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Research Article
Nano-Materials Effect on Improving the Productivity of Pomegranate (*Punica granatum* L.) Wonderful Cultivar Under Saline Stress

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Abstract

Background and Objective: Salinity is the most limiting factor for growth and production in pomegranate trees in the newly reclaimed lands this study aimed to alleviate the adverse effect of salinity on pomegranate wonderful CV. which grown under salinity stress and improve vegetative growth and fruit quality by using some of Nano-material's fertilizers as a foliar application. **Materials and Methods:** This investigation study carried out during two successive seasons (2019 and 2020) at a private orchard located in the desert of West Minia Governorate the pomegranate trees were at vigour status and selected by choosing 21 trees (seven treatments and each treatment was replicated three times) the chosen trees were 5 years old, cultivated 3×4 m, irrigated with drip irrigation system, all trees were free of pathogens and physiological disorders and took all agricultural processes and fertilization treatments except the foliar application of examined materials. **Results:** Application of Nano silicon with Nano clay was better than using silicon with clay together. The use of silicon at Nano size was significantly more than using silicon at normal size while Nano-clay treatment and clay treatment were non-significant compare to control. The examined Parameters were leaf nutrient contents, fruit physical and chemical characterization and yield. **Conclusion:** Application of Nano silicon with Nano clay was the superior treatment in all of the parameters which have been examined.

Key words: Pomegranates, wonderful, salinity, silicon, nano silicon, clay, growth, abiotic stress

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Pomegranate (*Punica granatum* L.) has picked up fame in later a long time because of its multi-usefulness what's more, healthy benefit in human eating routine. The pomegranate fruit product is filled universally in numerous diverse geographical districts, fulfilling the wholesome and restorative necessities of populaces of different nations[1].

Salinity in water or soil has been an important point in agriculture processes. Salinization of soils has created instability and has frequently destroyed ancient and recent agrarian societies[2]. The excessive concentration of soluble salts contained by saline water and soil may cause injury to plants in two ways, first by increasing the salt concentrations of the soil solution and second by increasing the degree of saturation of the exchange complex of the soil exchangeable sodium. Plants generally require silica to control biotic and abiotic stress[3,4].

The presence of silicon reduces toxic metal elevation and increases water use efficiency and photosynthesis rate in plants. Furthermore, silicon also acts as a bio protectant against fungal attack so protect the plat and direct his effort to enhance the growth[5].

Currently, different sources of silica are used as fertilizer for crops but their effect on soil chemical and physical properties is still not clear. These sources are routinely applied for promoting the growth of crops such as sugarcane and rice[6-8].

Even though different sources of silica are used as silicon fertilizers, eco-toxicological properties and the risks of silicon fertilizers in terms of soil microbial health and soil nutrient values are found to be scanty to the best of our knowledge. It is well known that Plant Growth-Promoting Rhizobacteria (PGPR) plays a key role in recycling and maintenance of soil health which improves plant growth[9,10].

Using Nano-silica as nanoparticles can improve the physical and chemical properties of the soil which reflection on the environmental media of plant growth so enhance plant growth and fruiting. Karunakaran *et al.*[11] mentioned that the agricultural application of nanoparticles is currently an interesting area of the production of crops. Also, the addition of Nano-silica in soil enhances the growth of maize, cucumber and beans[12].

Xiaochuan and Kai[13] investigate the effects of Nano-silica on the physical and mechanical properties of silty clay soil through scanning electron microscopy and a series of tests measuring specific gravity, liquid and plastic limits, uniaxial compression and frost heave indicated that increasing Nano. However, there was no change in the specific gravity of the clay sample. Further, Nano-silica did not affect the composition of the clay sample but reduced its average pore size, making its structure uniform.

Using clay at normal size and Nano-material size enhance the plant response to abiotic stress where the clay act as an effective factor in plant growth under salinity by reducing the adverse effect of salinity stress[14].

Nano zeolite and Nano clay can improve the long-term availability of nutrients and enhance the germination and growth of plants[15].

Another study[16] showed an excellent effort to explore the application of Nano-materials. They found that the life cycle of Nano fertilizer applied wheat plants was 23.5% shorter (130 days compared with 170 days) for yield production from the date of sowing compared to conventional fertilizer-applied plants. The main purpose of this study was to examine the effect of some Nano-materials on the growth and productivity of pomegranate trees wonderful cultivar under salinity stress.

MATERIALS AND METHODS

Study area: The current study carried out during the seasons of 2019 and 2020 at the Pomology orchard located in the desert of West Minia Governorate. This experimental study conducted on pomegranate wonderful cultivar by choosing 21 trees (seven treatments and each treatment was replicated three times) the chosen trees were 5 years old, cultivated 3×4 m, irrigated with drip irrigation system, all trees were free of pathogens and physiological disorders and took all agricultural processes and fertilization treatments except the foliar application of examined materials.

Soil analysis: Soil analysis was done according to other studies[17-19] as shown in Table 1.

Table 1: Analysis of the tested soil

Content	Value
Sand (%)	93.0
Silt (%)	4.2
Clay	2.3
Texture grade	Sandy
pH (1:2.5 extract)	7.91
EC (1:2.5 extract) (ds m^{-1})	4.3
Calcium carbonate (%)	2.5
Total N (%)	0.08
Available P (olsen, ppm)	1.9
Available K (ammonium acetate, ppm)	92.0
Available micronutrient (ppm)	-
Zn	0.7
Fe	0.6
Mn	0.7
Cu	0.1

The investigation included the following seven treatments:

- Control (spraying water)
- Spraying of clay
- Spraying of nano clay
- Spraying of silicon
- Spraying of nano silicon
- Spraying mixture of silicon with clay
- Spraying mixture of nano silicon with nano clay

Both clay and silicon sprayed at 500 ppm concentrate at all treatments, the application was 3 times at mid of June mid of July and mid of August. The experiment was arranged in a Randomized Complete Block Design (RCBD) with seven treatments and three replications for each treatment one tree per each. During the two seasons, the following parameters were measured: Nutrient content of leaves (N, P, K, Ca and Mg), number of fruit/tree, the yield of fruit per tree (kg), fruit weight (g), fruit length (cm), fruit diameter (cm), fruit volume (cm^3) as well as Total Soluble Solids (TSS), reducing sugars, total acidity and vitamin c in fruit.

Measurement of parameters: The following parameters were recorded in both seasons:

- Percentages of N, P, K, Ca, Mg in dried leaves was determined[17,20]
- Fruit length, fruit diameter in (cm) and fruit volume
- Number of fruit per tree
- Fruit weight (g)
- Yield
- Some chemical characteristics of the fruits namely total soluble solids (%), total sugars (%)[21], total acidity (%) (as g malic acid/100 g pulp)[21], vitamin C observed[22]

Statistical analysis: All the obtained data were tabulated and subjected to the proper statistical analysis using new LSD at 5%[22].

RESULTS

Percentages of N, P, K, Ca, Mg in dried leaves: As shown in Table 2 the effect of the foliar application of Nano silicon with Nano clay was the superior treatment and gave extreme values in all of the examined parameters in both seasons, where the percentage of nutrients in dried leaves were nitrogen (2.47, 2.49) phosphorus (0.42, 0.53), potassium (1.71, 1.73), calcium (1.74, 1.76) and magnesium (0.34, 0.35) compare to control which gave (2.16, 2.23) (0.12, 0.13) (1.32,1.34) (1.29, 1.31) (0.26, 0.27), respectively. While the effect of using the foliar spray of clay in its natural and Nanoscale size was slight and insignificant but using of silicon in both the normal and Nanoscale sizes was better than clay in results of these parameters but less or almost equal to the use of both silicon and clay in the regular size.

Fruit characterizes: Up to data tabulated in Table 3 Using both Nano silicon with Nano clay as foliar spraying was very significant in enhancing fruit dimension and fruit volume compare to all other treatments where fruit length was 8.42 and 8.47 cm at the two seasons, respectively while was in control 7.69 and 7.75 cm and also enhance the number of fruits per tree which were 82.63 and 84 in promised treatments while were 57.16 and 57.7 in untreated trees. Fruit weight by grams in both seasons 2019 and 2020 enhanced from (371.6 and 372.8)-(439.4 and 442). Up to data shown in the same Table 2 Using of silicon at Nano size alone was significantly more than using only silicon at normal size while Nano clay treatment and normal size clay treatment were non-significant compare to

Table 2: Effect of silicon, clay, nano silicon, nano clay and its combinations on the percentage of nutrient (N, P, K, Ca and Mg) in dry leaves of pomegranate wonderful cv

	N (%)		P (%)		K (%)		Ca (%)		Mg (%)	
Treatments	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Control	2.16^{e}	2.23^{f}	0.12^{f}	0.13^{d}	1.32^{f}	1.34^{f}	1.29^{e}	1.31^{e}	0.26^{f}	0.27^{e}
Silicon	2.32^{c}	2.34^{d}	0.29^{d}	0.3^{b}	1.46^{c}	1.48^{c}	1.42^{d}	1.43^{d}	0.29^{cd}	0.30^{c}
Nano-si	2.37^{b}	2.4^{c}	0.35^{c}	0.3^{b}	1.48^{c}	1.49^{c}	1.48^{c}	1.49^{e}	0.30^{c}	0.30^{c}
Clay	2.19^{e}	2.24^{f}	0.18^{e}	0.2^{c}	1.37^{e}	1.37^{e}	1.31^{e}	1.33^{e}	0.28^{e}	0.28^{de}
Nano-clay	2.23^{d}	2.29^{e}	0.20^{e}	0.2^{c}	1.40^{d}	1.42^{d}	1.34^{e}	1.35^{e}	0.28^{de}	0.29^{d}
Si+cl	2.40^{b}	2.45^{b}	0.37^{b}	0.33^{b}	1.58^{b}	1.59^{b}	1.62^{b}	1.64^{b}	0.32^{b}	0.34^{b}
N si+n cl	2.47^{a}	2.49^{a}	0.42^{a}	0.53^{a}	1.71^{a}	1.73^{a}	1.74^{a}	1.76^{a}	0.34^{a}	0.35^{a}
LSD 0.05	0.035	0.036	0.023	0.055	0.028	0.031	0.052	0.052	0.011	0.011

Si: Silicon, cl: Clay and n: Nano. These alphabets indicate the significant differences, where the letter "a" represents high value, then "b" and so on

Table 3: Effect of silicon, clay, nano silicon, nano clay and its combinations on fruit characterizes pomegranate wonderful cv

	Fruit length		Fruit diameter		Fruit volume		No. of fruit		Fruit weight	
Treatments	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Control	7.69^{e}	7.75^{e}	8.66^{g}	8.68^{f}	395.3^{f}	397.2^{e}	57.16^{f}	57.7^{g}	371.6^{f}	372.8^{g}
Silicon	8.16^{bc}	8.20^{bc}	9.15^{d}	9.16^{d}	423.33^{cd}	425.8^{c}	70.43^{d}	71.6^{d}	406.5^{c}	408.0^{d}
Nano-si	8.22^{b}	8.24^{b}	9.26^{c}	9.27^{c}	424.86^{c}	426.1^{c}	74.4^{c}	75.0^{c}	417.6^{b}	419.0^{d}
Clay	7.92^{d}	7.93^{d}	8.91^{f}	8.94^{e}	406.9^{e}	409.3^{d}	59.1^{f}	60.3^{f}	388.2^{e}	389.5^{f}
Nano-clay	8.13^{c}	8.16^{c}	8.97^{e}	8.98^{e}	418.53^{d}	420.7^{c}	65.7^{e}	66.3^{e}	397.3^{d}	398.8^{e}
Si+cl	8.36^{a}	8.40^{a}	9.48^{b}	9.5^{b}	435.06^{b}	436.5^{b}	78.40^{b}	79.8^{b}	435.2^{a}	437.1^{b}
N si+n cl	8.42^{a}	8.47^{a}	9.57^{a}	9.59^{a}	445.4^{a}	448.0^{a}	82.63^{a}	84.0^{a}	439.4^{a}	442.0^{a}
LSD 0.05	0.07	0.06	0.056	0.052	6.23	6.31	2.72	2.36	4.23	3.78

Si: Silicon, cl: Clay and n: Nano. These alphabets indicate the significant differences, where the letter "a" represents high value, then "b" and so on

Table 4: Effect of silicon, clay, nano silicon, nano clay and its combinations on yield and some fruit chemical composition of fruit of pomegranate wonderful cv

	Yield		TSS		TS		Acidity		Vitamin C	
Treatments	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Control	20.4^{f}	21.2^{f}	12.1^{e}	12.2^{f}	11.05^{f}	11.07^{f}	1.35^{a}	1.33^{a}	23.1^{g}	23.3^{g}
Silicon	26.7^{c}	27.5^{c}	13.7^{c}	13.8^{d}	12.3^{d}	12.3^{d}	1.22^{c}	1.2^{c}	24.2^{d}	24.2^{d}
Nano-si	27.7^{c}	28.2^{c}	14.4^{b}	14.5^{c}	12.8^{c}	12.8^{c}	1.17^{d}	1.16^{d}	24.8^{c}	24.9^{c}
Clay	22.8^{e}	23.2^{e}	12.6^{d}	12.7^{e}	11.2^{f}	11.2^{f}	1.3^{b}	1.28^{b}	23.5^{f}	23.6^{f}
Nano-clay	25.03^{d}	25.3^{d}	12.8^{d}	12.9^{e}	11.6^{e}	11.7^{e}	1.28^{b}	1.26^{b}	23.9^{e}	23.9^{e}
Si+cl	29.5^{b}	30.0^{b}	15.3^{a}	15.3^{b}	13.3^{b}	13.4^{b}	1.1^{e}	1.09^{e}	25.7^{b}	25.7^{b}
N si+n cl	31.3^{a}	31.8^{a}	15.6^{a}	15.6^{a}	13.8^{a}	13.9^{a}	1.05^{f}	1.03^{f}	26.8^{a}	26.9^{a}
LSD 0.05	1.02	0.85	0.3	0.24	0.2	0.2	0.02	0.02	0.23	0.22

Si: Silicon, cl: Clay, n: Nano, TSS: Total soluble salts, TS: Total sugar. These alphabets indicate the significant differences where the letter "a" represents high value, then "b" and so on

control in all parameter of fruit dimension, fruit volume and fruit weight during the two seasons up to data which obtained.

Yield and some fruit chemical composition of fruit: The data in Table 4 shows the total yield of the promised treatment in the two seasons increased significantly compare to untreated trees where the yield of a tree was 31.3 and 31.8 kg per tree in 2019 and 2020 respectively while yield was 20.4 and 21.2 during the two seasons Where the percentage increase during the two seasons was 53 and 50%.

Both total soluble salts and total sugar were very high in fruits which treated by Nano silicon with Nano clay compares to control and other treatments while this promised treatment reduces the total acidity as the lowest value and lower than control, Nano clay, clay, silicon, Nano silicon and clay plus silicon. Vitamin C increased by using Nano silicon with Nano-clay more than all other treatments.

DISCUSSION

This study helps to obtained results that by using Nanomaterials namely Nano clay and Nano silicon enhance growth parameters and fruiting of pomegranate trees under salinity stress. The adverse effects of salinity on plant production are associated with the low osmotic potential of the soil solution (water stress), nutritional imbalance, specification effects (salt stress) or a combination of these factors[23].

Utilizing silicon appears to profit plants when they are under pressure. It has been found to improve dry spell resilience and defer shrinking in specific harvests where the water system is retained and may upgrade the plant's capacity to oppose micronutrient and other metal poison levels (for example aluminium, copper, iron, manganese, zinc and so forth) Additionally, silicon has been found to help increment stem strength. Just as the impact of silicon in improving the resistance of the trees to all anxieties, take-up and transport of water and various supplements, root advancement and cell reinforcement safeguard frameworks[24]. Previous studies showed that the application of silicon was very effective in promoting the growth and fruiting of fruit crops[25,26]. The current study showed that the application of potassium silicate significantly increased the yield and quality of pomegranate fruit. The effect of silicon in improving yield and fruit quality of pomegranates was supported by[27, 28].

The spraying of pomegranate tree by a 1% of potassium silicate caused about 60% increase in the fruit yield, moreover, this treatment improved the quality of fruit. Previous studies showed that silicon increased the activities of antioxidant

enzymes in the leaves that protect plant tissues from oxidative damage under unfavourable conditions[25]. Using Nano-silica with Nano clay increase plant growth and these agreed with[11].

CONCLUSION

Application of Nano silicon with Nano clay at 500 ppm 3 times at mid of June, mid of July and mid August, was the superior treatment in all of the parameters which have been examined and enhance the growth, yield and fruit quality of pomegranate wonderful under salinity stress.

SIGNIFICANCE STATEMENT

This study discovered that using both silicon and clay at Nanoscale with a foliar application can be beneficial for alleviating adverse effects of salinity on the growth and fruiting of wonderful pomegranate and this study will help the researchers to uncover the critical areas of pomegranate wonderful cultivar grown under salinity stress that many researchers were not able to explore. Thus a new theory on alleviating salinity stresses may be arrived at.

REFERENCES

1. Stover, E. and E.W. Mercure, 2007. The pomegranate: A new look at the fruit of paradise. HortScience, 42: 1088-1092.
2. Pagliarulo, C., V. De Vito, G. Picariello, R. Colicchio, G. Pastore, P. Salvatore and M.G. Volpe, 2016. Inhibitory effect of pomegranate (*Punica granatum* L.) polyphenol extracts on the bacterial growth and survival of clinical isolates of pathogenic *Staphylococcus aureus* and *Escherichia coli*. Food Chem., 190: 824-831.
3. Fekry, W.M.E., M.A. Rashad and A.H. Alalaf, 2020. Attempts to improve the growth and fruiting of barhi date-palms under salinity stress. Asian J. Plant Sci., 19: 146-151.
4. Ma, J.F., 2004. Role of silicon in enhancing the resistance of plants to biotic and abiotic stresses. Soil Sci. Plant Nutr., 50: 11-18.
5. He, C., L. Wang, J. Liu, X. Liu and X. Li *et al*., 2013. Evidence for 'silicon' within the cell walls of suspension cultured rice cells. New Phytol., 200: 700-709.
6. Shahrtash, M., 2017. Effects of Silicon and Nitrogen Fertilization on Growth, Yield and Leaf Rust Disease Development in Wheat. MSC Thesis, Louisiana State University.
7. Chiba, Y., N. Mitani, N. Yamaji and J.F. Ma, 2009. HvLsi1 is a silicon influx transporter in barley. Plant J., 57: 810-818.
8. Currie, H.A. and C.C. Perry, 2007. Silica in plants: Biological, biochemical and chemical studies. Ann. Bot., 100: 1383-1389.
9. Ortíz-Castro, R., E. Valencia-Cantero and J. López-Bucio, 2008. Plant growth promotion by *Bacillus megaterium* involves cytokinin signaling. Plant Signaling Behav., 3: 263-265.
10. Gholami, A., S. Shahsavani and S. Nezarat, 2009. The effect of plant growth promoting rhizobacteria (PGPR) on germination, seedling growth and yield of maize. https://zenodo.org/record/1083385#.YScrSY4zbIU.
11. Karunakaran, G., R. Suriyaprabha, P. Manivasakan, R. Yuvakkumar, V. Rajendran, P. Prabu and N. Kannan, 2013. Effect of nanosilica and silicon sources on plant growth promoting rhizobacteria, soil nutrients and maize seed germination. IET Nanobiotechnol., 7: 70-77.
12. Yuvakkumar, R., V. Elango, V. Rajendran, N.S. Kannan and P. Prabu, 2011. Influence of nanosilica powder on the growth of maize crop (*Zea mays* L.). Int. J. Green Nanotechnol., 3: 180-190.
13. Ren, X. and K. Hu, 2014. Effect of nanosilica on the physical and mechanical properties of silty clay. Nanosci. Nanotechnol. Lett., 6: 1010-1013.
14. Shang, Y., M.K. Hasan, G.J. Ahammed, M. Li, H. Yin and J. Zhou, 2019. Applications of nanotechnology in plant growth and crop protection: A review. Molecules, Vol. 24. 10.3390/molecules24142558.
15. Manjaiah, K.M., R. Mukhopadhyay, R. Paul, S.C. Datta, P. Kumararaja and B. Sarkar, 2019. Clay Minerals and Zeolites for Environmentally Sustainable Agriculture. In: Modified Clay and Zeolite Nanocomposite Materials, Mercurio, M., B. Sarkar and A. Langella (Eds.)., Elsevier Inc., pp: 309-329.
16. Abdel-Aziz, H.M.M., M.N.A. Hasaneen and A.M. Omer, 2016. Nano chitosan-NPK fertilizer enhances the growth and productivity of wheat plants grown in sandy soil. Spanish J. Agric. Res., Vol. 14. 10.5424/sjar/2016141-8205.
17. Piper, C.S., 1950. Soil and Plant Analysis. Interscience Publisher, New York, Pages: 368.
18. Black, C.A., 1965. Methods of Soil Analysis. 1st Edn., American Society Agronomy, Madison, WI., USA.
19. Munson, R.D. and W.L. Nelson,1990. Principles and Practices in Plant Analysis. In: Soil Testing and Plant Analysis, Westerman, R.L. (Ed.)., Wiley Online Library, pp: 359-387.
20. Tabassum, T., M. Farooq, R. Ahmad, A. Zohaib and A. Wahid, 2017. Seed priming and transgenerational drought memory improves tolerance against salt stress in bread wheat. Plant Physiol. Biochem., 118: 362-369.
21. Baur, F.J. and L.G. Ensminger, 1977. The Association of official analytical chemists. J. Am. Oil Chem. Soci., 54: 171-172.
22. Mead, R., R.N. Curnow and A.M. Hasted, 2002. Statistical Methods in Agriculture and Experimental Biology. 3rd Edn., Chapman and Hall/CRC, Boca Raton, Pages: 488.

23. Grattan, S.R., F.J. Díaz, F. Pedrero and G.A. Vivaldi, 2015. Assessing the suitability of saline wastewaters for irrigation of *Citrus* spp.: Emphasis on boron and specific-ion interactions. Agric. Water Manage., 157: 48-58.
24. Hattori, T., S. Inanaga, H. Araki, P. An, S. Morita, M. Luxova and A. Lux, 2005. Application of silicon enhanced drought tolerance in *Sorghum bicolor*. Physiol. Planta., 123: 459-466.
25. Luyckx, M., J.F. Hausman, S. Lutts and G. Guerriero, 2017. Silicon and plants: Current knowledge and technological perspectives. Front. Plant Sci., Vol. 8. 10.3389/fpls.2017.00411.
26. Ahmed, M., M. Akl, A. Moawad, A. Mohamed, M. Hamdy, I. Ibrahim and H. Mohamed, 2015. Productive capacity of manfalouty pomegranate trees in relation to spraying of silicon and vitamins B. World Rural Obs., 7: 108-118.
27. Ahmed, F.F., M.M. Mohamed, A.M.A. Abou El-Khashab and S.H.A. Aeed, 2014. Controlling fruit splitting and improving productivity of manfalouty pomegranate trees by using salicylic acid and some nutrients. World Rural Obs., 6: 87-93.
28. Wassel, A.H.M., A.A. Gobara, H.I.M. Ibrahiem and M. Shaaban-Mai, 2015. Response of wonderful pomegranate trees to foliar application of amino acids, Vitamins B and silicon. World Rural Obs., 7: 91-6.