concentration in the juice of these plants. Also, in an experiment, the highest vitamin C concentration and phenolic compounds in Chinese cabbage were obtained after the application of calcium nitrate fertilizer (Borkowski *et al*., 2007). Some other sources also report the increase of vitamin C in parsley plants after the application of nitrogen fertilizers, which is consistent with the results of this research (Pasikowska *et al*., 2002). Although the amount of nitrogen in the plant tissues increased in all nitrogen treatments, this amount of nitrogen is not considered a threat to human health, so Turan and Sevimli (2005) stated that the increase of nitrate in broccoli plants up to 1650 mg does not cause any danger to humans. An increase in nitrogen concentration in other plants has also been mentioned after the use of nitrogen fertilizers (Vagen, 2003). It has also been reported that increasing the amount of nitrogen in the soil where parsley is cultivated increases the nitrate concentration in the leaves of this plant (Pasikowska *et al*., 2002). It is natural that the application of calcium nitrate increases the calcium concentration in the leaves. In this regard, the researchers reported that the application of urea fertilizer in the form of spraying solution and soil application led to an increase in calcium concentration in broccoli leaves, which is not consistent with the results of this research (Yildirim *et al*., 2007). The reason for the contradiction between the results of the mentioned researchers and the findings of this research can be the different conditions of that experiment, especially in terms of soil texture. It has also been reported that calcium nitrate fertilizer increases the calcium concentration in the leaves and fruits of the watermelon, and as a result, the amount of blossom end rot caused by calcium deficiency is also greatly reduced (Kashi *et al*., 2003). The effect of ammonium nutrition on the chemical composition of the plant is different from the effects of nitrate (Hohjo *et al*., 1995). A decrease in calcium, potassium, and magnesium concentration as a result of an increase in the amount of ammonium in tomatoes, carrots, watermelon, corn, and cucumber has also been reported (Hohjo *et al*., 1995; Kotsiras *et al*., 2002; Magalhaes and Wilcox 1983). In another experiment, the highest amount of leaf calcium concentration in Chinese cabbage was obtained after the application of calcium nitrate fertilizer (Borkowski *et al*., 2007). Iron nutrition in plants is significantly affected by the form of consumed N, and this problem is due to the change in the absorption ratio of cations and anions and the change in the pH of the cellular apoplast in the plant (Tadayon and Maafpourian, 2010). The use of nitrogen fertilizer in the form of nitrate causes the accumulation of iron in the roots. Meanwhile, the consumption of nitrogen in the form of ammonium increases the Fe concentration in young leaves and decreases the amount of Fe in the roots (Tadayon and Maafpourian, 2010). It has been reported that increasing nitrogen in plants increases iron absorption, and similar results have been obtained in tomatoes and lettuce (Alan and Padem, 1994; Padem and Alan, 1995).

In another experiment, foliar spraying with 1% urea caused a 40% increase in leaf iron in broccoli (Yildirim *et al*., 2007). According to the results obtained from the experiments of the researchers, the use of ammonium had a significant role in the transfer of iron from the root to the shoot and the regeneration of iron in an active form that can be absorbed by cells in young leaves (Tadayon and Maafpourian, 2010). Regarding the effect of ammonium nitrate and urea fertilizers on Fe concentration in wheat, it has been reported that these two fertilizers significantly increase the iron of grain and leaf, and there is no significant difference between the two sources (Noorgholipour *et al*., 2015).

Table 1- Analysis of variance of parsley characteristics.

Source	df	Fresh weight of shoot	Dry weight of shoot	Fresh weight of root	Plant height	Leaf length	Total chlorophyll	Vitamin C concentration	N concentration	Ca concentration	Fe concentration
(N)	2	4.26**	0.68**	1.18**	6.12**	0.02ns	0.32**	2.26ns	0.00ns	0.13*	6.86ns
(F)	3	17.84**	0.61**	1.20**	33.29**	0.49**	0.09**	27.20**	0.55**	0.15*	421.36*
N×F	6	0.53**	0.13**	0.16**	1.19**	0.09ns	0.04**	0.27ns	0.00ns	0.02ns	3.19ns
Total error	24	0.07	0.00	0.02	0.38	0.04	0.00	0.84	0.01	0.03	14.50
CV		5.17	12.87	13.81	2.29	7.96	6.71	1.79	16.61	17.31	4.35

**, * and ns–significant at P≥0.01 and p≤0.05 and non-significant, respectively.

Table 2- Correlation coefficient characteristics studied of parsley.

Characteristics	Fresh weight of shoot	Dry weight of shoot	Fresh weight of root	Plant height	Leaf length	Total chlorophyll	Vitamin C	N	Ca	Fe
Fresh weight of shoot	1									
Dry weight of shoot	0.75**	1								
Fresh weight of root	0.80**	0.72**	1							
Plant height	0.93**	0.85**	0.76**	1						
Leaf length	0.56**	0.50**	0.40*	0.65**	1					
Total chlorophyll	0.10ns	-0.25ns	-0.18ns	0.09ns	0.34*	1				
Vitamin C	0.89**	0.62**	0.63**	0.81**	0.59**	0.26ns	1			
N	0.77**	0.77**	0.51**	0.72**	0.56**	0.40*	0.76*	1		
Ca	0.57**	0.30**	0.52**	0.52**	0.33**	0.15ns	0.53**	0.35*	1	
Fe	0.80**	0.80**	0.51**	0.72**	0.51**	0.24ns	0.71**	0.78**	0.45**	1

**, * and ns–significant at P≥0.01 and p≤0.05 and non-significant, respectively.

5. Conclusions

The results of this research indicated that the effect of nitrogen sources on all measured traits was significant. So, the highest amount of shoot dry weight, plant height and leaf length, and leaf iron concentration was obtained from the ammonium sulfate source. The highest amount of shoot and root fresh weight, vitamin C concentration, and leaf calcium concentration was obtained from the fertilizer source of calcium nitrate, and the highest total amount of chlorophyll from the urea.

Declaration of Competing Interest

The authors report no declarations of interest.

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