

The Effect of Agricultural Sulfur on Reduce the Effects of Irrigation Water Salinity on growth of the Broad Bean Plant in Southern Iraq

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Abstract: Broad bean (*Vicia faba*) is one of the most important crops grown in central and southern Iraq and has great economic importance. Its cultivation has been affected in recent years by the high level of salinity in irrigation water, which has led to the decline of its cultivation in many rural areas previously known for its cultivation in areas close to the banks of the Euphrates River. This forced us to estimate how much this plant is affected by salinity levels and treat it with agricultural sulfur to reduce the damage. The experiment was conducted during the 2022-2023 growing season at the Second Research Station Al-Bandar affiliated with the College of Agriculture / Al-Muthanna University, to study the effect of irrigation with saline water on broad bean plants grown in 5 kg pots at four salinity levels (0, 4, 8, 12 ds m⁻²). Agricultural Sulfur was added at three levels (0, 3.0, 6.0 g pot⁻¹). The experiment was designed following the Randomized Complete Block Design (R.C.B.D.) with three replicates below a significant level 0.05. The results showed significant differences using agricultural sulfur with salinity-free treatments in vegetative properties and chemical properties. However, the results also showed the positive effect of adding agricultural sulfur at high levels of 6 g pot⁻¹ when irrigated with saline water up to 12 ds m⁻². As for the chemical properties, the results showed the extent of the effect of adding agricultural sulfur 6 g plant⁻¹ anvil with irrigation with water salinity up to 12 ds m⁻² on the chemical properties. The result confirmed that adding agricultural sulfur to pots planted with riverside soil reduced the harmful effect of irrigation with saline water on the growth of some legume plants.

Keywords: chemical properties, vegetative, *Vicia faba*, Salt, Sulfur.

Introduction

Beans are winter crops rich in carbohydrates, vitamins, minerals and proteins that may reach about 25-40% (Gutierrez *et al.*, 2008). Plant residues and bean waste or seeds were used after drying and grinding as a rich source of protein when feeding livestock. Legume plants played an important role in improving the chemical properties of the soil by fixing atmospheric nitrogen because their root nodules contain atmospheric nitrogen-fixing bacteria (FAO,2003). In Iraq, the area planted with bean crops in 2021 amounted to about 6174 hectares with a production rate of 7.3 tons per hectare (Ministry of Planning / Central Bureau of Statistics / Directorate of Agricultural Statistics, 2021).

Soil salinization rates have increased due to the misuse of surface irrigation systems, especially in the central and southern Iraq regions. The harmful salts have increased in the soils of the dry and semi-arid southern Iraqi governorates, especially the high levels of sodium and chloride ions in the irrigated soil solution, as these soils are heavily clayey. Treating the worsening salinity by adding agricultural sulfates led to raising the pH values, which improved the plants' ability to absorb nutrients. The accumulation of high concentrations of bicarbonate, borate, and lithium in the root zone negatively affected plant growth by reducing the availability of some important nutrients to complete the plant life cycle. (Ethbeab *et al.*,2013) It was found that exposure of bean plants (Rena Mora) to salt stress (NaCl) resulted in a decrease in the number of branches, plant height, and NPK ions content in their leaf extract with an increase in the accumulation of sodium ions concentrations in the extract of those leaves.

(Al-Hady *et al.*,2013) It was found that irrigating bean plants with it supposed increased not negatively affected the plant height and number of branches. (Abbas *et al.*,2018) It was found that irrigating okra plants (*Abelmoschus esculentus* L.) with saline water (8 ds m⁻²) reduced the potassium and nitrogen contents, as well as a significant decrease in the chlorophyll content of leaves, with an accumulation of sodium ions in the leaf and root extracts. (Al-Jarah *et al.*,2019) It was reported that irrigation with well water (11.68 and 16.55 ds m⁻²) for two consecutive seasons on (*Brassica oleracea* L.) var. Capitata plants led to a weakening of the vegetative growth characteristics and the nutritional content of the leaves with an increase in the harmful sodium ions.

Sulfur is one of the essential elements for plants that enters into the composition of many organic compounds such as the amino acids methionine and cysteine. Sulfur is also included in the composition of some vitamins such as thiamine B1 and biotin B7, and also enters into the composition of the enzyme cofactor COA and some proteins. Sulfur plays a pivotal role in the composition of vital elements such as ferredoxins necessary for carbon absorption and nitrogen fixation (Abu Dahi, & Al-Younis, 1988). Sulfur deficiency in the soil led to a decrease in the formation of root nodules due to its negative effect on the activity of root nodule bacteria. (Gao *et al.*, 2024). (Alwan *et al.*, 2011) It was found that adding agricultural sulfur at a rate of 4 tons ha⁻¹ led to an improvement in the height of bean plants and the number of their branches.

The study aimed to find the effect of adding agricultural sulfates to saline irrigation water to try to reduce the toxicity of that water on

agricultural soils located in southern Iraq (Muthanna) and irrigated with untreated saline Euphrates River water.

To come up with safe recommendations on the use of agricultural sulfates and their quantities in the growth of bean plants.

Materials & methods

The seeds of broad bean variety (broad-leaved) were planted in 5 kg plastic pots during the 2022-2023 growing season at the Bandar II Research Station, College of Agriculture, Al-Muthanna University. The number of plants is not appropriate for the size of the pot.

The experiment was carried out the effect of two Deleted please factors on irrigation water, namely the effect of sulfur and irrigation salt water, separately and their interaction. Initially, a plan was developed to add agricultural sulfur at three concentrations (0, 3.0, 6.0 g pot⁻¹). These planted pots were irrigated with saline water at four levels (0, 4, 8, 12 ds m⁻²). The control treatment was irrigated directly with tap water. Then, sulfur was dissolved at different levels in several concentrations of saline water, according to the distribution of the treatments shown later. The treatments were distributed in the experiment using a Randomized Complete Block Design (R.C.B.D.) within factorial experimental, And in three replications. Each replicate had 12 treatments, so the total number of experimental units was 36, with six pots per experimental unit. It supposed taken with the first harvest the planted fava bean plants, physical (leaf area, plant height, plant dry weight, number of branches) and chemical (proline, nitrogen, phosphorus, potassium, and sodium) vegetative growth parameters were

taken. The chlorophyll index in the leaves was adopted as a biological factor.

The washed Euphrates shore soil was used as a media for pots. The Texture of this soil are silty clay.

Results & Discussion

The results in table (1) showed that the effect of irrigation with saline water (deep water) mixed with agricultural sulfur on some vegetative growth traits of bean plants led to a significant direct decrease in the values of all of these traits (plant height, leaf area, number of branches, and dry weight) compared to the control treatment, the lowest values appeared when the treatments were irrigated with a concentration of (12 ds m⁻²) individually, except for the dry weight trait, whose values were the lowest possible when irrigated with a concentration of (8 ds m⁻²). However, the responses of green beans changed when agricultural sulfur was added.

These additions investigated a significant effect in reducing the damage of all vegetative growth traits (6.0 g) of Agricultural sulfur. This is a natural result of plants being exposed to salt stress, and this is due to the direct effect of salt accumulation in the root growth zone, which causes a decrease in the rate of chlorophyll synthesis and its destruction in the leaves (Al-Alawy *et al.*,2020; Patel *et al.*,2020) which in turn causes a general weakness in plant growth due to a decrease in the process of carbon assimilation. The reason may also be due to the increase in the biosynthesis of Absciscic Acid (ABA) in the root zone because of increased salt stress.

This salt accumulation has effectively affected the flexibility of the cells and prevented them

from growing normally (Singh *et al.*,2021). The above results are consistent with what was found (Hiji, *et al.*,2019) when treating lettuce plants

(*Lactuca sativa* L.) grown under salt stress conditions with Agricultural sulfur.

Table(1:) The effect of Agricultural Sulfur addition and irrigation with saline water and their interaction on some vegetative growth of broad bean.

Salt ds m ⁻²	Sulfur g Pot ⁻¹	Plant Height Cm	Leaves area Cm ²	Branch No.	Dry W. g plant ⁻¹
0	0	46.77	80.71	4.56	12.95
	3.0	48.77	87.37	5.03	13.45
	6.0	57.36	99.21	6.02	15.60
4.0	0	35.77	75.74	4.00	10.20
	3.0	40.72	80.73	4.58	11.43
	6.0	49.38	85.58	4.85	13.60
8.0	0	27.44	69.68	3.04	8.12
	3.0	36.88	75.28	3.55	10.48
	6.0	39.77	81.31	4.29	11.20
12.0	0	25.94	60.78	2.34	8.88
	3.0	35.38	67.71	3.29	11.24
	6.0	38.27	74.08	3.93	11.96
L.S.D		3.59	2.79	0.15	0.89
Effect Salt	0	50.97	89.09	5.20	14.00
	4.0	41.96	80.68	4.48	11.74
	8.0	34.70	75.42	3.63	9.93
	12.0	33.20	67.52	3.19	10.69
L.S.D		2.07	1.61	0.09	0.52
Effect Sulfur	0	33.98	71.73	3.49	10.03
	3.0	40.44	77.77	4.11	11.65
	6.0	46.20	85.04	4.77	13.09
L.S.D		1.79	1.40	0.08	0.45

The results in table (2) show the effect of irrigation by saline water added with agricultural sulfur and their interaction on some chemical properties of bean plant leaves. A negative decrease was observed in the chlorophyll index and the leaf content ratios of essential nutrients (N, P, K), especially at the highest concentration (12.0 ds m⁻²), in contrast to the leaf content of proline and sodium ions, as their concentrations in the leaves increased significantly when plants were treated with saline water at a concentration of (12.0 ds m⁻²). It was observed that adding sulfur at a concentration of (6.0 g) significantly

affected all chemical growth properties. In the case of the interaction between the two factors, it was observed that treating bean plants with saline water at a concentration of zero (tap water) and adding sulfur at a concentration of (6.0 g) gave the highest values of the chlorophyll index and the highest content of essential nutrients. While, the mixed treatment of sulfur (6.0 g) + saline irrigation water (12.0 ds m⁻²) achieved the highest proline content, comparison to the control treatment. High salts in irrigation water affected a sharp decrease in chlorophyll content in leaves.

Table (2): The effect of Agricultural Sulfur and irrigation with salt water and their interaction on some chemical characteristics of broad leaves.

Salt ds m ⁻²	Sulfur g Pot ⁻¹	Chlorophyll index SPAD	Proline μmol g ⁻¹ dry w.	N %	P %	K %	Na %
0	0	29.78	18.49	3.45	0.347	1.39	0.96
	3.0	33.15	20.77	3.96	0.403	1.95	0.84
	6.0	37.65	22.84	4.48	0.473	2.00	0.73
4.0	0	24.68	26.20	3.25	0.330	1.16	1.43
	3.0	28.47	24.47	3.36	0.363	2.45	1.21
	6.0	33.31	22.55	3.62	0.387	2.71	1.09
8.0	0	20.26	30.66	2.59	0.300	1.13	1.68
	3.0	24.05	26.99	3.03	0.320	1.62	1.40
	6.0	29.39	23.95	3.75	0.337	2.58	1.50
12.0	0	16.89	36.51	2.13	0.237	1.01	2.11
	3.0	21.87	29.43	2.81	0.293	1.84	1.84
	6.0	27.09	26.29	3.27	0.303	2.33	1.68
L.S.D		0.83	0.77	0.31	0.021	0.345	0.08
Effect Salt	0	33.53	20.70	3.96	0.408	1.78	0.84
	4.0	28.82	24.41	3.41	0.360	2.11	1.24
	8.0	24.57	27.20	3.12	0.319	1.78	1.53
	12.0	21.95	30.74	2.74	0.278	1.73	1.88
L.S.D		0.48	0.46	0.18	0.012	0.20	0.05
Effect Sulfur	0	22.90	27.97	2.86	0.303	1.17	1.54
	3.0	26.88	25.41	3.29	0.345	1.97	1.32
	6.0	31.86	23.91	3.78	0.375	2.40	1.25
L.S.D		0.41	0.39	0.16	0.011	0.17	0.04

This is due to protein deficiency because these plants were exposed to salt stress, which decreases the effectiveness of the nitrate reductase (NR) enzyme (Zaidalkilani *et al.*, 2024 Hiji, *et al.*, 2019, Rashid, 2016). Therefore, increasing the amount and effectiveness of this enzyme leads to an increase in the synthesis of some amino acids (Yaquby *et al.*, 2024). Proline may play an important role in the osmotic adjustment process, thus increasing the plant's ability to tolerate salt stress conditions and contributing to the destruction of free radicals. Therefore, the plant may resort to increasing

proline synthesis to protect the components of living cells store amino acids as a source of nitrogen, and remove free radicals, which are important indicators of the accumulation of free amino acids (Shakya *et al.*, 2024). (Franco & Veliz, 2007) stated that high proline content leads to reducing the harmful effects of salinity and increasing water retention within the plant. This increase was necessary for protecting the tissues responsible for carbon metabolism, as the accumulation of proline under salt stress conditions provides the plant with the energy

needed for growth and tolerance to environmental stresses.

Conclusion

1-Irrigation with saline water negatively affected the vegetative growth characteristics and Chemical properties of leaves of the broad bean plant.

2- Adding agricultural sulfur to the soil under the influence of salt stress positively affected the vegetative growth characteristics and chemical characteristics the broad bean plant.

Recommendations

According to previous results. The addition of agricultural sulfur in high concentrations mixed with saline irrigation water is necessary to reduce the toxic effects and poor growth of broad-leaved fava beans.

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Contributions of authors

A.M.J: Collection of specimens, Laboratory techniques, wrote and revised the manuscript.

A.N.S: Suggestion the proposal of the article and revised the manuscript.

S.S.S: Suggestion the proposal of the article, wrote and revised the manuscript,

T.M.M: Statistical analysis and revised the manuscript.

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Ethical approval

All ethical guidelines related to plant and care issued by national and international organizations were implemented in this report.

Conflicts of interest:

The authors declare that they have no conflict of interests.

References

- Abbas, M. F., Abdullah, A. A.& Hammed, N. N. (2018). Effect of Salinity irrigation water and Selenium spraying in chemical constituents of leaves of Two Cultivars of Okra (*Abelmoschus esculentus* L.) Cultivated in Greenhouses. *Arab Journal of Sciences and Research Publishing*, 2(2),1-17. <https://doi.org/10.26389/AJSRP.N160418>
- Abu Dahi, Y. M. & Al-Younis, M. A. (1988). Plant nutrition guide. Dar Al Hekma Press for Printing and Publishing. *Ministry of Higher Education and Scientific Research. University of Baghdad. Iraq.* https://www.agro-lib.site/2022/09/blog-post_957.html#google_vignett
- Al-Alawy, H. H., Al-Tamimy, W. H. & Falih, S. T. (2020). effect of spraying ascorbic acid and salicylic acid on the growth and yield of faba bean (*vicia faba* L.) growing in salt soil. *Diyala Agricultural Sciences Journal*, (12), 244-250. <https://doi.org/10.52951/dasj.20121022>
- Al-Hady, A. H., Al-Taher, A. Y., Abou Al-Fatouh, M. A. & Omar, S. B. (2013). Effect of added gypsum and saline irrigation water on the growth and productivity of broad beans. *International Journal of Development*, 2(1),45-60. 10.21608/JAID.2013.222051
- Al-Jarah, T. M., Jerry, A. N. & Jasim, A. M. (2019). Effect of Sodium Nitroprusside (SNP) on Minerals Content of Cabbage Brassica oleracea var. capitata L. Grown under Salt Stress. *Basrah Journal of Agricultural Sciences*, 32(2), 44-59. <https://doi.org/10.37077/25200860.2019.196>
- Alwan, T. A., Jasim, A.A. & Farhan, L. D. (2011). The effect of animal manure and sulphur on some soil physical properties, growth and yield of broad bean

- (*Vicia faba* L.) under saline calcareous soil condition. *Diyala Agricultural Sciences Journal*, 3(2), 250-261. <https://www.iraqoj.net/iasj/download/7c6e7531c21540f8>
- Ethbeab, I. J., Al- Miah, F. H., Saudi, A. H. & Al-Kaaby, M. J. (2013). Effect of salinity with use Different concentration of NaCl on some of growth properties and yield of Broad bean (*Vicia faba* L.) plant . University of Thi-Qar J. ofSci.,3(4),49-56. <https://doi.org/10.32792/utq/utjsi/v3i4.546>
- Food and Agriculture Organization(FAO) .(2003). Data base: Rome, Italy. <https://www.fao.org/4/y5085e/y5085e00.htm>
- Franco, S.V.A. & Veliz, J.A. (2007). Responses of the cactus pear (*Opuntia ficusindica* L.) to NaCl. *Interciencia*,32(2),125-130. . <https://bit.ly/3c2gxhW>
- Gao, L., Haesaert, G., Bockstaele, F. V., Vermeir, P., Skirtach, A. & Eeckhout, M. (2024). Combined effects of nitrogen and sulfur fertilizers on chemical composition, structure and physicochemical properties of buckwheat starch. *Food Chemistry*, 459, 140351. <https://doi.org/10.1016/j.foodchem.2024.140351>
- Gutierrez, N ., C. M, Avila., M. T, Moreno., & Torres, A.M.(2008). Development of SCAR Markers Linked to Zt-2, One of The Genes Controlling Absence of Tannins in Faba Bean. *Australian J. of Agricultural Research*, 59(1), 62–68. <https://doi.org/10.1071/AR07019>
- Hiji, J. H., Jasim, A. M. & Jerry, A. N. (2019). Effect of Sulfur and Clean Salt on Antioxidant Enzymes and Proline Content in Improving Salt Tolerance of Two Lettuce Cultivars Grown in Basrah .*Basrah Journal of Agricultural Sciences*, 32(Spec Issue), <https://doi.org/10.37077/25200860.2019.142>
- Jabeen, N. & Ahmad, R. (2011). Foliar application of potassium nitrate affects the growth and nitrate reductase activity in sunflower and safflower leaves under salinity. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*,39(2),172-178. <https://doi.org/10.15835/nbha3926064>
- Ministry of Planning / Central Bureau of Statistics / Directorate of Agricultural Statistics, (2021). <https://cosit.gov.iq/ar/>
- Patel, D., Jayswal, S., Solanki, H. & Maitreya, B. (2020). Effect of salinity on different vegetable crops – a review. *International Journal of Recent Scientific Research*, 11 (2), 37418-37422. <http://doi.org/10.24327/ijrsr.2020.1102.5104>
- Rashid, Z. S. (2016). Effect of Salt Water Irrigation and Amino Acid (Proline and Arginine) on Some Chemical Components of Potato (*Solanum tuberosum* L.) Leaves. *Basrah J. Agric. Sci.*, 29 (2): 445-460. <https://www.iraqoj.net/iasj/download/37718cab5648c426>
- Shakya, N. R., Mandal, M. P. & Ranjan, R. D. (2024). Impact of salinity on protein metabolism and enzyme activities in salt-tolerant and susceptible rice genotypes. *Journal of Pharmacognosy and Phytochemistry*, 13 (5), 740-745. <https://doi.org/10.22271/phyto.2024.v13.i5j.15148>
- Singh, M., Nara, U., Kumar, A., Choudhary, A., Singh, H. & Thapa, S. (2021). Salinity tolerance mechanisms and their breeding implications. *J. of Genetic Engineering and Biotechnology*, 19 (1), 173. <https://doi.org/10.1186/s43141-021-00274-4>
- Yaquby, A. M.; Rabbani, B. & Saddam, S. (2024). Effect of Humic Acid and Ascorbic Acid on Seed Germination and Growth of Cucumber (*Cucumis sativus* L.) under Salinity Stress. *Basrah J. Agric. Sci.*, 37(1), 105-118. <https://doi.org/10.37077/25200860.2024.37.1.09>
- Zaidalkilani, A. T., Al-Kaby, A. H., El-Emshaty, A. M., Alhag, S. K., Al-Shuraym, L. A., Salih, Z. A., Taha, A. A., Al-Farag, A. M., Eshmawi, A. E., Hamad, S. A., Abd El-Raouf, H. S., Ahmed, S. E., El-Taher, A. M., Chamba, V. M. & Badawi, T. A. (2024). Effect of Salt Stress on Botanical Characteristics of Some Table Beet (*Beta vulgaris* L.) Cultivars. *ACS OMEGA*, 48 (9) ,47788-47801. <https://pubs.acs.org/doi/full/10.1021/acsomega.4c08161>
- Zhou, M., Renard, M., Quinet, M. & Lutts, S. (2019). Effect of NaCl on proline and glycinebetaine metabolism in *Kosteletzkya pentacarpos* exposed to Cd and Zn toxicities. *Plant Soil*,441,525-542. <https://doi.org/10.1007/s11104-019-04143-5>

تأثير الكبريت الزراعي على تقليل تأثير ملوحة ماء الري لنبات الباقلاء الذي ينمو في جنوب العراق

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المستخلص: تعتبر الباقلاء أحد المحاصيل المهمة التي تنمو في وسط وجنوب العراق الذي له أهمية اقتصادية كبيرة. تأثرت زراعة الباقلاء في السنوات الأخيرة في ارتفاع مستويات الملوحة في مياه الري التي أدت الى تراجع الزراعة في العديد من المناطق الريفية الزراعية المجاورة لنهر الفرات، هذا اضطرنا الى إعادة تقييم كم كان تأثير الملوحة على النبات ومعالجته بالكبريت الزراعي لتقليل الاضرار. اجريت التجربة في عام 2022-2023 خلال الموسم الزراعة الشتوي في محطة الأبحاث الثانية (ال بندر) التابعة لجامعة المثنى/ كلية الزراعة لدراسة أربعة مستويات من ملوحة ماء الري (0، 4، 8، 12) ديسيمينز لنبات الباقلاء المزروع في سنادين بوزن 5 كغم، وإضافة الكبريت الزراعي بنسب (0، 3، 6) غم سندانة⁻¹، تم تصميم التجربة وفقاً لتصميم القطاعات العشوائية الكاملة وبثلاث مكررات بمستويات معنوية 0.05. تفوقت المعاملات الخالية من الملوحة في الصفات الخضرية والصفات الكيميائية كما أظهرت النتائج التأثير الإيجابي لإضافة الكبريت الزراعي بمستويات 6 غم سندانة⁻¹ عند الري بمياه مالحة حتى 12 ديسيمينز، أما بالنسبة للخواص الكيميائية فقد أظهرت النتائج مدى تأثير إضافة الكبريت الزراعي 6 غم سندانة⁻¹ مع الري بمياه ملوحة تصل إلى 12 ديسيمينز على الخواص الكيميائية حيث بلغ مؤشر الكلوروفيل 31.86، النيتروجين 3.78%، الفوسفور 0.375%.

الكلمات المفتاحية: الصفات الكيميائية، الخضرية، الباقلاء، الملوحة، الكبريت.