Research Article

Influence of Madram G Soil Conditioner on Leaf Mineral Content of Okra (*Abelmoschus esculentus* L.) Under Saline Conditions

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Abstract | In Iraq, okra (*Abelmoschus esculentus* L) is a very popular and valuable vegetable crop. But, because of both environmental and human-caused factors, Basrah Governorate, in particular, has seen a big drop in agricultural output because of the rise in salinity in irrigation water and soil. Madram G, a soil conditioner, was given in amounts of 0, 0.5, and 1 mL L^{-1} with two different application intervals in the current study to boost okra plants' salinity tolerance. The findings showed that treating plants with 1 mL L^{-1} of Madram G caused a significant rise in leaf nitrogen, phosphorus, potassium, calcium, potassium/sodium (K^+/Na^+), and ratios of calcium/sodium (Ca^{2+}/Na^+) in comparison with the un treated control plants. On the other hand, the same treatment dramatically lowered the chlorine and sodium concentrations in the leaves. Furthermore, using Madam G every 15 days enhanced the ionic balance (K^+/Na^+ and Ca^{2+}/Na^+) and concentrations of advantageous nutrients (N, P, K, Ca), therefore lowering Na^+ and Cl^- build.

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Introduction

Abelmoschus esculentus L., or Okra, is a member of the Malvaceae family and one of the most common summer vegetables grown in Iraq. It is valued for its sweet flavor and high nutrient content, serving as a significant source of carbohydrates, minerals, and vitamins. The composition of 100 grams of fresh okra pods has about 88.6 g of water, 36 calories, 2.10 g of protein, 8.2 g of carbohydrates, 0.20 g of fat, 1.7 g of fiber, 84.00 mg of calcium, 90.00 mg of phosphorus, 1.20 mg of iron, 185.00 µg of beta-carotene, 0.08 mg of riboflavin, 0.04 mg of thiamine, 0.60 mg of niacin, and 47.00 mg of ascorbic acid (Benchasri, 2012). In 2022, the area of okra under cultivation in Iraq was around 56,054 dunums with an average yield of 1,585 kg per dunumn (Central Statistical Bureau, 2024).

Soil salinity is a significant limiting factor to agricultural yield and environmental stability, especially in arid and semi-arid areas. The increasing rates of salinity in the water of irrigation, particularly

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in Basrah Governorate, severely affect the crop production and threaten food security both currently and in the future (Kreiba, 2019). Okra is moderately sensitive to salinity (Unlukara *et al*., 2008), and most of the central and southern parts of Iraq are suffering from different levels of soil salinity (Haq *et al*., 2023).

Soil management practices are imperative to maintain crop growth particularly in the case of soils with salinities greater than 3.4 dSm^{-1}. They are also required to improve the organic physical and chemical properties of saline soils. One of the method is the application of a soil conditioner such as Madram G which reduces salinity. Madram G has been found to contain higher amounts of organic matter and calcium, which is important for plant growth, microbial activity and cation exchange capacity (McCauley *et al*., 2017).

Calcium plays an essential role in improving available organic carbon in soil as it mediates the interaction of the organic and mineral components (Shabtai *et al*., 2023). Madram G also contains fulvic and humic acids, its enhance plant growth through their positive effects on nutrient availability, chemical, biological, and physical soil characteristics (Sootahar *et al*., 2019; Radhi and Alkarawia, 2021). Hiji *et al*. (2019) stated that with the same treatment of soil conditioner, the salinity tolerance of the sensitive plant species Lactuca sativa was improved.

The study, determines the efficacy of Madram G as a soil conditioner to reduce the negative effects of salinity on okra plants. The most effective concentration and best application frequency will be observed to improve plant development in saline soils.

Materials and Methods

Soil analysis

The research was conducted in the 2024 growing season in a private orchard in the Yusufan area of the Abu Al-Khaseeb district, Basrah Governorate Iraq. Composite samples that represented the experimental soil were obtained from various locations in the orchard, each at a depth of 0-30 cm. The samples were air dried, mixed thoroughly and then analyzed in the laboratories of the Department of Soil and Water Sciences, College of Agriculture, University of Basrah. The soil physical and chemical properties are given in Table 1.

Table 1: *Physical and chemical characteristics of the orchard soil.*

No	Indicator	Values
1	EC dS m^{-1}	8.43
2	pH	7.20
3	N (g kg^{-1})	14.0
4	P(g kg^{-1})	10.24
5	K(g kg^{-1})	128
6	Organic matter(g kg^{-1})	8.43
7	Ca (g kg^{-1})	32.89
Soil separators %		
1	Sand	23.2
2	Silt	29.8
3	Clay	47.0
4	Soil texture	Silty clay

Soil preparation and okra cultivation

Prior to planting, the orchard soil was amended with fully decomposed cow manure; and then ploughed twice in perpendicular directions to a depth of 30 cm. After ploughing, the soil surface was leveled and shaped into rows spaced 1 m apart, and 20 m long by 35 cm wide for each row. Then, black polyethylene mulch was applied over the rows to suppress weed growth and retain soil moisture. Seeds of Khnaisri okra variety were soaked in water for 12 hours before being sown, which was done on July 3, 2024, into holes made 3-5 cm deep and filled with peat moss. The holes were spaced 40 cm apart along the rows. Two weeks after sowing, excess seedlings were thinned out, and any missing hills were replanted to maintain two strong plants in each hole. A combination of Previcur Energy fungicide (0.35 mL L^{-1}) and Engeo insecticide (0.40 mL L^{-1}) were prescribed as needed for the build-up of fungal diseases and insect pests in the orchard. Plants were fertilized with Triferto (15-15-15) at an application rate of 5 mL L^{-1}, and were irrigated by drip irrigation to ensure even distribution of the water.

Elemental content determination

Green okra plants leaves were collected, dried in an oven, ground and digested according to method described by Cresser and Parsons (1979). The elemental composition was measured as follows:

Nitrogen (N%) was measured using Micro Kjeldahl method (Page *et al*., 1982); Potassium (K%) and sodium (Na%) were assessed using a flame-photometer (Page *et al*., 1982); Phosphorus (P%) was estimated spectrophotometrically (Jakson, 1958); Calcium (Ca%) was measured using atomic absorption spectrophotometry; Chlorine (Cl-), was assessed according to method described by Furman (1962); The K+/Na+ and Ca2+/Na+ ratios were assessed to measure ionic homeostasis in the plant tissue (Table 2).

Table 2: *Components of soil conditioner Madram G.*

No	The material	Ratio
1	Total N	% 5
2	Nitric Nitrogen	% 4
3	Organic nitrogen	% 0.7
4	Ammoniacal Nitrogen	% 0.3
5	Potash Oxide	% 2.5
6	Calcium oxide complexed with lignosulfinate	% 7.5
7	Humic acid	% 9.5
8	Fulvic acid	% 9.5

Experiment design and statistical analysis

The experiment was performed utilizing a Randomized Complete Block Design (RCBD) structured as a factorial experiment including two factors:

1. Mardam G 3 concentration- 0, 0.5, 1 mL L^{-1}
2. Application frequency- no application, every 15 days, and every 30 days.

Data were analyzed statistically through the GenStat software (Version 2013) where treatment means were compared using analysis of variance (ANOVA) and the differences among means were recognized to be significant at the 0.05 probability level, as described by Al-Rawi and Khalaf Allah (2000).

Results

The information shown in Tables 3, 4, 5 and 6 shows the impact of Madram G concentration and application intervals on the leaf content of nitrogen (N), potassium (K), phosphorous (P), and calcium (Ca) in okra plants. 1 ml/L application of Madram G had a positive effect on the amount of N, K, P, and Ca in okra leaves, where the recorded values were 4.245%, 4.756%, 0.410%, and 1.312%, respectively in comparison to the control (no application).

Every 15 days, Madram G had a significant effect on the leaf content of N, K, P, and Ca, with 4.366%, 4.778%, 0.406% and 1.235% respectively in comparison to the control. The two treatment combination of 1 ml/L Madram G and every 15 days was higher than the control, with respect to all four nutrient concentrations, where nitrogen (4.821%), potassium (5.021%), phosphorous (0.457), and calcium (1.441) were highest overall other treatments.

Table 3: *Effect of Madram G concentration and application interval on nitrogen (N%) content in okra leaves.*

Mean of Madram G	Treatment date: Every 30 days	Every 15 days	Without treatment	Madram G (ml/L)
3.838	3.932	4.021	3.562	0
4.034	4.112	4.257	3.732	0.5
4.245	4.521	4.821	3.933	1.0
	4.188	4.366	3.742	Mean of treatment date
L.S.D p< 0.05				
Madram G + Treatment date		Treatment date	Madram G	
0.483		0.209	0.209	

Table 4: *Effect of Madram G concentration and application interval on potassium (K%) content in okra leaves.*

Mean of Madram G	Treatment date: Every 30 days	Every 15 days	Without treatment	Madram G (ml/L)
4.072	4.213	4.482	3.521	0
4.538	4.585	4.832	4.198	0.5
4.756	4.814	5.021	4.432	1.0
	4.537	4.778	4.050	Mean of treatment date
L.S.D p< 0.05				
Madram G + treatment date			Treatment date	Madram G
0.491			0.211	0.211

Table 5: *Effect of Madram G concentration and application interval on phosphorous (P%) content in okra leaves.*

Mean of Madram G	Treatment date: Every 30 days	Every 15 day	Without treatment	Madram G (m/L)
0.331	0.330	0.365	0.298	0
0.369	0.372	0.396	0.339	0.5
0.410	0.411	0.457	0.363	1.0
	0.371	0.406	0.333	Mean of treatment date
L.S.D p< 0.05				
Madram G + Treatment date		Treatment date	Madram G	
0.059		0.033	0.033	

Table 6: *Effect of Madram G concentration and application interval on calcium (Ca%) of okra leaves.*

Mean of Madram G	Treatment date			Madram G (ml/L)
	Every 30 days	Every 15 day	Without treatment	
0.851	0.861	0.980	0.712	0
1.120	1.156	1.283	0.921	0.5
1.312	1.321	1.441	1.175	1.0
	1.113	1.235	0.936	Mean of treatment date
L.S.D p< 0.05				
Madram G + treatment date		Treatment date	Madram G	
0.387		0.178	0.178	

Table 7: *Effect of Madram G concentration and application interval on percentage of Potassium/Sodium (K^+/Na^+) in okra leaves.*

Mean of Madram G	Treatment date			Madram G (ml/L)
	Every 30 days	Every 15 day	Without treatment	
9.044	9.131	10.613	7.388	0
11.693	11.540	13.569	9.971	0.5
13.690	13.965	15.482	11.623	1.0
	11.545	13.221	9.661	Mean effect of treatment
L.S.D p< 0.05				
Madram G + Treatment date		Treatment date	Madram G	
1.532		1.105	1.105	

Table 8: *Effect of Madram G concentration and application interval on percentage of Calcium/Sodium (Ca^{2+}/Na^+) in okra leaves.*

Mean of Madram G	Treatment date			Madram G (ml/L)
	Every 30 days	Every 15 day	Without treatment	
1.893	1.866	2.321	1.492	0
2.900	2.910	3.603	2.187	0.5
3.844	3.832	4.617	3.082	1.0
	2.869	3.514	2.254	Mean of treatment date
L.S.D p< 0.05				
Madram G + Treatment date		Treatment date	Madram G	
0.517		0.233	0.233	

The Tables 7 and 8 illustrate the influence of Madram G and its application intervals on the potassium to sodium (Na+/K+) and calcium to sodium (Ca^{2+}/Na^+) ratios in okra leaves compared to the control treatment, a remarkable improvement in both ratios after the application of Madram G at 1 ml/L was noted with values of 13.690% and 3.844%, respectively. Application every 15 days, showed a further increase of 13.221% (K^+/Na^+) and 3.514% (Ca^{2+}/Na^+) ratios compared to untreated plants. The combined treatment of I ml/L applied every 15 days produced the highest ionic balance, achieving 15.482% (K^+/Na^+) and 4.617% (Ca^{2+}/Na^+).

Table 9: *Effect of Madram G concentration and application interval on sodium (Na^+%) content of okra leaves.*

Mean of Madram G	Treatment date			Madram G (ml/L)
	Every 30 days	Every 15 days	Without treatment	
0.4536	0.4614	0.4223	0.4771	0
0.3915	0.3973	0.3561	0.4210	0.5
0.3460	0.3447	0.3121	0.3813	1.0
	0.4011	0.3635	0.4265	Mean of treatment date
L.S.D p< 0.05				
Madram G + treatment date		Treatment date	Madram G	
0.0710		0.0433	0.0433	

Table 10: *Effect of Madram G concentration and application interval on Chloride (Cl%) content of okra leaves.*

Mean of Madram G	Treatment date			Madram G (ml/L)
	Every 30 days	Every 15 day	Without treatment	
3.932	3.955	3.611	4.229	0
3.665	3.677	3.475	3.843	0.5
3.104	3.107	2.874	3.331	1.0
	3.580	3.320	3.801	Mean of treatment date
L.S.D p< 0.05				
Madram G + Treatment date		Treatment date	Madram G	
0.532		0.271	0.271	

Tables 9 and 10 outline the results related to the value of Madram G and treatment frequency on sodium (Na+) and chlorine (Cl-) levels in Okra leaves. A significant decrease in either ion were recorded when the plants were treated with 1 ml/L of Madram G, which were recorded as 0.3460 % cl and 3.104% cl, contrasting untreated plants, and the treated plants levelsa results every 15 days were observed to be statistically significant (Na= 0.0034) (Cl = 0.0035) sodium (Na) and chlorine (Cl) content were also significantly less with 1 ml/L Madram G, or otherwise indicated that the efficiency of Madram G in reducing the accumulation of salt in the leaves of okra increased following 15 days of treatment, resulting in reduced sodium (Na) content and chlorine (Cl) content of about 0.363 % and 3.320%, respectively.

Discussion

Madram G application every fifteen days significantly improved nitrogen, potassium, phosphate, and calcium concentration in okra leaves (Tables 3, 4, 5). Improvement in calcium content is due to added calcium from Madram G, crucial for maintaining the integrity and function of cell membranes. It improves the ability of plants to cope with saline conditions through modulation of ion exchange, regulation of ion transport and selectivity, and activation of several enzymes in the cell wall (Hadi and Karimi, 2012). It is reported that calcium inhibited the absorption of sodium into the root cells of wheat playing a protective role under saline stress (Allan *et al*., 1995).

Madram G also contain potassium oxide, K2O improving the osmotic regulation, stomatal conductance, and ionic equilibrium of the plants, thereby reducing the detrimental effects of salinity. Such physiological changes improve plant resistance, development, and productivity under saline and water stress environments (Gupta *et al*., 1989; Mohapatra *et al*., 2021).

The composition also supplies nitrogen as in total, nitric, organic, and ammonical form playing a critical role in mitigating salt stress. Membrane stability, leaf water status, and gas exchange, as well as enhancement of nutrient uptake, and activation of cellular signaling pathways that help prevent oxidative stress in plants depends on adequate nitrogen supply. Nitrogen is crucial for chlorophyll synthesis and photosynthesis, both of these processes are adversely by salinity (Aslam *et al*., 2023; Alkarawi *et al*., 2024). Interestingly, Madram G reduced soil salinity levels at the end of the growing season. This reduction could be due to improved soil fertility and better physical and chemical properties of soil because Madram G contains humic and fulvic acids that improve soil structure and lessened the detrimental effects of salts in the soil. Lastly, Ennab *et al*. (2023) established that humic acid improves salinity tolerance by improving soil aggregation, increasing water retention, and facilitating nutrient uptake. Additionally, both humic and fulvic acids increased total yield and number of fruit as a result of increased soil organic matters. Studies conducted by Ennab *et al*. (2023) showed that applying humic acid either once or twice a month on Mexican lime trees, both in the soil and as a foliar spray, improves nutrient availability and enhances both growth and fruit yield.

According to the evidence shown in Tables 7 and 8, the application of Madram G significantly increased both potassium to sodium, and calcium to sodium ratios, in okra leaves. It is likely that K2O and CaO in Madram G improve the bioavailability of potassium and calcium in the soil for uptake (Hadi and Karimi, 2012; Mohapatra *et al*., 2021). Calcium is particularly important for maintaining the structural and functional integrity of cell membranes by facilitating selective permeability of potassium and calcium ions (Tuna *et al*., 2007).

In addition, Madram G treatments may influence the lipid composition of cell membranes to increase phospholipid and unsaturated fatty acid composition and decrease glycolipid levels. These physiological changes decrease sodium permeability, thereby enhancing K+/Na+ and Ca2+/Na+ transport in plants and improve tolerance. These findings are similar with those of Yu *et al*. (1998) in barley. Finally, the humic and fulvic acids in Madram G also maintained low soil pH along with increased nitrogen, phosphorus, potassium, and calcium solubility (Abdelhamid *et al*., 2013; Gerson and Hinckley, 2023).

Madram G application increased sodium and chloride contents (Tables 9 and 10) in leaves as compared to control plants. This reduction may arise from the increased uptake of essential nutrients, such as nitrogen, potassium, phosphorous, and calcium, which took place with a decrease in sodium and chlorine.

Conclusion

The findings indicate the ability of Madram G in enhancing the growth of okra under saline soil. The foliar spray of 1 ml/L Madram G after every 15 days exhibited the highest levels of nitrogen, potassium, phosphorous, and calcium in leaves. The treatment also improved the K/Na and Ca/Na ratios and reduced the levels of sodium and chloride in tissues. Therefore, 1 ml/L Madram G spray after every 15 days during the growing season is recommended to improve salinity tolerance, maximum nutrient uptake, and productivity of okra in saline soil.

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Novelty Statement

The present investigation helps to understand the effectiveness of Madram G, a calcium-and humic acid-based soil amendment, for improving nutrient uptake and salt tolerance in okra plants under saline environment. Unlike previous work, which mostly focused on traditional fertilizer or single nutrient supplements, this study showed that regular application of Madram G improved essential nutrient levels and ionic balance by improving the K/Na and Ca/Na ratios, as well as reducing sodium and chloride accumulation. The present findings represent a practical and sustainable method to grow okra in saline soils.

Author's Contribution

H. M. Gabash and Z.A. Saihood: Conceptualization.
J. Abdul Al-Rabea'a and W.H. Neamah: Methodology.
H. M. Gabash and Z.A. Saihood: Validation.
J. Abdul Al-Rabea'a and W.H. Neamah: Investigation.
H.M. Gabash and Z.A. Saihood: Writing-original draft preparation.
H. M. Gabash and J. Abdul Al-Rabea'a: Supervision.
All authors have read and agreed to the published version of the manuscript.

Generative AI and AI assisted technology statement
The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Conflict of interest
The authors have declared no conflict of interest.

References

Abdelhamid, M., E. Eldardiry and M.A. El-Hady, 2013. Ameliorate salinity effect through sulphur application and its effect on some soil and plant characters under different water quantities. Agric. Sci., 4(1): 39. https://doi.org/10.4236/as.2013.41007

Alkarawi, H.H., I.M. Radhi and M.M. Hamid, 2024. Impact of bio-fertilizer and nano iron and chelated iron in the growth and production of cayenne pepper. AIP Conf. Proc., 3079(1): 020004. AIP Publishing LLC. https://doi.org/10.1063/5.0203066

Allen, G.J., R.G. Wyn Jones and R.A. Leigh. 1995. Sodium transport measured in plasma membrane vesicles isolated from wheat genotypes with differing K+/Na+ discrimination traits. Plant Cell Environ., 18(2): 105-115. https://doi.org/10.1111/j.1365-3040.1995.tb00344.x

Al-Rawi, K.M. and A.M. Khalaf Allah. 2000. Design and analysis of agricultural experiments. Faculty of Agriculture and Forestry. University of Al Mosul. Ministry of Higher Education and Scientific Research, Republic of Iraq.

Aslam, M.T., K. Imran, M.U. Chattha, R. Maqbool, M. Ziaulhaq, W. Lihong and M. Arshad. 2023. The critical role of nitrogen in plants facing the salinity stress: Review and future prospective. Not. Bot. Hortic. Agrobo., 51(3): 13347-13347. https://doi.org/10.15835/nbha51313347

Benchasri, S., 2012. Okra (*Abelmoschus esculentus* (L.) Moench) as a Valuable Vegetable of the World, Ratar. Povrt. 49: 105-112. https://doi.org/10.5937/ratpov49-1172

Central Statistical Organization, 2024. Ministry of Planning - Republic of Iraq.

Cresser, M.S. and J.W. Parsons. 1979. Sulphuric-perchloric acid digestion of plant material for the determination of nitrogen, phosphorus, potassium, calcium and magnesium. Anal. Chim. Acta, 109 (2): 431-436. https://doi.org/10.1016/S0003-2670(01)84273-2

Ennab, H.A., A.H. Mohamed, H.M. El-Hoseiny, A.A. Omar, I.F. Hassan, M.S. Gaballah and S.M. Alam-Eldein. 2023. Humic acid improves the resilience to salinity stress of drip-irrigated Mexican lime trees in saline clay soils. Agronomy, 13(7): 1680. https://doi.org/10.3390/agronomy13071680

Furman, N.H., 1962. Standard methods of chemical analysis. 6th Ed. D.Van Nostrand Co., Inc., Princeton, N.J., pp. 365.

Gerson, J.R. and E.L.S. Hinckley, 2023. It is time to develop sustainable management of agricultural sulfur. Earth's Future, 11(11): e2023EF003723. https://doi.org/10.1029/2023EF003723

Gupta, A., G. Berkowitz and P. Pier. 1989. Maintenance of photosynthesis at low leaf water potential in wheat. Plant Physiol., 89(4): 1358-1365. https://doi.org/10.1104/pp.89.4.1358

Hadi, M.R. and N. Karimi. 2012. The role of calcium in plants salt tolerance, J. Plant Nutr., 35: 2037-2054. https://doi.org/10.1080/01904167.2012.717158

Haq, Y.U., M. Shahbaz, H.S. Asif, A. Al-Laith, and W.H. Alsabban. 2023. Spatial mapping of soil salinity using machine learning and remote sensing in Kot Addu, Pakistan. Sustainability, 15(17): 12943. https://doi.org/10.3390/su151712943

Hiji, J.H., A.M. Jasim and A.N. Jerry. 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. J. Agric. Sci., 32: 80-89. https://doi.org/10.37077/25200860.2019.142

Jackson, M.L., 1958. Soil chemical analysis. Prentice Hall Inc., Englewood Cliffs, N.J., USA. pp. 498.

Kreba, S.A.S., 2019. Soil Salinity: Causes and impacts on agriculture and the environment. J. Agric. Vet. Sci., 3(4): 32-18. https://doi.org/10.26389/AJSRP.S070419

Sootahar, K.M., X. Zeng, S. Su, Y. Wang, L. Bai., Y. Zhang and X. Zhang. 2019. The effect of fulvic acids derived from different materials on changing properties of albic black soil in the Northeast Plain of China. Molecules, 24(8): 1535. https://doi.org/10.3390/molecules24081535

McCauley, A., C. Jones and K. Olson-Rutz. 2017. Soil pH and organic matter. Nutrient Management Module No. 8. Montana State University Extension, pp. 16.

Mohapatra, A., D. Jena, P.P. Pradhan, D. Debasish Pattnaik, A.K. Pal and M.R. Pattanik. 2021. Interactive effects of potassium and saline water on yield, nutrient accumulation and uptake by rice. Int. J. Chem. Stud., 9(1): 2936-2943. https://doi.org/10.22271/chemi.2021.v9.i1ao.11676

Page, A.L., R.H. Miller and D.R. Keeney. 1982. Methods of soil analysis. Part 2, end ed., Agron. 9. Publisher, Madison, Wisconsin, USA.

Radhi, M. and H.H. Alkarawia. 2021. Impact of foliar application of silicon on salinity tolerance of two olive (*Olea europaea* L.) cultivars. Agric. Res. J., 58(2): 240-251. https://doi.org/10.5958/2395-146X.2021.00036.3

Shabtai, I.A., R.C. Wilhelm, S.A. Schweizer, C. Höschen, D.H. Buckley and J. Lehmann, 2023. Calcium promotes persistent soil organic matter by altering microbial transformation of plant litter. Nat. Commun., 14(1): 6609. https://doi.org/10.1038/s41467-023-42291-6

Tuna, A.L., C. Kaya, M. Ashraf, H. Altunlu, I. Yokas and B. Yagmur. 2007. The effects of calcium sulfate on growth, membrane stability and nutrient uptake of tomato plants grown under salt stress. Environ. Exp. Bot., 59: 173-178. https://doi.org/10.1016/j.envexpbot.2005.12.007

Unlukara, A., Kurunç, A., Kesmez, G.D. and Yurtseven, E., 2008. Growth and evapotranspiration of okra (*Abelmoschus esculentus* L.) as influenced by salinity of irrigation water. J. Irrig. Drain. Eng., 134(2): 160-166. https://doi.org/10.1061/(ASCE)0733-9437(2008)134:2(160)

Yu, B., Gong, H. and Liu, Y., 1998. Effects of calcium on lipid composition and function of plasma membrane and tonoplast vesicles isolated from roots of barley seedlings under salt stress, J. Plant Nutr., 21: 1589-1600. https://doi.org/10.1080/01904169809365506