



Effect of nitrogen, potassium, and iron nutrition on growth and physiological characteristics of local melon accession of Shahdad

Mahmoud Reza Ragami^a, Vajihe Iranfard^a, Mohammad Reza Azizi Ilami^{*a}

^a Department of Horticultural Sciences, College of Agriculture, Vali-e-Asr University of Rafsanjan, Rafsanjan, Kerman, Iran

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ABSTRACT

Yield and plant growth are affected by fertilization and irrigation. Therefore, effective fertilization methods and optimum use of fertilizers play a major role in improving fertilizer use efficiency and plant yield. This experiment was conducted to investigate the effects of nitrogen, potassium, and iron fertilizers on growth indices, photosynthetic pigments, mineral element concentrations, and yield indices of melon plants grown under field conditions. The fertilizer treatments were applied via fertigation and consisted of a control, as well as treatments with urea, potassium sulfate, Fe-EDDHA, urea + potassium sulfate, urea + Fe-EDDHA, and urea + potassium sulfate + Fe-EDDHA. The experiment was laid out in a randomized complete block design with three replications. The results showed that the application of urea, potassium sulfate, and the combined application of these fertilizers increased the fresh and dry weight as well as the shoot length of the melon plants. However, the application of Fe-EDDHA alone had no significant effect on the growth indices. Regarding fruit yield indices, the number, length, diameter, and total yield of the fruits increased under the urea, potassium sulfate, urea + potassium sulfate, and urea + potassium sulfate + Fe-EDDHA treatments compared with the control. The application of urea and potassium sulfate as fertigation can be considered an effective management strategy to enhance the growth and yield parameters of melon plants.

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* Corresponding author: M. R. Azizi ilami

E-mail address: mazizi13982019@gmail.com

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1. Introduction

Melons are considered a common and relatively important crops in Iran, ranking third in the world in terms of production. However, in terms of production per hectare, China, Spain, the United States, Egypt, and Iran are ranked first to fifth, respectively (FAO, 2013). It seems that one of the reasons for the decrease in yield per unit area is the lack of proper farm management practices. Therefore, proper farm management can improve the quantity and quality of crop production per unit area. Several factors improve yield per unit area, such as selecting suitable cultivars, using appropriate irrigation methods, and providing proper nutrition (Seilsepour, 2005). Melon plant requires three kg of nitrogen, one kg of phosphorus, and three to four kg of potassium to produce one ton of fruit. Therefore, providing potassium fertilizer is one of the key indicators in melon fruit production (Seilsepour, 2005). The determination of the required nutritional elements for plants can be assessed through soil testing methods, as well as by analyzing the concentration of elements in plant tissue. However, determining the appropriate method for supplying the nutritional elements requires investigation. There are different methods for supplying plant nutrients such as soil application, foliar spraying, and fertigation. Therefore, fertilization method has a fundamental role in the efficiency of fertilizer use and crop yield. Water use efficiency is also influenced by crop performance and the amount of water used. With optimal fertilizer application, it is possible to increase the efficiency of fertilizer use as well as crop yield and water use efficiency (Vaezi et al., 2002). In Iran, chemical fertilizers are mostly applied using the surface broadcast method. Due to this, the efficiency of fertilizer use, yield, and water use efficiency are low. Fertigation, which is the application of fertilizer through the irrigation water during the plant growth period, plays an important role in increasing the efficiency of using these two inputs, ultimately leading to increased crop yield (Vaezy et al., 2002). Optimal use of fertilizers and increasing their use efficiency play an important role in crop production. The amount of nutrient uptake changes during the growth period. In some plants, the time of greatest need is in the initial stage of the growth period, and in others it is in the later stages. On the other hand, in different fertilization methods, since the efficiency of fertilizer use is different, the amount of fertilizer used is not equal. It is obvious that by consuming nutrients based on the plant's needs during the growth period, the efficiency of fertilizer use also increases. Therefore, the fertigation method can play an important role in supplying nutrients at different stages of plant growth (Hebbar et al., 2004). Although plant mineral nutrition is complex, every plant needs essential nutrients for growth and development (Mehr avaran, 2003). In a study related to the use of potassium fertilizer in the form of fertigation under stress conditions on potato plants, it was shown that the use of potassium sulfate increased the growth indices under saline stress conditions (Hosseini and Amini, 2014). In a study on tomato plants, it was shown that the use of fertigation of different iron sources led to changes in the growth indices of tomato plants, and among the iron sources, the use of EDDHA had better efficiency compared to the use of DTPA and ferrous sulfate (Chohura et al., 2012).

Nitrogen is one of the essential nutrients for plants, playing a vital role in the formation of chlorophyll and protoplasm, as well as in energy changes and plant growth. A lack of nitrogen can halt the growth of plants and roots. Leaves remain small and turn from bright green to yellow in early growth stages due to nitrogen deficiency. As the deficiency continues, the color of the leaves changes from light yellow to golden yellow, eventually turning brown, drying out, and falling off. A melon plant requires approximately 80 to 150 Kg of nitrogen per hectare in one growth season (Roosta, 2016). Potassium is the most important element for the growth and development of melons. The crop's requirement for this element is higher compared to other nutrients. Given the role of potassium in sugar production and importance of sugar percentage as a quality factor in this crop, optimum application of this element nutrient is crucial (Roosta, 2016). Another important micronutrient element is iron. Iron is the fourth most abundant element in the earth's crust after oxygen, silicon and aluminum with an amount of 5.6% and its average amount in soil is estimated at 3.8% and can be found in almost every type of soil. In general, the role of iron in plants includes: chlorophyll production, catalytic role in enzyme activity, role in oxidation and reduction processes (redox), oxygen transfer, photosynthesis, nitrogen fixation, etc. (Jafari, 2015).

Based on the issues mentioned, this research was conducted under the hypothesis that the application of nitrogen, potassium, and iron using a novel fertigation method improves the growth characteristics, performance, and physiological properties of the plant. The study was carried out to investigate the growth characteristics and performance of the native melon cultivar Shahdad (local melon), under the influence of nitrogen, potassium, and iron nutrition using the fertigation method.

2. Materials and methods

This research was conducted to investigate the effect of nitrogen, potassium, and iron fertigation (fertilization through irrigation water) on the growth and physiological characteristics of the local melon (a type of melon) in a private farm located in Shahdad district of Kerman Province, Iran (with geographical coordinates of 30°25'02"N and 75°42'07"E). The experiment was carried out in a randomized complete block design with three replications during the spring and summer seasons of 2017. The fertilizer treatments (control, nitrogen, potassium, iron, nitrogen+potassium, nitrogen+iron, and nitrogen+potassium+iron) were applied along with the irrigation water (fertigation), one month after the seedlings emerged.

For this purpose, first, a soil sample was taken from the desired farm at a depth of 30-40 centimeters, and it was transferred to the soil science laboratory at the Faculty of Agriculture of Vali-e-Asr University to perform chemical and physical soil analysis. Finally, the soil texture characteristics of the desired farm are presented in Table 1. First, the local melon seeds were obtained from the Agricultural Research Center of Kerman Province. After obtaining the seeds, the desired land was prepared in the form of furrows and ridges, with each ridge being 2 meters long. The melon seeds were soaked in distilled water for 24 hours and three days after irrigation sown in clumps on the ridges (5 centimeters above the hot spot of the irrigation water) at a distance of 2 meters between ridges. Immediately after sowing the seeds, the field was irrigated

again. 12 days after sowing, the plants emerged and were irrigated at 12-day intervals. After the plants had 2-3 true leaves, thinning and earthing up were carried out, and the plants were irrigated at 11-day intervals. The fertilizer treatments (control, nitrogen, potassium, iron, nitrogen + potassium, nitrogen + iron, and nitrogen + potassium + iron) were applied 33 days after sowing (formation of 2 lateral stems) along with the irrigation water. In this experiment, urea (concentration of 253 mg/L) was used as the nitrogen source, potassium sulfate (concentration of 420 mg/L) as the potassium source, and Fe-EDDHA (concentration of 20 mg/L) as the iron source. At the end of the experiment (140 days after sowing), some morphological and physiological traits, nutrient elements, and fruit quality indices of the local melon were measured.

In order to determine the texture and chemical analysis of the soil at the test site, a soil sample from a depth of 40 centimeters was taken using an Oger. Then, for analysis and determination of texture, electrical conductivity and pH, it was transferred to the laboratory. Then, the hydrometer method was used to determine the soil texture (Table 1).

Table 1 Characteristics of the soil in the study farm

Characteristics		Characteristics	
Electrical conductivity	2.25 ds/m	Absorbable potassium (mg.kg ⁻¹)	16.2
pH	8.3	Absorbable phosphorus (mg.kg ⁻¹)	32.1
Sand	69%	Absorbable manganese (mg.kg ⁻¹)	18.5
Clay	14%	Absorbable iron (mg.kg ⁻¹)	15.6
Silt	17%	Absorbable zinc (mg.kg ⁻¹)	17.6
Total nitrogen	0.18%	Absorbable copper (mg.kg ⁻¹)	1.35
SAR	1.92	Sodium (meq.L ⁻¹)	4.33

The growth parameters measured in this experiment included: leaf area, main stem length, stem diameter, and plant dry weight. The stem diameter was measured using a caliper (digital ruler). To measure the dry weight, the plant was first cut at the collar region and the fresh weight was calculated. To measure the dry weight, the samples were placed in an oven at 72 °C for 48 hours and then weighed. For measuring the leaf area, three healthy leaves from the central part of each plant were selected and measured using a leaf area meter (model CI 202 made in the USA). At the end of the experiment, the reproductive parameters such as fruit yield, fruit number, fruit diameter, fruit length, and fruit flesh diameter were also examined.

This experiment was conducted as a factorial experiment in a completely randomized design with 3 replications, and in each replication 4 plants were used. The statistical analysis of the data was performed using the SAS software at a 5% level, and the plotting of graphs and tables and displaying the information was also done using the Excel software. The comparison between the means was done using the LSD (Least Significant Difference) multiple range test.

3. Results

Based on the results of the analysis of variance table (Table 2), the fertigation treatment was significant at the 1% probability level on the leaf area index. The results of the mean comparison between the treatments showed that plant nutrition with nitrogen, potassium, and iron individually increased the leaf area by 15.3%, 14.5%, and 14.5%, respectively, compared to the control plants. While the combined application of nitrogen and iron, nitrogen and potassium, and nitrogen, potassium, and iron increased the leaf area by 16.2%, 21.2%, and 27.9%, respectively, compared to the control plants (Table 2).

As shown in Table 2, stem length was significantly affected by the fertigation treatment at the 1% probability level. The results showed that plant nutrition with iron source alone did not have any effect on the stem length of local melon, but the application of nitrogen and potassium resulted in 52.9% and 19.6% increase in stem length, respectively, compared to the control plants. The results also showed that the simultaneous application of nitrogen and iron, nitrogen and potassium, and nitrogen, potassium, and iron sources resulted in 62.7%, 89.2%, and 90.1% increase in stem length, respectively, compared to the control plants (Table 2).

According to the results of the analysis of variance, plants nutrition by fertigation method did not have a significant effect at the 5% probability level on the stem diameter of the local melon plant (Table 2). As shown in Table 2, the combined use of different sources of nitrogen, iron, and potassium relatively increased the stem diameter.

Table 2 Results of analysis of variance and comparison of the effect of nitrogen, potassium and iron nutrition on the growth indices of local melon plant under field conditions

Treatment	Leaf area (cm ² .plant ⁻¹)	Main stem length (cm)	Stem diameter (mm)	Shoot dry weight (g.plant ⁻¹)	
Control	1976 e	34 e	8.93 a	38 c	
N	2278 c	52 c	8.73 a	46.3 b	
Fe	2090 d	37.7 d	9.07 a	36.7 c	
K	2264 c	40.6 c	8.33 a	44.3 b	
N + Fe	2296 c	55.3 c	9.2 a	46.3 b	
N + K	2395 b	64.3 b	9.20 a	56.3 a	
N + K + Fe	2527 a	64.7 a	9.40 a	58.3 a	
Sources of Variation	df	Mean Squares			
Block	2	79.8	16.1	2.66	2.33
Nutrition	6	100275**	473**	0.38 ^{ns}	205**
error	12	24838	6.60	0.93	5.78
Coefficient of Variation (%)		9.11	8.15	9.11	15.5

ns - no significant difference and ** - significant difference at the 1% probability level (LSD).

The different letters on the columns indicate that the difference in the means is statistically significant at the 5% probability level in the LSD (Least Significant Difference) test.

As shown in Table 2, the dry weight of the aerial parts was affected nutrition by fertigation method at the 1% probability level. The results showed that plant nutrition with iron source alone did not affect the dry weight of the aerial parts of the local melon plant, but the application of nitrogen and potassium increased the dry weight of the aerial parts compared to the control plants. However, the application of iron alone did not affect the dry weight of the aerial parts.

The results also showed that the simultaneous application of nitrogen and iron sources, nitrogen and potassium, and nitrogen, potassium and iron increased the dry weight of the aerial parts by 22%, 48.2%, and 53.5% respectively, compared to the control plants (Table 2).

Based on the results of the analysis of variance table (Table 3), the fertigation treatment was significant at the 1% probability level on the fruit yield index. The results of the mean comparison between the treatments showed that plant nutrition with nitrogen, iron and potassium alone resulted in a 37%, 28%, and 44% increase in fruit yield, respectively, compared to the control plants. While the combined application of nitrogen and iron, nitrogen and potassium, and nitrogen, potassium and iron resulted in a 26.6%, 41.6%, and 46% increase in fruit yield, respectively, compared to the control plants (Table 3).

As shown in Table 3, the number of fruits was affected by nutrition by fertigation method treatment at a 1% probability level. The results showed that feeding the plants with a combined source of nitrogen and iron had no effect on the local melon plant, but the application of nitrogen and potassium increased the number of fruits by 7.1% and 22.2%, respectively, compared to the control plants. However, feeding the plant with an iron source resulted in a 8.3% decrease in the number of fruits compared to the control plants. The results also showed that the simultaneous application of nitrogen and potassium sources, as well as nitrogen, potassium, and iron sources, increased the local melon plant by 5.2% and 25.8%, respectively, compared to the control plants (Table 3).

Based on the results of the analysis of variance table (Table 3), the fertigation treatment was significant at the 1% probability level for the fruit diameter index. The results of the mean comparison between the treatments showed that plant nutrition with the iron source led to a decrease in fruit diameter, but plant nutrition with nitrogen and potassium alone resulted in a 7.7% and 10% increase in fruit yield, respectively, compared to the control plants. While the combined application of nitrogen and iron, nitrogen and potassium, and nitrogen, potassium, and iron resulted in a 10.5%, 26.5%, and 27.8% increase in fruit diameter, respectively, compared to the control plants (Table 3).

As shown in Table 3, fruit length was significantly affected by nutrition using the fertigation method at the 1% probability level. The results indicated that plant nutrition with potassium led to a 9.6% increase in fruit length compared to control plants, but nitrogen and iron treatments alone had no effect on fruit length. The results also showed that simultaneous application of nitrogen and iron, nitrogen and potassium, and nitrogen, potassium, and iron resulted in a 12.8%, 20.3%, and 23.6% increase in fruit length compared to control plants, respectively (Table 3).

According to the results of the analysis of variance, plant nutrition using fertigation method did not have a significant effect at the 5% probability level on the fruit flesh length of local melon. (Table 3).

Table 3 Results of analysis of variance and mean comparison of the effect of nitrogen, potassium and iron nutrition on fruit characteristics and yield of local melon under field conditions

Treatment	Fruit Yield (Kg.plant ⁻¹)	Number of fruits (no.plant ⁻¹)	Fruit diameter (cm)	Fruit length (cm)	Fruit flesh diameter (cm)	
Control	1.73 d	2.53 bc	9.59 d	8.37 d	3.17 ab	
N	2.38 b	2.7 b	10.3 bc	8.83 cd	3.18 ab	
Fe	2.21 c	2.31 c	9.77 cd	9.03 cd	3.26 a	
K	2.49 a	3.08 a	10.5 b	9.17 c	3.19 ab	
N + Fe	2.20 c	2.49 bc	10.6 b	9.44 bc	3.2 ab	
N + K	2.45 ab	2.66 b	12.1 a	10.1 ab	3.11 b	
N + K + Fe	2.53 a	3.17 a	12.3 a	10.3 a	3.21 ab	
Sources of Variation	df	Mean Squares				
Block	2	0.004	0.006	0.02	0.03	0.0007
Nutrition	6	0.23**	0.29**	3.38**	1.42**	0.006 ^{ns}
error	12	0.003	0.02	0.13	0.15	0.005
Coefficient of Variation (Percent)		5.31	4.63	11.14	13.01	12.43

ns - no significant difference and ** - significant difference at the 1% probability level (LSD).

The different letters on the columns indicate that the difference in the means is statistically significant at the 5% probability level in the LSD (Least Significant Difference) test.

4. Discussion

Multiple factors influence plant growth, which can be divided into environmental and genetic factors. Among the environmental factors that affect growth indices, one can refer to light, temperature, nutrients elements, and others, where an excess or deficiency of any of these factors can affect plant growth (Delfin et al., 2005). Given that most regions of Iran, especially Kerman region, due to incorrect irrigation practices or excessive use of chemical fertilizers, one of the limiting factors for plant growth is the nutrients (Souza et al., 2017). Nitrogen is considered a determining element in plant nutrition, growth, and performance, so that the amount of accessible nitrogen for the plant can increase the chlorophyll content of the leaves and the size and volume of cell protoplasm, as well as affect the leaf surface and photosynthetic activity (Delfin et al., 2005). In other words, there is a direct relationship between plant vegetative growth power and the amount of nitrogen. This element plays a very important role in vegetative growth, flowering, fruit formation, fruit ripening, and crop yield (Estaji et al., 2011). According to the results obtained from the present study, growth indices increased due to the application of nitrogen. It has been reported that nitrogen increased the growth indices of apple rootstocks by increasing the amount of nitrogen in leaf tissue and increasing the amount of chlorophyll, leading to an increase in dry matter production and ultimately an increase in the growth of apple rootstocks (Parsa et al., 2007). Additionally, Zhou et al. (2011) showed that the application of nitrogen increased growth indices of cucumber plants by affecting the levels of photosynthetic pigments and increased carbon dioxide metabolism. It has been reported that the application of nitrogen along with phosphorus as fertigation increased growth indices of watermelon plants, which is consistent with the results of the present study (Emongor et al., 2017). Given that nitrogen is involved in many plant processes such as the synthesis of amino acids and proteins,

nucleic acids, and enzyme activity, the application of nitrogen affects these processes, leading to an increase in plant growth indices (Roosta, 2016). The results of the present study also showed that the application of potassium as fertigation increased growth indices of melon plants under field conditions, which is consistent with the results obtained on potato plants (Hosseini and Amini, 2014), wheat (Ghalenovi et al., 2014), cabbage (Inthichack et al., 2012), and eggplant (Souza et al., 2017). Potassium also increases transpiration by regulating the plant's osmotic balance and affecting stomatal opening and closing, leading to an increase in the rate of photosynthesis (Souza et al., 2017). On the other hand, the application of potassium while maintaining the water relations of tomato plants leads to an increase in growth indices of these plants under stress conditions (Ghasemi and Shahabi, 2010). It has also been reported that the application of potassium as fertigation on potato plants increased the dry weight of stems, leaves, roots, and tubers, leaf surface index, and the overall dry weight of the plant under Mashhad conditions (Sobhani and Hamidi, 2013). The results of the present study also showed that the application of iron as fertigation did not have any significant effect on plant vegetative growth indices measured in this experiment, except for the leaf surface area. However, when iron was applied in combination with nitrogen and nitrogen and potassium, it led to an increase in growth indices of local melon plants. These results are consistent with the results obtained on chickpea plants (Nenova, 2006). Caliskan et al. (2008) also demonstrated in a study on soybean plants that the application of iron alone did not have any effect on plant growth indices, but when applied together with nitrogen, it increased growth indices of soybean plants. The results of the present study also showed that the application of iron along with other fertilizers significantly improved growth. In a study on soybean plants, it was demonstrated that the application of iron increased the efficiency of nitrogen fertilizer and enhanced the absorption of this element (Caliskan et al., 2008). The results of the current research also indicated that the application of potassium, nitrogen, and iron led to an increase in growth indices of local melon plants. The increase in growth indices under the combined application of potassium, iron, and nitrogen can be attributed to the higher concentration of these elements in leaf tissues and an increase in chlorophyll content, which consequently enhances photosynthesis and ultimately increases dry matter production and plant growth.

Functional indices of a plant vary depending on the type of crop, but in fruit-bearing plants, the performance of a plant is evaluated based on fruit weight, number of fruits, and ultimately fruit yield per plant or per hectare (Lester et al., 2005). Multiple factors, such as genetic and environmental factors (light, temperature, water, soil, and nutrition), influence fruit performance (Merghany et al., 2015). Plant nutrition is one of the fundamental factors that affect all stages of plant growth, influencing the formation of reproductive organs as well as the growth and fruit development (Roosta, 2016). Khosravi Mashizia and Sar Cheshme Poor (2015) demonstrated in a study on the Galia melon variety that the application of potassium and calcium resulted in a significant increase in both quantitative and qualitative fruit yield of melons. Based on the results of the current study, the application of potassium sulfate played a significant role in increasing functional indices of local melon compared to the application of urea and Fe-EDDHA, in a way that the sole use of potassium led to an increase in yield, number of fruits, fruit length, and fruit diameter. It has been reported that among the essential nutrients elements, potassium plays a prominent role in the growth and performance of agricultural, horticultural, and greenhouse crops. The importance of potassium in the growth and performance of plants from the Cucurbitaceae family is such that the yield is positively and significantly correlated with the available soil potassium content. Since potassium has a regulatory role and also affects cell

division, plant growth and fruit size are strongly influenced by potassium (Merghany et al., 2015). It has also been observed that in the reproductive growth stage, root activity for the absorption of nutrients, especially potassium, increases. Since potassium plays an important role in the loading of carbohydrates and their transport in the phloem, the application of potassium not only increases fruit growth and size, but also affects the quality indices of the fruit (Marschner, 1995). On the other hand, due to the role of potassium in enzyme activity, protein synthesis, and cell division, the application of potassium has been found to increase growth indices in cucurbit plants (Lester et al., 2005). Merghany et al. (2015) demonstrated in a study on two varieties of melon in Egyptian climatic conditions that the application of potassium resulted in an increase in the number of fruits, fruit weight, fruit diameter, and fruit length compared to control plants; which is consistent with the results of the current research. Furthermore, the current study also showed that the application of urea led to an increase in functional indices of local melon, as nitrogen can not only directly affect growth and fruit development but also improve fruit growth by increasing the amount of potassium in plant tissues.

5. Conclusions

Based on the findings of this study, the application of urea, potassium sulfate, and the combined treatment of potassium sulfate, urea, and iron (Fe-EDDHA) led to significant improvements in the growth characteristics of the local melon variety under field conditions. Specifically, these fertilizer treatments resulted in increased shoot fresh and dry weights, as well as enhanced shoot length, compared to the control. The results also revealed that the application of potassium sulfate and urea, both individually and in combination, led to a substantial increase in fruit yield parameters, including fruit number, length, diameter, and total fruit yield.

Therefore, the strategic application of these fertilizers through fertigation at different growth stages can be considered an effective management approach to enhance the productivity and performance of melon cultivation for farmers in the Kerman region. By providing the optimal balance of essential nutrients, this fertilization strategy can help maximize the growth and yield potential of the local melon variety under field conditions. Overall, the findings from this study provide valuable insights for melon growers in the region, demonstrating that the judicious use of urea, potassium sulfate, and their combination with iron can be a viable solution to improve the growth and fruit yield of this important crop.

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