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The role of silicon and salt stress in some vegetative traits and mineral content of mint plant *Mentha piperita* L.

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ABSTRACT

The experiment was carried out during agricultural season 2021, to study the effect of adding two types of silicon on the vegetative growth characteristics and mineral content of mint plant grown under the salt stress. The experiment was designed using Randomized Complete Block Design RCBD as a factorial experiment with two factors and three replicates, each replicate contains 9 experimental units, each unit consists 3 pots. The first factor included adding two types of silicon oxide as well as the comparison (S0 control, S1 nano-silicon, and S2 normal silicon); the second factor is salt stress included adding pure NaCl in three concentrations, (N_0 0 g L^{-1}, N_1 0.45 g L^{-1} and N_2 1.45 g L^{-1}). The results of study showed that there are significant differences caused by the experiment factors in number of lateral branches, number of leaves, and total leaf area, as the treatment S_2N_2 outperformed significantly with highest value of branches number, leaves number, and total leaves area which were 8.60 branches $plant^{-1}$, 286.80 leaves $plant^{-1}$, 1211.5 cm^2 $plant^{-1}$ respectively compared with control S_0N_0 which gave the lowest values; 7.10 branches $plant^{-1}$, 182.90 leaves $plant^{-1}$, 643.3 cm^2 $plant^{-1}$ for the same traits. S_2N_0 treatment was significantly superior in mineral content of NPK in leaves and gave the highest percentages of N 3.30%, P 0.5550%, K 1.96% compared with S_0N_2 treatment with the lowest percentages of N 2.90%, P 0.4283%, K 1.81%.

دور السيليكون والشد الملحي في بعض الصفات الخضرية والمحتوى المعدني لنبات النعناع *Mentha piperita* L.

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الخلاصة

نفذت التجربة خلال الموسم الزراعي للعام 2021 لدراسة تأثير أضافة نوعين من السيليكون في صفات النمو الخضري والمحتوى المعدني لنبات النعناع المزروع تحت تأثير الشد الملحي، صممت التجربة باستخدام القطاعات العشوائية الكاملة RCBD كتجربة عامليه ذات عاملين وبثلاثة مكررات وكل مكرر يحتوي على 9 وحدات تجريبية تتكون كل وحدة من 3 اصص، تضمن العامل الاول إضافة أوكسيد السيليكون بنوعين فضلاً عن المقارنة (S_0 مقارنة و S_1 سيليكون نانوي و S_2 سيليكون عادي)، العامل الثاني هو الشد الملحي (إضافة كلوريد الصوديوم NaCl النقي بثلاث تراكيز) (N_0 0 غم. لتر$^{-1}$، N_1 0.45 غم. لتر$^{-1}$، N_2 1.45 غم. لتر$^{-1}$). اظهرت نتائج الدراسة ما يلي، هناك فروقات معنوية سببتها عوامل التجربة في صفة عدد الافرع الجانبية، عدد الأوراق الكلية، المساحة الورقية الكلية، اذ تفوقت المعاملة S_2N_2 معنوياً بأعلى قيم بلغت 8.60 فرع. نبات$^{-1}$، 286.80 ورقة.

نبات$^{-1}$، 1211.5 سم^{2}.نبات$^{-1}$ مقارنة مع معاملة المقارنة S_0N_0 التي أعطت أقل القيم بلغت 7.10 فرع. نبات$^{-1}$، 182.90 ورقة. نبات$^{-1}$، 643.3 سم^{2}. نبات$^{-1}$ للصفات نفسها. وتفوقت معاملة S_2N_0 معنوياً في صفة المحتوى المعدني NPK في الأوراق وأعطت أعلى نسب 3.30% N، 0.5550% P، 1.96% K مقارنة مع معاملة S_0N_2 بأقل نسب 2.90% N، 0.4283% P، 1.81% K.

الكلمات المفتاحية: النعناع، السيليكون، الاجهاد الملحي، المحتوى المعدني.

INTRODUCTION

The mint plant, *Mentha piperita* L. is one of medicinal and aromatic plants types belonging to Lamiaceae family, which are almost the largest and most widespread plant families in the world. This family includes 200 gender, and 2000 to 5000 species of aromatic annuals and bushes (Lawrence, 2006). The plants of this family are characterized by being annual or perennial herbs, sometimes bushes, and scarcely climbers. These plants contain glandular hairs or oil glands containing essential oils. The original home area of mint is the Mediterranean basin, and mint is a plant with a good aromatic smell, and it reproduces in several ways, such as seeds, rhizomes, and suckers. Fresh or dried leaves are used as spices to improve the food and drink taste due to the oil contained in mint plant. Mint oil is colorless or yellow, it contains medicinal substances and effective compounds, the most important of which are lemon, apigen, rutin, benzoic, phyllandrin, menthol, carvone, and tannins, these materials are medicinal materials that relieve pain and spasms, and the essential oil of these materials is included in the composition of many medicines, gastric ulcer treatments, cosmetics and food industries (Patra et al., 2002). Therefore, type of oil and its composition are greatly affected by conditions surrounding the plant, such as salinity (salt tension), drought (water stress), temperature, light and the type of agricultural medium (soil). These factors lead to oils production with varying specifications in terms of quantity and quality. (Tawfeeq, 2017). The ratios of oil and the accumulation of active substances in the plant are related to the biotic and abiotic stresses to which the plant is exposed, and these stresses are abiotic such as fresh water sources lack and uses of saline water sources such as springs, wells, and even sewage water sometimes after treatments, that salt stress is abiotic stress has a direct impact on many agricultural crops around the world (Ashraf and Foolad, 2007) and 100 million hectares or 5% of the arable land around the world is negatively affected by the high concentration of sodium chloride (NaCl) which reduces crop growth and productivity (Heuer, 1994 ,Ghassemi et al., 1995). Therefore, some studies indicated the role of silicon in reducing biotic and abiotic stresses on the plant, which plays different beneficial roles in growth and its stages and relieve the impact of biotic and abiotic stresses (Hana and Abbas, 2016). Silicon is one of the abundant elements in the earth's crust and found mainly in the inert state, and a little in the soluble state (Savant et al., 1999). Silicon one of the mineral elements that has been used in recent years as a fertilizer element for its effective role in reducing the harmful effects of salinity, although it is not in the essential elements list for plant growth, but one of the most important beneficial elements has an important role in many essential physiological processes. The most important role is improving the efficiency of photosynthesis and increasing roots activity in absorbing necessary nutrients that plant needs from the soil, and reducing the toxicity of heavy elements that may be present in some types of soil (Liang et al., 2007, Al- Wakeel et al., 2010, Adrees et al., 2015).

This study aimed to demonstrate the silicon effect on vegetative growth characteristics and mineral content of mint plants under the influence of salt stress..

MATERIAL AND METHODS

The experiment was carried out in the lath house of the Department of Horticulture and Landscape/College of Agriculture/Tikrit University for a period from 10/5/2021 to 28/10/2021 to know the response of mint plant *Mentha piperita* L. to adding silicon in two different synthetic forms and their effect on vegetative growth traits and mineral content under salt stress conditions where the suckers obtained from a farm in Tikrit / Salah al-Din. The suckers were taken from one plant and rooted before planting them in pots (20 x 23 cm) filled with a mixture of soil consisting of 4:1 soil to compost. The experiment consisted of two factors, the first is addition of two different types of silicon, which are silicon oxide in its natural and nano form. In addition to the control which its symbol (S0, S1, S2) for each of the control, the nano-form and the natural form of silicon oxide SiO_2, respectively the addition of silicon was at the same concentration, as 1 g of silicon was dissolved for both types in 1 liter of distilled water separately, and 400 ml of the solution was added to the cultivation medium (soil) on 9/23/2021 at 10:00 a.m. and only 400 ml of distilled water added to control plants with the symbol (S0), which is the same amount of silicon solution that added to the rest plants, while the second factor was addition of pure sodium chloride (NaCl) in three concentrations including control (0 g L^{-1}, 0.45 g L^{-1}, 1.45 g L^{-1}), and symbolized (N0, N1, N2) respectively. This amount of solution was added to each plant in the experimental unit on 26/9/2021 after the plant dried for two days.

Table (1) Physical and chemical properties of soil used in agriculture

Measurement	Unit	Specified ratio
pH	——	7.0
EC	$Ds.m^{-1}$	1.046
Silicon	%	45.622
Available nitrogen	%	39.2
Available Phosphorus	%	9.22
Available potassium	%	98.80
sand	%	33
silt	%	43%
clay	%	24%
Soil texture	Sandy loam	
Moisture at field capacity	%	36.43%
Moisture at permanent wilting point	%	9.24%
Available water	%	27.19%

Vegetative growth characteristics:

1- Number of lateral branches (branch plant^{-1}): It was measured at the end of the experiment and included the branches emerging from the main stem and all plants in each experimental unit and their average was taken.

2- Total leaves number (leaf plant^{-1}): It was measured at the end of the experiment by calculating the leaves on the plants for each plant in the experimental unit and taking their average.

3- Total leaf area (cm^2): The total leaf area was measured by the following equation (the area of one leaf x the number of leaves).

The leaf area of one leaf was measured at the end of the experiment by taking a sample consisting of six fully grown leaves from each experimental unit by using weighted method (Wallace and Munger 1965), this sample weighed using a sensitive balance (three digits after zero) then leaves are holed using a special drill with known diameters, (6 mm) from the center and for all the six leaves together, then the discs cut from the leaves are weighed and recorded after that, the following equation is applied to find one leaf area.

one leaf area = (full leaves weight) / (discs weight) x disk area

Mineral content of leaves:

The mature and complete leaves were collected, washed with distilled water, air dried and placed in paper bags after their weigh recorded, then placed in oven at a temperature of 65-70 ° C for 48-72 hours until the weight was stable, then they were ground well and a weight 0.5 g was taken for each sample and digested using (10 ml) of concentrated sulfuric acid H_2SO_4 and (2 ml) of perchloric acid $HClO_4$ according to what was mentioned by Al-Sahaf (1989) and the elements were estimated after the completion of the digestion process using the following methods:

1- Percentage of nitrogen in leaves (%): The nitrogen in the digested plant leaves was estimated using the Micro-Kjeldahl apparatus according to the method mentioned by (Estefan et al, 2013).

2- Percentage of phosphorous in leaves (%): The phosphorus was estimated in digested plant leaves, by colorimetric method, and using a spectrophotometer UV-1100 EMC lab, and read the absorption of light at wavelength 410 nm, according to what was mentioned by (Naseem and Muhammad, 2011).

3- Percentage of potassium in leaves (%): The potassium in leaves was estimated using Flame Photometer apparatus type Elico CL-378, according to what was stated in (Estefan et al, 2013).

RESULTS AND DISCUSSION

Table (2) shows that addition of silicon (S_2) and sodium chloride (N2) were significantly gave the highest values compared with control treatment of silicon (S_0) and sodium chloride (N_0) gave the lowest values of lateral branches number, total leaves number, and total leaf area. The positive effect of silicon addition (S_2) shows the important role of silicon in reducing the harmful effects of abiotic stresses such as salt stress, this is because silicon has an active role in many physiological processes, such as improving the availability of the necessary elements in soil, which may not be ready for absorption by the roots due to high osmotic potential, which negatively affects plant growth by reducing the percentage of necessary elements in the soil (Liang et al., 2006). Also, silicon is importance to improve the vegetative growth because of its direct and effective impact on the metabolic processes that occur inside the plant, and has a major role in simplifying nutrients absorption that needs by the plant for photosynthesis. Robatjazi et al. (2020) studied the influence of silicon on the physiological characteristics and vegetative growth of *Ocimum basilicum* L. under salt stress. The results showed the superiority of vegetative growth characteristics by lateral branches number, total leaves number, total leaf area when adding sodium chloride (N2). This effect could be due to the defensive physiological role of the plant when the growth medium contains high concentration of salt or heavy elements, by increasing the total vegetative ratio compared with root system. The increase in leaves number, lateral branches, and leaf area is positively reflected on the increase in the carbonization rate in the plant, and thus the photosynthesis processes increase, which in turn increases respiration and transpiration in order to reduce the high concentrations of salts inside the plant (Manchanda and Garg, 2008). The mineral content of NPK in leaves increased significantly with the combination treatment of silicon (S_2) and sodium chloride (N_0) by highest percentages compared with combination treatment of silicon (S_0) and sodium chloride (N_2) by the lowest percentages. This is due to the positive role of silicon (S_2) in increasing the activity of transporter protein ATPase found in the plasma membranes of root cells, which is active in transporting ions of NPK, especially potassium K (Liang et al., 2006). Also, silicon regulates the relationship between mineral elements and Na by reducing the concentration of sodium in the soil and preventing its permeation through the plasma membranes of the root, and this increases the activity and effectiveness of the proteins that are responsible for entering ions (Liang et al., 2007). Also, sodium chloride (N_0) was significantly superior, which gave the highest percentages of NPK in leaf compared with the addition of sodium chloride (N_2) which gave the lowest percentages. This is because the negative effect of sodium chloride on soil, which causes an increase in sodium ions in soil solution and thus a high osmotic potential, which causes difficulty in absorbing water and the necessary mineral elements that the plant needs in his physiological processes. Furthermore, the high osmotic potential in soil causes competition between chloride ions and mineral elements ions that reduce their availability in soil (latef and Chaoxing, 2011).

Table (2) Effect of adding two types of silicon on the vegetative growth and mineral content of mint plants grown under salt stress conditions.

treatments	Lateral branch number	Total leaves number	total leaf area	N %	P %	K %
S_0	6.95 b	190.49 b	753.9 b	3.05 c	0.4550 c	1.84 c
S_1	7.49 ab	213.26 ab	798.4 b	3.13 b	0.4833 b	1.87 b
S_2	8.01 a	247.34 a	1037.4 a	3.15 a	0.5022 a	1.89 a
N_0	7.53 ab	218.00 b	844.7 b	3.22 a	0.5205 a	1.92 a
N_1	7.38 b	201.58 b	844.5 b	3.16 b	0.4744 b	1.86 b
N_2	7.55 a	231.51 a	900.6 a	2.95 c	0.4455 c	1.82 c
S_0N_0	7.10 ab	182.90 b	643.3 b	3.14 b	0.4816 b	1.88 c
S_0N_1	6.99 ab	193.97 ab	836.3 ab	3.11 e	0.4550 e	1.84 e
S_0N_2	6.77 b	194.62 ab	782.1 b	2.90 g	0.4283 f	1.81 g
S_1N_0	7.60 ab	247.80 ab	1005.6 ab	3.24 b	0.5250 b	1.93 b
S_1N_1	7.60 ab	178.87 b	681.6 b	3.18 c	0.4750 d	1.86 d
S_1N_2	7.27 ab	213.12 ab	708.1 b	2.98 f	0.4500 e	1.83 f
S_2N_0	7.88 ab	223.30 ab	885.1 ab	3.30 a	0.5550 a	1.96 a
S_2N_1	7.55 ab	231.92 ab	1015.6 ab	3.18 c	0.4933 c	1.88 c
S_2N_2	8.60 a	286.80 a	1211.5 a	2.98 f	0.4583 e	1.83 f

CONCLUSION

The results showed that silicon and sodium chloride had a significant effect on the vegetative growth characteristics and mineral content of mint plants, where the addition of normal silicon significantly outperformed in vegetative growth and mineral content traits. Addition of sodium chloride at a concentration of 1.45 g L^{-1} was significantly superior in vegetative growth. On the other hand, control treatment in affected clearly in percentages of mineral content.

REFERENCES

Adrees, M., Ali, S., Rizwan, M., Zia-ur-Rehman, M., Ibrahim, M., Abbas, F., and Irshad, M. K. (2015). Mechanisms of silicon-mediated alleviation of heavy metal toxicity in plants: Areview. Ecotoxicology and Environmental Safety, 119, 186-197

Al-Sahhaf, Fadel Hussein. (1989). Applied plant nutrition. Baghdad University. Ministry of Higher Education and Scientific Research. Iraq

Al-Wakeel, Muhammad Abdul-Rahman and Wael Muhammad Al-Wakeel. (2010). Silicon and plant health. Web: http://osp.mans.edu.eg/wakil

Ashraf, M. F. M. R., and Foolad, M. R. (2007). Roles of glycine betaine and proline in improving plant abiotic stress resistance. Environmental and Experimental Botany, 59(2): 206-216.

Estefan, G.R. Sommer and J. Ryan. (2013). Methods of soil plants and water analysis. A Manual for the West Asia North Africa region. 236-244

Ghassemi, F., Jakeman, A. J., and Nix, H. A. (1995). Salinisation of land and water resources: human causes, extent, management and case studies. CAB international.

Hana Hassan Muhammad and Roaa Salam Abbas, Al-Mustansiriya University/College of Basic Education-Department of Science. (2016). The use of nanomaterials to mitigate the effects of moisture stress. Journal of the College of Basic education, 22(96/sci).

Heuer, B. (1994). Osmoregulatory role of proline in water-and salt-stressed plants. Handbook of Plant and Crop Stress, 19, 363-481.

Latef, A. A. H. A., and Chaoxing, H. (2011). Effect of arbuscular mycorrhizal fungi on growth, mineral nutrition, antioxidant enzymes activity and fruit yield of tomato grown under salinity stress. Scientia Horticulturae, 127(3): 228-233.

Lawrence, B.M. (2006). The Composition of commercially important mints. Medicinal and Aromatic Plants- Industrial Profiles. CRC Press; pp. 247-286.

Liang, Y., Sun, W., Zhu, Y. G., and Christie, P. (2007). Mechanisms of silicon-mediated alleviation of abiotic stresses in higher plants: A Review. Environmental Pollution, 147(2): 422-428.

Liang, Y., Zhang, W., Chen, Q., and Ding, R. (2006). Effects of silicon on H+-ATPase and H+-PPase activity, fatty acid composition and fluidity of tonoplast vesicles from roots of salt-stressed barley (*Hordeum vulgare* L.). Environmental and Experimental Botany, 53(1): 29-37.

Manchanda, G., and Garg, N. (2008). Salinity and its effects on the functional biology of legumes. ActaPhysiol Plant 30: 595–618.

Naseem, Maher Georgie and Wafaa Hassan Mohamed (2011). Important botanical analysis. College of Agriculture - Saba Pasha. Alexandria University. Publisher Knowledge facility in Alexandria. Al-Jalal Printing Company.

Patra DD.M,Anwar,S. chand,Usha kiran ,DK.Rajput and S.Kumar. (2002), Nimin and Mentha spicata oil as nitrification inhibitors for optimum yield of Japanese Mint. Commun soil Sci plant.Anal. 33(3and4):451-460.

Robatjazi, R., Roshandel, P., and Hooshmand, S. D. (2020). Benefits of silicon nutrition on growth, physiological and phytochemical attributes of basil upon salinity stress. International Journal of Horticultural Science and Technology, 7(1): 37-50.

Savant, N. K., Korndörfer, G. H., Datnoff, L. E., and Snyder, G. H. (1999). Silicon nutrition and sugarcane production: A Review. Journal of Plant Nutrition, 22(12): 1853-1903.

Tawfeeq, A. (2017). Factors affecting essential oil production in rosemary (Rosmarinus officinalis L.) (Doctoral dissertation, University of Reading).

Wallace, D. H. and Munger, H. M. (1965). Studies of the physiological basis for yield differences. I. Growth analysis of six dry bean varieties 1. Crop Science: 5(4): 343-348.