International Journal of Advanced Biotechnology and Research (IJBR)
ISSN 0976-2612, Online ISSN 2278–599X,
Vol-13, Issue-3, 2022, pp13-23
http://www.bipublication.com

Research Article

Antagonistic effects of potassium and sodium with different ratios of organic matter and pumice on the cultivation of nectarine split root

Mostafa Asadi[1], Yavar Sharafi[2*],
Sayed Jalal Tabatabayi[3] and Ayatollah Rezaei[4]
[1-4]Department of horticultural sciences,
Faculty of Agriculture,
Shahed University, Tehran, Iran
[*]Corresponding author: Email: y.sharafi@shahed.ac.ir

[Received 17 Dec-2020, Modified: 10 July-2022, Accepted 11 Sept-2022, Published 30 Sept-2022]

DOI: 10.5281/zenodo.7588280

ABSTRACT:
The use of new techniques, such as soilless cultivation and split root system in the field of modern agriculture allows for the better and more accurate control of plant nutrition. In this research, the antagonistic effects of potassium and sodium with different ratios of organic matter and pumice were investigated in the cultivation of nectarine split root; and the experiment was conducted in the form of a Randomized Complete Block design with five treatments and four replications. The treatments included 100% pumice and 0% organic matter, 75% pumice and 25% organic matter, 50% pumice and 50% organic matter, 0% pumice and 100% organic matter, and without culture (control). The results showed that the best potassium uptake in the growth medium contained 75% pumice and 25% organic matter as well as 50% pumice and 50% organic matter where the plant showed the best response and a higher vegetative level. In this environment, the ratio between the elements was such that no adverse effect was imposed on the absorption of each other by the plant.

Keywords: Antagonistic effects, split root system, potassium, sodium, nectarine

[I] NTRODUCTION

The increasing world population and the consequent need to provide food have put more pressure on agricultural lands. The use of new techniques, such as soilless cultivation (hydroponics) and split root system in the field of modern agriculture has provided the possibility of exerting better and more accurate control of plant nutrition. Nowadays, the use of soilless cultivation is rapidly on the rise. This technique considered as a kind of plant production technology that increases the quality and quantity of horticultural products. With the increasing population, the cultivable land resources is shrinking day to day. To meet the food, fiber, fuel, fodder, and other needs of the growing population, the productivity of agricultural land and soil health needs to be improved [1]. Approximately four-fifths of the land areas of the world are located in arid and semi-arid areas. And Iran is one of the world's low rain regions [2].

Salinization of soils in arid and semi-arid regions has become a serious problem for the development of agriculture and the sustainable use of soil and water resources [3]. Soil salinity problems have increased dramatically in the world for the past 30 years. Soil salinity and water salinity are among the environmental stressors that cause problems for plants in terms of nutrition and metabolic processes in addition to disrupting and reducing the absorption capacity of water by roots [4]. Salinity is one of the most important stresses that affect the plant productivity since salt in the soil causes stomatal closure through its osmotic effect and, thereby, the CO_2 / O_2 ratio in the leaves is reduced and CO_2 stabilization is prevented [5].

Potassium plays such an important role in the transfer of photosynthetic materials and elements that photosynthetic products should be transferred from the origin of production (leaves) to the place of consumption (reservoir). Moreover, potassium has a part in the nitrogen absorption of plants and this plays a pivotal role in the interaction and absorption of elements in vegetative growth. Potassium, as a cation, is involved in the transfer of nitrate from the phloem and the root to the plant shoots and its return through phloem in the form of malate [6]. The presence of this element is necessary for the synthesis and transfer of nutrients in plants and it helps with the elimination of the negative effects of some soil nutrients' deficiencies and also helps with the regulation of the activity of water absorption. The role of potassium in fruit trees is as follows: 1) It increases the resistance of plants to dehydration and frost hazards; 2) It increases the resistance of plants against pests and diseases, including fire blight in pears and canker in citrus; 3) It increases the quality and the storage properties of garden products; 4) It controls the intensity of light, enhances photosynthesis, and increases the efficiency of irrigation water. Potassium is involved in the growth and development of plant cells, the creation of cellular turgor pressure, the opening and closing of stomata, and the synthesis of various carbohydrates; thus, it plays an important role in the growth, development, yield, and quality of products [7].

In addition to its very important physiological functions in the plant, potassium also is of special importance in improving the quality of agricultural products; hence, it is called the element of quality [8]. Fruits are strong consumers of potassium and, therefore, potassium is of high importance in maximizing fruit size and quality. Many of the quality and quantity factors in plants are affected by the amount of potassium in plants and, especially, fruits in such a way that the size, color, and acidity of fruits have a positive correlation with the amount of potassium [9]. The process of cellular development and growth during plant growth is influenced by the amounts of potassium present in the plant. In this case, there is even a very close relationship between potassium and hormones that affect the plant growth. The increase of fruit quality factors influenced by potassium concentration of nutrient solutions can be related to the role of potassium in plant metabolism and activation of enzymes. These effects of potassium can be expressed directly and indirectly in plants. Potassium, along with other qualitative elements, such as nitrogen and calcium, plays the most important role in the quality of products [10]. Furthermore, the properties of different culture media in hydroponics have direct and indirect effects on the growth and development of plants, and different varieties provide different responses in varying culture media [11].

The antagonism between plant nutrients is referred to as a condition whereby the surplus of a nutrient reduces the plant absorption from other essential nutrients. In this line, the antagonism between the nutrients is responsible for the effective or ineffective absorption of potassium. The relationship between nutrients in the plant system is very complex and interdependent on each of the nutrients.

[II] MATERIALS AND METHODS

2.1. Time and place of the culture medium and its preparation method

This experiment was conducted in the split root Research Garden of Shahed University in February 2015. The culture medium was made of black and thick nylon bags 80 cm in length and 50 cm in width. One side was sewn by a staple and the prepared bags were filled with the organic matter and pumice were in volumes of 60 cm3. When the volume of the nylon bags reached two thirds, the other side was also sewn by a stapler so that there would be no seam. Under each medium, three holes were created to remove excess water and provide the conditions for the movement and penetration of the roots toward the medium.

Next to the cultivated plants, some holes 50 cm in depth, 50 cm in width, and 80 cm in length were drilled with a 30-centimeter distance from each other. The nylon bags that had been filled with a mixture of pumice and organic matter were placed on the right side of each plant so that the split root system could be applied in this way.

2.2. Plant materials and their properties

Independans, Stargeld, Stark Sanglu, Sunking, Giota, Karaj Shabrang, Mashhad Red autumn, Vega, Orion, Jiawaya, and Moghan constitute the commercial varieties of nectarine in Iran. In this experiment, Moghan variety was used.

2.3. Installation of the irrigation system

The irrigation system will be fulfilled by embedding a 2000-liter tank as well as the conduct of minor and major plumbing. The sub-tubes will be pulled down on the media next to each plant and the water will be directed into the medium by two pressure reducing drippers and one plastic tube to ensure the full water entry into the medium.

Next to the major tank, a small 200-liter tank will be embedded to provide nutrition for the plants. In the small tank, macro and micro elements are poured in stock and this tank is connected to the large tank by small tubes and an EC and PH controller device. Then, the nutrient solution is injected into from the small tank to the large tank, which contains the solution. This is accomplished through the device's control and by using the EC and PH of the large tank. The large tank consists of an automatic float that carries water and nutrients into the tank by reducing the water level to a specified limit and diluting the work solution. The flow of the drippers placed on each medium is 4 liters per hour and, thereby, 8 liters of water enters each medium from the two drippers.

2.4. Potassium measurement

The amount of potassium in the plant tissue was read by the flame photometer using flame diffusion method and, finally, the obtained consecration was calculated in the form of concentration per dry matter. For this purpose, the standard solution was prepared.

To obtain the standard solution, 0.95 grams of potassium chloride was dissolved in a small amount of water and was reached to a volume of 100 ml in the volumetric flask. Therefore, the obtained solution is 5000 mg /L. Using this solution, a standard solution of 100 milligrams per liter was prepared via the following formula.

$$5000 \times V1 = 100 \times 100$$

For the preparation of the standard solution, at first, 0, 2, 4, 6, 8, and 10 milliliters of the 100-mg/liter solution was removed and the volume of 100 ml was obtained. The device was first set to zero by using distilled water; then, the remaining solutions were used to calibrate the device, and the numbers of the plant specimens were read by the device [12].

2.5. Sodium measurement

The amount of sodium in the plant tissue was read by flame photometer using flame diffusion method and, finally, the obtained consecration was calculated in the form of concentration per dry matter. The standard solution was prepared for this purpose.

To obtain the standard solution, 0.95 grams of potassium chloride was dissolved in a small amount of water and was reached to a volume of 100 ml in the volumetric flask. Therefore, the obtained solution is 5000 mg /L. Using this solution, a standard solution of 100 milligrams per liter was prepared through the following formula.

$$5000 \times V1 = 100 \times 100$$

For the preparation of the standard solution, at first, 0, 20, 15, 10, 5, and 25 milligrams per liter of the 100-mg/liter sodium solution was removed using sodium chloride and the volume of 100 ml was obtained. The device was first set to zero by using distilled water; then, the remaining solutions were used to calibrate the device, and the numbers of the plant specimens were read by the device (10).

The analysis of variance and comparison of means were performed using SPSS at the probability levels of 1% and 5% through .... tests. The graphs have been drawn using Excel 2016 software.

[III] RESULTS AND DISCUSSION

The results of analysis of variance on the properties under investigation in Table 1 showed that the following treatments among the different treatments being examined were cultivated without any culture medium: 100% pumice and 0% organic matter, 75% pumice and 25% organic matter, 50% pumice and 50% organic matter, 0% pumice and 100% organic matter. In the assessment of the growth and physiological characteristics of the plant, we weight, dry weight, the number of leaves, the total number of buds, chlorophylls a and b, and anthocyanin were significant. In the same way, the assessment of the antagonistic effects revealed that the highest potassium and sodium levels were respectively found the medium of 75% pumice and in the treatment without any medium (control). This is the results of the different reaction of the treatments.

Treatments			Characteristics											
Organic materials	Pumice	Treatment number	potassium	Sodium	Chlorophyll a	Chlorophyll b	Carotenoid	Whole buds	Height cm	Trunk diameter mm	Number of leaves	Fresh weight	Dry weight	Leaf area
0	0	1	$10/47^{ab}$	$15/25^{a}$	$0/016^{cd}$	$0/02^{b}$	$0/005^{a}$	$108/00^{b}$	$98|75^{a*}$	$21/57^{c}$	$991/50^{d}$	$6/86^{a}$	$2/11^{b}$	$148.00/00^{a}$
0	100	2	$10/37^{b}$	$7/00^{c}$	$0/018^{b}$	$0/02^{b}$	$0/003^{b}$	$116/00^{a}$	$99/75^{a}$	$24/15^{a}$	$1176/50^{bc}$	$6/17^{ab}$	$2/31^{ab}$	$231/75^{a}$
50	50	3	$10/60^{a}$	$8/00^{c}$	$0/017^{b}$	$0/03^{a}$	$0/005^{a}$	$114/50^{a}$	$103/50^{a}$	$27/34^{a}$	$1349/75^{ab}$	$5/42^{b}$	$2/48^{a}$	$105/50^{c}$
25	75	4	$10/45^{ab}$	$11/70^{b}$	$0/02^{a}$	$0/02^{b}$	$0/006^{a}$	$120/25^{a}$	$103/50^{a}$	$28/58^{a}$	$1484/75^{a}$	$6/13^{ab}$	$2/09^{b}$	$119/50^{c}$
100	0	5	$10/52^{ab}$	$8/50^{c}$	$0/015^{d}$	$0/03^{a}$	$0/006^{a}$	$104/25^{b}$	$77/00^{b}$	$23/16^{bc}$	$1012/50^{cd}$	$6/63^{a}$	$2/29^{ab}$	$158/00^{b}$

Table: 1. Average Comparison Characteristics Examined

Resources	Degrees of freedom	Average of Squares											
		Potassium	Sodium	Chlorophyll a	Chlorophyll b	Carotenoid	Whole buds	Height cm	Trunk diameter mm	Number of leaves	Fresh weight	Dry weight	Leaf area
frequency	3	/002^{ns}	0/90^{ns}	0/000002^{ns}	0/0000003^{ns}	0/0000003^{ns}	5/73^{ns}	^{ns}267/33	^{ns}0/88	^{ns}12334/3	^{ns}0/08	^{ns}0/03	60/07^{ns}
Treatment	4	0/03^{ns}	30/05**	0/00006**	0/00001**	0/000006**	164/60**	493/87*	10/77**	251182/1**	1/26**	0/08*	8482/07**
Error	12	0/02	1/70	0/0000002	0/0000009	0/000001	16/44	106/71	0/46	13054/8	0/18	0/02	125/77
Coefficient of variation%		1/25	13/38	8/88	3/17	21/43	3/60	10/70	3/95	10/22	7/47	6/07	6/71

Table: 2. Variance analysis table

3.1. Sodium

The results of Fig. 1 indicate that the medium without organic matter and pumice (control treatment) has witnessed the highest sodium content to be absorbed by nectarine tree among the other treatments. This can be the reason for the reduction of dry weight, wet weight, and the number of leaves under the control conditions. Due to the fact that the highest sodium content was observed in the in the control conditions, other elements such as calcium, phosphorus, and potassium were absorbed to the plant to a lesser extent. Therefore, lower values were naturally observed for growth characteristics, especially the dry weight. The amount of sodium in the treatment of 75% Pumice and 25% organic matter was such that it did not make any interference with the absorption of potassium, phosphorus, and calcium. In this treatment, the plant enjoyed favorable vegetative growth in addition to the absorption of elements.

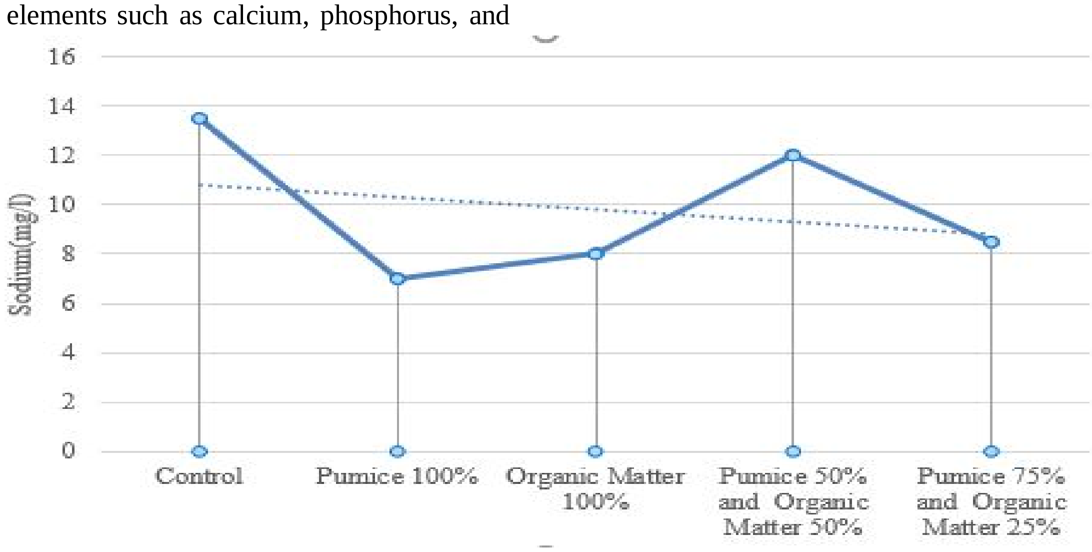

Fig. 1. Diagram of sodium variation in the treatments under study in nectarine tree at the probability level of 5% (similar letters indicate no significant difference between the treatments)

3.2. Potassium

The results of Fig. 2 indicate that the culture medium containing 100% organic matter and no pumice has witnessed the highest potassium content to be absorbed by nectarine tree. In the second order, the culture medium of 75% pumice and 25% organic matter contained the second highest potassium content to be absorbed by nectarine tree. On the other hand, the lowest potassium uptake was observed in 100% Pumice treatment. While examining the weight of wet leaves, the weight of dry weight leaves, and the number of leaves, it was observed that the growth factors were higher in the treatments where higher potassium adsorption had occurred. The findings of this study are consistent with those of the study carried out by Faraji et al. (2016) where the researchers reported the effect of lowering sweating materials and potassium on the yield and quality of strawberry fruit (Camarosa cultivar) in hydroponic culture system.

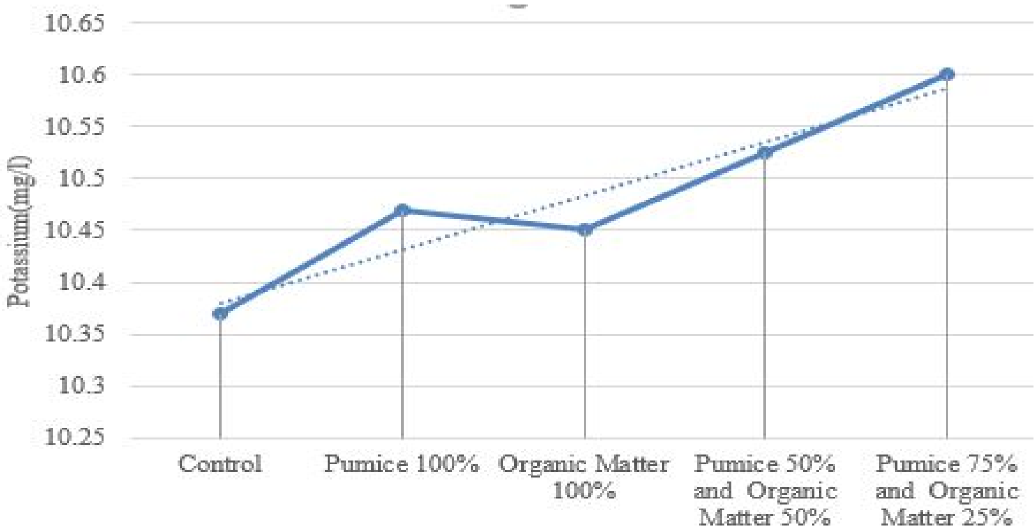

Fig. 2. Diagram of Potassium variation in the treatments under study in nectarine tree at the probability level of 5% (similar letters indicate no significant difference between the treatments)

An increase in sodium and potassium levels is expected. High concentrations of sodium in the shoots cause a variety of plant osmotic and metabolic problems, may lead to the probable toxicity resulting from the excessive accumulation of this ion in the plant organs, and may reduce the production of the dry matter of the plant [14]. The collapse of ion ratios in the plant under different growth conditions is the result of the interference of sodium adsorption with potassium adsorption. The similarity between the sodium hydride ion radius and potassium ion radius makes it difficult for the carrier proteins to differentiate between the two ions; in this way, sodium toxicity is provided. The activity of the enzymes present in the cytoplasm is highly sensitive to salt and, therefore, maintaining the high ratio of potassium to sodium in cytosol is a fundamental requirement for plant growth under different growth conditions.

The high ratio of potassium to sodium in the plant under different environmental conditions is one of the important criteria for plant reaction to different treatments [15]. Hence, the presence of the antagonistic effect between the sodium and potassium absorbed by the plant can be referred to as the reason for the reduction of potassium ion in plant organs. The frequency of sodium ion in environmental conditions and its replacement with potassium ion at the level of colloids and the soil solution phase and, consequently, its higher absorption by the root lead to the increase of its concentration and decrease of other ions, especially potassium. The high concentration of sodium in the plant causes ion toxicity and reduces plant production and growth. It seems that despite the effect of the environment and the amount of soil salinity on the amount of these ions in plant tissues, the final amounts of their concentrations are determined by the plant [16].

The balance of nutrients and the interactions between them can be involved in achieving different results. The collapse of the nutrient balance and the increase of toxicity in the root environment reduce the photosynthesis and the plant's dry weight [17]. The vegetative growth of the plant was reduced in the treatments with the increased potassium concentration (220 mg / L). It has also been reported that the absorption of the main nutrient elements, such as magnesium, calcium, and ammonium is greatly reduced as a result of the high consumption of potassium [18]. Potassium levels in the nutrient solution lead to the reduction of magnesium absorption by the plant due to the presence of antagonistic effects between potassium and magnesium and between calcium and magnesium [19]. On the other hand, high levels of potassium can prevent the absorption of calcium and magnesium by the plant and the reverse of it also holds true [20].

Another related research has also reported that a high increase in the concentration of nutrient solution led to an increase in the salinity of the nutrient solution, which was followed by the reduced dry weight of the plant organs [21]. Performance and quality of different products are influenced by genetic and environmental factors. From among the environmental factors, plant nutrition plays an important role in this field [22]. In another study, it was reported that soluble solids increased with an increase in the concentration of the elements and salinity levels due to a decrease in water absorption and thickening of the carbohydrate in the fruit [23]. The reduced concentration of highly-consumed nutrient elements decreased the percentage of soluble solids [24]. In another study, it was reported that an increase in the concentrations of nutrients reduced the yield, wet and dry weight of the shoots, and leaf area. This can be due to the increased salinity in the nutrient solution, which prevents the absorption of more nutrients by the plant. The addition of organic materials to the soil has different effects on its physical, chemical, and biological properties depending on the features of these materials. In most cases, the optimization of these properties and conditions provides the possibility of producing high-performance products in terms of quality and quantity [25].

3.3. Growth and physiological properties of nectarine plant

The results of the comparison of the means between different treatments (culture media) based on changes in the growth properties of nectarine plant showed that there was a significant difference between the treatments. The highest dry and wet weight of the leaves was observed when the plant was cultured in 75% pumice and 25% organic matter and it was followed by the treatment with 50% pumice and 50% organic matter. On the other hand, the lowest dry and wet weight of the leaves was observed in control treatment (without the use of pumice and organic matter).

The highest number of leaves was observed in two treatments of 50% Pumice and 50% organic matter and also 75% Pumice and 25% organic matter, whereas the lowest number of leaves was observed in 100% Pumice treatment.

The highest leaf area was observed in 100% Pumice treatment and the lowest leaf area was observed in 100% organic matter treatment. Moreover, there was no statistically significant difference between the treatment with 75%

pumice and 25% organic matter and the one with 50% pumice and 50% organic matter.

The highest trunk diameter was observed in the treatment with 75% pumice and 25% organic matter and the lowest trunk diameter was observed in the control treatment.

The highest number of buds was observed in the treatment with 50% pumice and 50% organic matter. However, the lowest number of buds was observed in the treatment containing 100% pumice and the control treatment where the two treatments did not show significant statistical difference with each other in this line.

The lowest height was observed in the treatment with 50% pumice and 25% organic matter, which had a significant difference with other treatments. Other treatments did not significantly differ from each other in terms of height.

With regard to the comparison of the culture media (treatments), it can be argued that the treatments with porous media showed greater growth properties, such as wet weight, dry weight, the number of leaves, plant height, etc. than the control treatment, which was consistent with the results of the study conducted by Hesari et al. (2012) and Salimi et al. (2016). This can be due to the presence of pumice with different values, the improvement of the aqueous relations in the root, and the better absorption of water in the treatments with porous media. Another reason for this finding can be stated as the possibility of meeting and controlling the plant's needs for organic elements and materials in the hydroponic culture system in such a way that no toxicity may be produced for the plant.

The results of this study showed that organic matters have a significant effect on the growth indices. This seems to be due to the provision of more suitable ventilation and moisture conditions (the improvement of the physical structure of the soil), as well as easier access to nutrients (the improvement of the chemical structure of the soil) [28]. In fact, the addition of organic matters to the soil, similar to the function of plant hormones, stimulates the plant to absorb nutrients, improves the metabolism of the plant, and increases the plant growth [29]. In fact, the increase in nutrients leads to more carbon uptake by the plant; then, the increase in the growth of the stem length is provided by stimulating the plant and consequent access to a higher amount of light and the increase in the amount of photosynthesis [30,31,32].

The results of the comparison of the means between different treatments (culture media) based on changes in chlorophylls a and b and carotenoid showed that there was a significant difference between different treatments. In this regard, the lowest levels of chlorophylls a and b and carotenoid in the leaves of nectarine plant were observed in the control medium. On the other hand, the highest levels of chlorophylls a and b in the leaves of nectarine plant were observed in the culture media containing 75% pumice and 25% organic matter, and 50% pumice containing 50% organic matter. The highest level of carotenoid was observed in the culture medium containing 50% pumice and 50% organic matter. According to the obtained results, it can be claimed that the plant has shown a more appropriate vegetative reaction and has had higher amounts of Chlorophyll and carotenoid in the leaves in the media wherein the absorption of organic matters and nutrients (75% pumice and 25% organic matter; and 50% pumice and 50% organic matter) has been fulfilled well.

[IV] CONCLUSION

Potassium is an essential element for plant growth and is a very dynamic ion in the plant and soil system. As an ion, potassium is very mobile in the plant system, but it is only relatively mobile in the soil system. As humans need a balanced diet with adequate amounts of carbohydrates, proteins, vitamins, minerals, fats, and water; plants also need a balanced diet. Antagonists between nutrients are responsible for the effective or ineffective absorption of potassium. The relationship between nutrients in the plant system is very complex and is interdependent on each of the nutrient elements. Therefore, further research should be conducted on molecular levels to explain the true relationship between potassium and other nutrient elements.

According to the findings of this study, it seems that the collapse of the balance of nutrients and the increased salinity in the root can reduce photosynthesis and dry weight of the plant. Moreover, the obtained results showed that the culture media with 50% pumice and 50% organic matter, and with 75% pumice and 25% organic matter were the best combinations of culture media where the plant showed the best reaction and formed a higher vegetative level. In this environment, the ratio between potassium and sodium is in a way that they had no adverse effect on each other's absorption by the plant. Indeed, all the elements and materials have been sufficiently absorbed.

Acknowledge: None stated.

Conflict of Interest: No potential conflict of interest declared.

REFERENCES

1. Nagesh N. Patil, Shruti D. Choudhari, Shweta S. Gawade, Carol V. Carvalho and Abhijeetkumar B. SharmaP. (2013). Effect of different carbon sources on production and stability of biofertilizer, International Journal of advanced Biotechnology and Research (IJBR), Vol-4, Issue-1, 85-95.
2. Sharifi, P. (2017). Effect of silicon nutrition on yield and physiological characteristics of canola (brassica napus) under water stress condition, International Journal of advanced Biotechnology and Research (IJBR), Vol-8, Issue-1, 144-153.
3. Valipour, M., Karimian Eghbal, M., Malakouti, M. & Khoshgoftarmanesh, A. H. (2008). The trend of salinity development and agricultural land degradation in Shams Abad area of Qom province, Science and Technology of Agriculture and Natural Resources, 12 (46), 683-691
4. Farhadi, H., Azizi, M., & Nemati, H. (2015). Investigation of the effects of salt stress on some physiological and biochemical characteristics of different landraces of fenugreek (Trigonella foenum - graecum L.), Iranian Journal of Horticultural Science and Technology, 13 (2), 411-419.
5. Hu, Y., Fricke, W., Schmidhalter, U., 2005. Salinity and the growth of non-halophytic grass leaves: the role of mineral nutrient distribution. Funct. Plant Biol. 32, 973–985.
6. Blevins, D. G., Barnett, N. M., Frost, W. B. 1978. Role of potassium and malate in nitrate uptake and translocatto drought and the interion by wheat seedlings. Plant Physiology. 784-788.
7. Ganjehea, B., & Glochin, A. (2011). The effect of different levels of N, K and Mg on yield and growth indices of strawberry in hydroponic culture, Journal of Science and Technology of Greenhouse Culture, 2 (8), 71-80.
8. Arancon, N.Q., C.A. Edwards, S. Lee and R. Byrne. 2006. Effects of humic acids from vermicomposts on plant growth. Eur Journal of Soil Biology. 42: 65-69
9. Behnamian, M. & Masiha, S. (2002). Strawberries. Sotoudeh Publication, 120 pages.
10. Gruda, N. 2005. Impact of environmental factors on product quality of greenhouse vegetables for fresh consumption Critical Reviews in Plant Sciences. 24: 227-274.
11. Tabatabai, J. & Mohammad Rezaei, R. (2006). Effect of different culture media on growth and yield of greenhouse cucumbers in hydroponic systems, Journal of Agricultural Science. 16 (2), 35-44.

12. Tabatabai, S., J. (2013). Principles of Plant Mineral Nutrition. Tabriz University, 544 pages.
13. Faraji, M. (2016). Effect of lowering sweating materials and potassium on the yield and quality of strawberry fruit (Camarosa cultivar) in the hydroponic culture system, Mater's Thesis, Faculty of Agricultural Sciences, Shahed University, 104 pages.
14. Tester, M. and R. Davenport. 2003. Na+ tolerance and Na+ transport in higher plants. Ann. Bot. 91: 503-527.
15. Ashraf, M. and A. Orooj. 2005. Salt stress effects on growth, ion accumulation and seed oil concentration in an arid zone traditional medicinal plant ajwain (Trachyspermum ammi L. Sprague). Department of Botany, University of Agriculture, Faisalabad 38040, Pakistan.
16. Khan M.A., Ungar I.A., Showalter A.M. (2005) Salt stimulation and tolerance in an intertidal succulent halophyte, Journal of Plant nutrition .28:1365-1374.
17. Khoshgoftarmanesh, A.H. (2007). Basics of Plant Nutrition. Publication of Isfahan University of Technology, 2-293 pages.
18. Mirmoghadami, A., M., & Ghareh Riazi, B. (2002). Physiological and vegetative aspects of salinity stress of plants. Isfahan University of Technology. 70 pages.
19. Locascio, S.J. and G.K. Saxena. 1967. Effect of potassium source and rate and nitrogen rate on strawberry tissue composition and fruit yield. Proc. Florida State Hort. Soc. 80: 173-176.
20. Awada, M. 1978. Relations of nitrogen, phosphorus and potassium fertilization to nutrient composition of the petiole and growth of papaya. Journal American Society for Horticultural Science. 102: 413-418.
21. Lamarre, M. and M.J. Lareau. 1997. Influence of nitrogen, potassium and magnesium fertilization on day-neutral strawberries in Quebec. Acta Horticulture. 439: 701 -704.
22. El-Bassiony, A.M., Z.F. Fawzy, E.H. Abd El-Samad and G.S. Riad. 2010. Growth, Yield and Fruit Quality of Sweet Pepper Plants (Capsicum annuum L.) as Affected by Potassium Fertilization Journal of American Science, 6: 722-729.
23. Counversa, G., P. Santamaria, O. Carofiglia, M. Gonnella and A. Parent. 2003. Response of cherry tomato to the electerial conductivity of the nutrient solution. ActaHort. 609:159-163.
24. Portela, A., P. Isabelita, M.N. Roberta and C.V. Rombaldi. 2012. Effect of nutrient concentration on growth, yield and quality of strawberries in hydroponic system. Horticultura Brasileira. 30: 266-270.
25. Cecil, F. and C. F. Tester. 1990. Organic amendment effects on physical and chemical properties of a sandy soil Soil. Science Society of America Journal. 54: 827-831.
26. Hesari, N., Zaghami, R., Bouzari, N., and Haji Mohammadi, A., 2012. The Effect of Elemental Iron Levels on Microscopicity of 4 Peach Cultivars Under In vitro Culture, 12th Iranian Congress of Genetics, Tehran, Iran Genetics Society, https://www.civilica.com/Paper-CIGS12-CIGS12_0230.html.
27. Salimi, M, 2016. The effect of various iron fertilizer on some vegetative and physiological traits of peach and nectariane grown in the split root system in soil media. Faculty of Agricultural Sciences, Shahed University, Tehran, Iran, 104 pages.
28. Shibu, M.E., P.A. Leffelaar, H. Van Keulen and P.K. Aggarwal. 2006. Quantitative description of soil organic matter dynamics—A review of approaches with reference to rice-based cropping systems, Geoderma 137: 1–18.

29. Tichy, V. and H.K. Phuong. 1975. On the character of biological effect of humic acids. Humus Planta 6: 379–382.
30. Landsberg, J.J. and S.T. Gower. 1997. Applications of physiological ecology to forest management. In: Mooney, H.A., (ED.), Academic press., USA.
31. Navarro, R.M., M.J. Retamosa, J. Lopez, A.D. Campo, C. Ceaceros and L. Salmoral. 2006. Nursery practices and field performance for the endangered Mediterranean species Abies pinsapo Boiss. Ecological Engineering. 27: 93-99.
32. Jocobs, D.F., K.F. Salifu and J.R. Seifert. 2005. Growth and nutritional response of hardwood seedlings to controlled-release fertilization at outplanting. Forest Ecology and Management. 214: 28-39.