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Effect of Combination of Fertilizer on the Concentration of Some Elements in Biomass and Quantitative Yield of *Asparagus officinalis* Genotypes

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ABSTRACT

BACKGROUND: Fertilizers play a vital role in providing essential nutrients to the plants, influencing their growth and ultimately affecting the crop production.

OBJECTIVES: To assess the effect of different fertilizer treatments on yield and agricultural characteristics of different varieties of asparagus current research in Safi Abad Dezful Agricultural Research Center during the 2021-2022 cropping season was done.

METHODS: An experiment was conducted as a split plot based on a completely Randomized Block Design. The main factor consisted of three cultivars of asparagus (Linda, Mike and Mary Washington). The sub-factor, on the other hand, involved five fertilizer levels (manure fertilizer, basic chemical fertilizers + manure fertilizer, basic chemical fertilizers + manure fertilizer + sulfur, Basic chemical fertilizers + manure fertilizer + calcium and basic chemical fertilizers + manure fertilizer + calcium + sulfur).

RESULT: The results indicated that both the cultivar and fertilizer treatment had a significant impact on dry yield of edible stems. Among different combinations tested, usage of manure fertilizer in combination with chemical fertilizers, sulfur, and calcium in the Mary Washington cultivar resulted in the highest dry yield of edible stems, with an increase of 665 $kg.ha^{-1}$ compared to other treatments. The Linda cultivar demonstrated superiority over other cultivars in terms of iron content across all fertilizer treatments. In Linda cultivar, the concurrent application of manure fertilizer and chemical fertilizers resulted in the highest manganese content in the asparagus plant, reaching 1.29 ppm.

CONCLUSION: For achieving the highest dry yield of edible stems recommended to use Linda cultivar and apply a combination of manure fertilizer along with chemical fertilizers, sulfur, and calcium. This particular combination proved to be most effective in enhancing both the yield and the nutritional content of the asparagus plant.

KEYWORDS: *Calcium, Copper, Iron, Manure, Sulfur.*

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1. BACKGROUND

In agricultural systems, the source of nutrients required by plants is chemical fertilizers, which are produced from mineral resources or non-renewable sources of fossil energy. Research indicates that more than 54% of the increase in agricultural production is related to the use of chemical fertilizers. Today, conventional agricultural methods have not been successful in resource management, and by relying too much on artificial institutions and injecting auxiliary energy such as poisons and chemical fertilizers, it has created an unstable system (Alizadeh Saravani *et al*., 2022). Asparagus is an export product and one of the most profitable products compared to other vegetables; And economically, it has a very high medicinal, food and industrial value. Also, this vegetable is rich in vitamin K, vitamins A, group B vitamins and an excellent source of manganese, potassium, iron, dietary fiber, copper and phosphorus. Also, this plant has many other properties such as soothing, antimicrobial, it is anti-inflammatory and anti-cancer. The high yield and quality of asparagus required the use of chemical fertilizers increasing costly production. Furthermore, it created environmental problems such as salt and hard soils (Khucharoenphaisan and Sinma, 2023). Long-term studies have shown that the excessive use of chemical fertilizers reduces the yield of crops; this decrease in yield is the result of soil acidification, reduction of soil biological activities, loss of soil physical properties and the absence of micro nutrients in nitrogen, phosphorus and potassium fertilizers. (Sabahi, 2006). Based on this, the management of agricultural systems should be seriously reviewed and new systems should be designed whose priority is long-term sustainability and, at the same time, maintaining production in the short term (Moridian, 2019). In this regard, organic fertilizers, especially manures fertilizer, play an important role in sustainable agriculture by providing nutrients needed by plants. In addition to providing nutrients needed by plants, organic fertilizers maintain plant health and improve the physical and chemical characteristics of soil (Tohidi Moghadam *et al*., 2016). Organic matter is considered as the life factor of the soil as well as a source of storage of nutrients. These materials play an important role in maintaining soil fertility and are considered as a source of soil nitrogen, phosphorus and sulfur and prevent the leaching of nutrients (Zamil *et al*., 2004). Organic materials prevent the formation of calcium phosphate by complexing dissolved calcium and reducing its concentration in the soil solution. Manure fertilizer can be used to increase the organic matter in calcareous soils. Manure fertilizer release nutrients gradually and prevents them from being wasted due to leaching and makes them absorb by the plant in the maximum amount. Besides being a good source of nutrients, these fertilizers also improve the physical, chemical and biological properties of the soil (Khadem *et al*., 2012). Long-term experiments in fixed plots of combined use of organic and chemical fertilizers showed the greatest increase in the amount of soil organic carbon compared to the use of each of the organic and chemical fertilizers alone. The use of organic fertilizers with their effect on soil stability and self-regulation should be considered. Organic fertilizers have an effect on the quantity and quality of carbon and soil capacity in storing and releasing nutrients needed for plant growth during the process of decomposition and mineralization. The usage of organic fertilizers is more effective in maintaining the structure of the soil and increasing its quality than directly helping to increase the yield of crops (Alipoor Miandehi *et al*., 2013). Therefore, to reduce the economic and environmental problems caused by the excessive use of chemical fertilizers, the use of organic fertilizers has been suggested, so that in addition to reducing the use of chemical fertilizers, the efficiency of using chemical fertilizers can also increase (Fallahi *et al*., 2009). Calcium plays an important role in regulating plant growth and development. By binding to phospholipids, this element stabilizes fat layers and ultimately causes the integrity of the structure of cell membranes. The results of some researches have shown that the application of calcium reduces the adverse effect of abiotic stresses, such as salinity, drought and heat in plants (Ebrahimi *et al*., 2016). The positive effect of calcium in improving the tolerance to abiotic stresses has been attributed to the regulation of water relations, the activity of antioxidant systems, the accumulation of osmolytes, the improvement of the content of photosynthetic pigments and nutritional balance (Ziaeian, 2016). Due to its essential role of plant nutrition, modification of calcareous, salty and alkaline soils and increasing the efficiency of consumption of other elements such as nitrogen and phosphorus, sulfur increases crop yield (Khadem *et al*., 2012). Sulfur is a constituent of the amino acids cysteine, methionine and a part of proteins, which plays an important role in the production of vitamins in plant cells, as a result of its deficiency, plants grow late and their quantitative and qualitative yield decreases (Marschner, 1995). Considering the importance of nutritional elements, it is necessary to investigate the effects of consumption of these elements in asparagus plant.

2. OBJECTIVES

This research was conducted with the aim of investigating the effects of combined nutrition on quantitative yield and concentration of elements in asparagus plant at Dezful Research Center.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This research was carried out in order to investigate the effect of different nutritional treatments with fertilizer on quantitative yield and the concentration of elements in different cultivars of asparagus plant. The experiment was carried out at Safi Abad Agricultural Research Center, Dezful, at an altitude of 82 meters above sea level, It is centered at 48 degrees and 26 minutes east longitude and 32 degrees and 16 minutes north latitude.. In order to determine the physical and chemical properties of the soil of the experimental field, the field soil was sampled from 0 to 30 depths and after preparing the composite sample, the desired properties were determined in the soil science laboratory. Based on this, the pH and salinity of the farm soil were equal to 7.3 and 2.3 ds/m, respectively. The amount of carbon in the soil was 0.76 and the amounts of potassium and phosphorus were determined at 209 and 13.6 ppm. The experiment was carried out as a split plot using Completely Randomized Block Design (RCBD). The main factor of the experiment consisted of three cultivars of asparagus [Mary Washington (C_1), Linda (C_2) and Mike (C_3)] and the sub-factor involved five fertilizer levels [manure fertilizer (a), basic chemical fertilizers + manure fertilize (b), basic chemical fertilizers + manure fertilize + sulfur (c), Basic chemical fertilizers + manure fertilizer + calcium (d) and basic chemical fertilizers + manure fertilizer + calcium + sulfur (e)]. At the beginning of the experiment, asparagus plants were moved from the treasury to the main field and planted in pits with a row spacing of 90 cm and distance between the plants on the row was 25 cm.

3.2. Farm Management

After one month of cultivation, the operation of soiling and changing the atmosphere and the piles started and the soil of the piles was transferred to the bottom of the fields. In early February of the following year, after cutting the dry aerial parts of asparagus, which had completely dried up due to the cold, the desired fertilizers were applied in all the plots. Nitrogen base fertilizer at the rate of 75 kg.ha^{-1}, phosphate fertilizer at the rate of 75 kg and potash at the rate of 75 kg, and sulfur and calcium at the rate of 25 kg.ha^{-1} were used. Edible stems started to grow from 8th of February month and with the increase in temperature, and harvesting was done every two to four days. By observing stems with a height of 18 to 20 cm, using a special knife and placing its tip at a depth of two centimeters under the soil, exactly under the same stem and with a slow movement, the stems were removed from the soil. The harvesting period lasted 8 weeks in the spring season from March 1st to April 30th.

3.3. Measured Traits

3.3.1. *Dry yield of edible stems*

After applying the experimental treatments, the stems were harvested from a surface equivalent to one square meter in each plot. First, the fresh weight of the stems was calculated and sampled. After drying the samples, their dry weight was weighed and the dry yield of the edible stem was calculated (Mousavizadeh *et al*., 2019).

3.3.2. *Measurement of elements*

To measure elements in asparagus samples, first the plant samples were extracted by dry burning method. In this method, after grinding the leaves, 0.5 g of it was extracted for 24 hours at the 550^{o}C with 1 normal sulfuric acid.

3.3.2. 1. *Calcium and Manganese*

To measure the amount of manganese in plant samples, first add 9.5 ml of lanthanum solution to 0.5 ml of the prepared extract and then use the atomic absorption device to measure the amount of manganese and calcium using the following equation Calculated:

Equ.1. E= ((A-B)×K×V)/(M×Dm×100)

E= element concentration (Calcium or Manganese)

A= element concentration in the solution (calcium or manganese)

B= element concentration in the control (calcium or manganese), K= reverse potassium dilution, V= final volume of the extract, M= sample mass in grams, Dm= percentage of dry matter

3.3.2.2. *Iron, Zinc, Copper, Manganese*

In order to measure the amount of iron, zinc and manganese in asparagus samples, atomic absorption device was used. In order to do this, first, the extraction solutions of each element were prepared and in order to calibrate the atomic absorption device, the standard curves of each element were drawn by the atomic device. Then, the desired samples were read by Varian spectra-10AA atomic absorption device and the amount of these elements was obtained according to the number read and the standard curve. The amount of elements was also calculated in terms of ppm and according to the following equation:

Equ.2. E= (A×B×V×100)/(M×Dm)

In this regard:

E= concentration of the desired element

A= concentration of the desired element in the solution.

B= Reverse dilution the of the solution in analysis

V= final volume of extracted extract for measurement

M= mass of the sample in grams

Dm= percentage of dry matter of the sample

3.4. Statistical Analysis

Analysis of variance was done by SAS software and mean comparison was done by Duncan test at 5% probability level. Graphs were also drawn by Excel software (Ver.2010).

4. RESULT AND DISCUSSION

4.1. *Dry matter yield of edible stems*

Linda, Mary Washington and Mike cultivar had the highest dry yield in all fertilizer levels, respectively, and the application of manure along with chemical fertilizers, sulfur and calcium in Linda Cultivar had the highest dry yield by 665 $kg.ha^{-1}$, and with other treatments had significant differences. The lowest dry matter yield by 173 $kg.ha^{-1}$ belonged to the Mike Cultivar and the sole usage of manure fertilizer (Fig. 1).

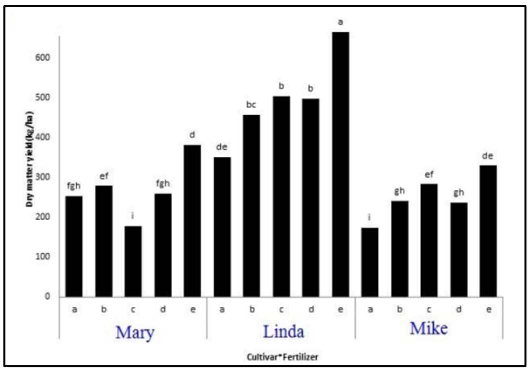

Fig. 1. Interaction effect of cultivar and fertilizer on dry matter yield. Means followed by similar letters in each column show non-significant difference according to Duncan tests at 5% level. a: manure fertilizer , b: basic chemical fertilizers + manure fertilizer, c: basic chemical fertilizers + manure fertilizer+ sulfur, d: basic chemical fertilizers + manure fertilizer+ calcium e: basic chemical fertilizers + manure fertilizer + calcium + sulfur.

Abdel Gawad *et al*. (2019) stated that the increase in the green cover of the plant due to the usage of basic chemical fertilizers, especially nitrogen, and as a result, the increase in the amount of radiation and materialization, are the main reasons for the increase in the amount of production and accumulation of dry matter and the increase in the plant biomass. Arazmjo *et al*. (2010) stated that the usage of chemical fertilizers has the greatest effect on increasing the amount of photosynthetic pigments in the plant and this increase in pigments leads to an increase in the amount of material production and as a result, an increase in the accumulation of dry matter and a more fresh and dry yield of edible stems. Also, Cassman *et al*. (2017) pointed out the relationship between the use of basic chemical fertilizers and the increase in the amount of photosynthetic pigments in the plant and stated that this increase in the amount of pigments has an important effect in increasing the rate of materialization and accumulation of dry matter. In general, the simultaneous consumption of chemical and fertilizers along with calcium and sulfur by increasing the amount of nitrogen in the plant has increased the amount of chlorophylls and carotenoids, which is followed by greenness, the ability to absorb sunlight, the production of photosynthetic substances and finally the growth and yield of dry matter in Asparagus should be increased. According to Fageria (1992), most of the dry matter produced by plant is due to the process of photosynthesis, and increasing the chlorophyll content of leaves through increasing photosynthesis and making more dry matter can be effective in improving dry matter yield.

4.2. *Iron element*

The interaction effect of cultivar and fertilizer treatments on the amount of iron in asparagus plant organs was significant (Table 1). Linda cultivar was superior to the other cultivars in terms of iron content at all fertilizer levels.

Table 1. Result of ANOVA of studied traits

S.O.V	df	Dry yield	Fe	Cu	Mn	Zn	Ca
Replication (R)	2	5488	0.84	0.001	0.02	0.01	86
Cultivar (C)	2	274404**	46.2**	0.012*	1.69**	0.24*	2940**
E_a	4	4469	1.21	0.002	0.004	0.02	46
Fertilizer (F)	4	48134**	7.82**	0.038**	0.19**	0.1*	970**
C×F	8	8452**	19.29**	0.097*	0.53**	0.78**	1015**
E_b	24	11.08	0.75	0.002	0.013	0.02	101
CV (%)		13.5	10.63	13.37	11.83	11.02	12

ns: Non significant, * and ** indicate significance at the level of 5% and 1%, respectively.

In Linda cultivar, the maximum amount of iron was obtained with the amount of 12.4 ppm only with the application of manure fertilizer, and the use of chemical fertilizers along with sulfur and calcium led to a further decrease in the amount of iron in this cultivar. In Mary Washington cultivar, the use of manure fertilizer along with chemical fertilizers, sulfur and calcium led to an increase in the amount of iron up to 12.2 ppm. According to the results, the lowest amount of iron (3.04 ppm) belonged to the Mike cultivar and the use of manure fertilizer alone, and in this respect, it had a significant difference with other treatments (Fig. 2).

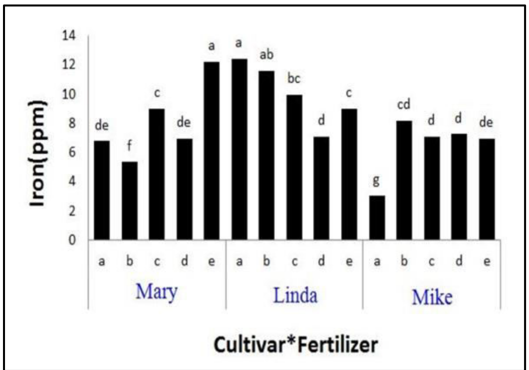

Fig. 2. Interaction effect of cultivar and fertilizer on Iron amount in organs. Means followed by similar letters in each column show non-significant difference according to Duncan tests at 5% level. a: manure fertilizer, b: basic chemical fertilizers + manure fertilizer, c: basic chemical fertilizers + manure fertilizer + sulfur, d: basic chemical fertilizers + manure fertilizer + calcium e: basic chemical fertilizers + manure fertilizer + calcium + sulfur.

Iron plays a key role in making many enzymes and proteins, especially in making chlorophyll pigment. Iron deficiency occurs mostly due to presence of lime, high soil pH, stagnant water and cold soil. The symptoms of iron deficiency are first seen in new shoots and leaves of asparagus. To eliminate iron deficiency, it is recommended to spray leaves with iron chelate with concentration of 1-1.5 per thousand, especially in calcareous soils. The best time to spray for asparagus is in May and after the end of spring harvest (Zarifinia, 2023).

4.3. *Copper element*

There was a significant difference in the response of three asparagus cultivars to the application of different fertilizer sources in terms of the amount of copper in asparagus (Table 1). In Mary Washington cultivar, use of manure fertilizer alone caused the highest amount of copper (0.75 ppm) to be obtained, while use of chemical fertilizers and calcium and sulfur along with manure fertilizer had negative effect on amount of copper in the organs. So that the lowest amount of copper was 0.13 ppm. So use of manure fertilizer along with basic chemical fertilizers and sulfur in the Mike cultivar caused highest amount of copper to be obtained as 0.44 ppm, while in Linda cultivar use of manure fertilizer along with chemical fertilizer and calcium caused highest amount of copper to reach 0.44 ppm (Fig. 3).

4.4. *Manganese*

There was a significant difference in the amount of manganese between different cultivars of asparagus in different fertilizer treatments (Table 1).

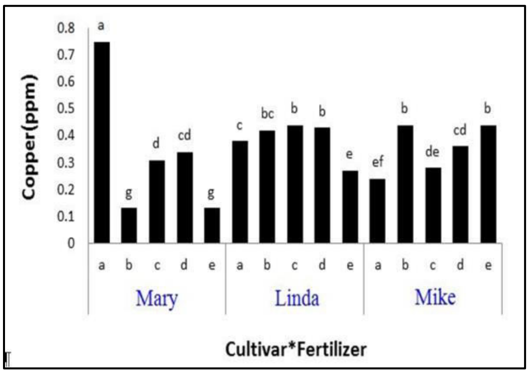

Fig. 3. Interaction effect of cultivar and fertilizer on Copper amount in organs. Means followed by similar letters in each column show non-significant difference according to Duncan tests at 5% level. a: manure fertilizer, b: basic chemical fertilizers + manure fertilizer, c: basic chemical fertilizers + manure fertilizer + sulfur, d: basic chemical fertilizers + manure fertilizer + calcium e: basic chemical fertilizers + manure fertilizer + calcium + sulfur.

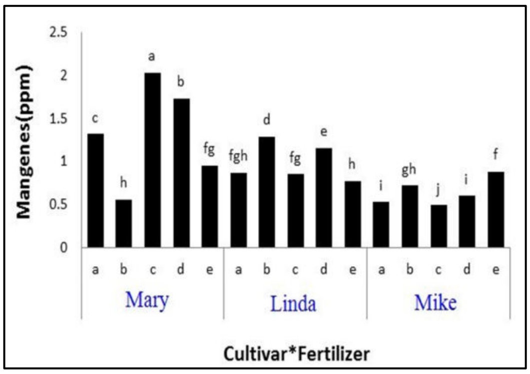

Fig. 4. Interaction effect of cultivar and fertilizer on Manganese. amount in organs. Means followed by similar letters in each column show non-significant difference according to Duncan tests at 5% level. a: manure fertilizer, b: basic chemical fertilizers + manure fertilizer, c: basic chemical fertilizers + manure fertilizer + sulfur, d: basic chemical fertilizers + manure fertilizer + calcium e: basic chemical fertilizers + manure fertilizer + calcium + sulfur.

The lowest amount of manganese element was related to the simultaneous application of manure fertilizer, basic chemical fertilizers and sulfur fertilizer at the rate of 0.49 ppm in Mike cultivar. In Linda cultivar, the simultaneous use of manure fertilizer and chemical fertilizers caused the highest amount of manganese in asparagus plant to be 1.29 ppm. Also, among all the experimental treatments, the highest amount of manganese in asparagus plant at the rate of 2.03 ppm belonged to simultaneous application of manure fertilizer, basic chemical fertilizers and sulfur, and in this respect, there was a significant difference with other treatments (Fig.4).

4.5. *Zinc*

At different levels of fertilizer treatments, asparagus cultivars had significant differences in zinc content (Table 1).

The simultaneous use of manure fertilizer, basic chemical fertilizers and sulfur caused the highest amount of zinc to be obtained in the Linda cultivar by 1.2 ppm, although the difference of this treatment with the treatments of simultaneous use of manure fertilizer, basic chemical fertilizers and calcium, also, treatment of simultaneous use of manure fertilizer and basic chemical fertilizers was not significant. In Mary Washington cultivar, the highest amount of zinc was 1.94 ppm due to the simultaneous application of manure fertilizer, basic chemical fertilizers and calcium, while in Mike cultivar, the highest amount of zinc was 1.93 ppm belonged to the treatment of simultaneous application of manure fertilizer, basic chemical fertilizers, sulfur and calcium. In all cultivars, the lowest amount of zinc belonged to different treatment levels (Fig. 5).

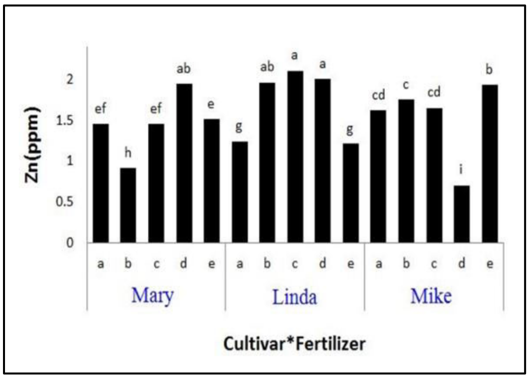

Fig.5. Interaction effect of cultivar and fertilizer on Zn amount in organs. Means followed by similar letters in each column show non-significant difference according to Duncan tests at 5% level. a: manure fertilizer, b: basic chemical fertilizers + manure fertilizer, c: basic chemical fertilizers + manure fertilizer + sulfur, d: basic chemical fertilizers + manure fertilizer + calcium e: basic chemical fertilizers + manure fertilizer + calcium + sulfur.

4.6. *Calcium*

The response of different asparagus cultivars to the application of different fertilizer treatments was different in terms of the amount of calcium (Table 1). In Mary Washington cultivar, the lowest amount of calcium was obtained with the application of manure fertilizer alone, while in two cultivars, Linda and Mike, the highest amount of calcium belonged to this treatment. Among all the experimental treatments, the highest amount of calcium was obtained with the amount of 120 ppm in Mike cultivar and application of manure fertilizer alone. In Mike and Mary Washington cultivar, the simultaneous application of manure fertilizer and basic chemical fertilizers with sulfur did not have a difference with the simultaneous application of manure fertilizer and basic chemical fertilizers with calcium, while in Linda cultivar; the difference between these treatments was significant. Among all the experimental treatments, the lowest amount of calcium (with an average of 40 ppm), belonged to the application of manure fertilizer alone, and this treatment was statistically significantly different from other experimental treatments (Fig. 6).

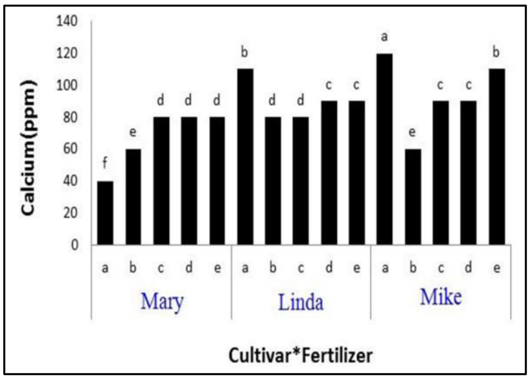

Fig. 6. Interaction effect of cultivar and fertilizer on C amount in organs. Means followed by similar letters in each column show non-significant difference according to Duncan tests at 5% level. a:manure fertilizer, b: basic chemical fertilizers + manure fertilizer, c: basic chemical fertilizers + manure fertilizer + sulfur, d: basic chemical fertilizers + manure fertilizer + calcium e: basic chemical fertilizers + manure fertilizer + calcium + sulfur.

5. CONCLUSION

The difference between different cultivars is the basis for the difference in the growth rate and final yield of cultivars and these differences can be due to genetic reasons or the cultivars' ability to use environmental resources. In this study, there was a significant difference between different asparagus cultivars in the growth characteristics, absorption of elements and their storage in the aerial organs, so that the cultivar Linda had the highest yield and dry edible stem and was superior to other cultivars in this respect. According to the results, different fertilizer treatments had a decisive effect on the growth rate and, as a result, fresh and dry yield of edible stem, as well as the amount of elements in the aerial parts of the asparagus plant. In terms of the amount of accumulated elements in the aerial organs, there was a significant difference between cultivars and different fertilizer levels. The results showed that the simultaneous application of manure fertilizer and basic chemical fertilizers resulted in the highest amount of nitrogen and protein in Linda cultivar. The use of proper nutrition caused a significant difference between the cultivars in terms of yield of edible stem, the amount of dry matter, as well as the quality of the edible stem, including the amount of calcium, zinc, manganese, copper and iron. The importance of these elements in human health and the therapeutic effect of these elements in blood purification and better functioning of the kidneys is one of the important points in choosing the cultivar and type of nutrition. Using management and nutritional methods based on soil and plant tests, in addition to increasing the volume of the crown and increasing the number of buds on the crown, increased the number of edible stems, increased stem diameter, marketability and shelf life of asparagus product (Zarifinia *et al*., 2011). Considering the production of the highest amount of fresh and dry yield of edible stem in Linda cultivar with the simultaneous use of manure fertilizer and chemical fertilizer, sulfur and calcium, this treatment is recommended in the cultivation of asparagus in Dezful region. On the other hand, in order to improve the quality characteristics of the asparagus plant, such as increasing the amount of protein, the simultaneous application of manure fertilizer and basic chemical fertilizers can be used.

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FOOTNOTES

AUTHORS' CONTRIBUTION: All authors are equally involved.

CONFLICT OF INTEREST: Authors declared no conflict of interest.

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