Enhancing Some Pomegranate Growth Characteristics Through Soil Application of Humic Acid and Silicon Foliar Spray

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ABSTRACT

The research was carried out in the lath house of the department of Horticulture and Landscape Engineering, University of Baghdad, Al-Jadriya Campus. A two-factor experiment was applied to pomegranate *Punica granatum* L. saplings. The first factor is humic acid at three concentrations (0, 5, and 10 g L^{-1} denoted as (H0, H1, and H2) respectively. The second factor involved the foliar application of silicone as potassium silicate at three concentrations (0, 2.5, and 5 ml L^{-1}) denoted as (S0, S1, and S2) respectively. The results demonstrated the positive effect of each factor independently. Treatment H2 produced the greatest enhancement associated with humic acid across all evaluated trails however the treatment S2 exhibited the highest overall effect among the silicone treatments. Moreover the interaction between both factors had a significant impact on the studied traits were the combined treatment H2S2 resulting in the most significant improvement across all the studded parameters, plant height (81.60 cm), Leaf Chlorophyll Content (45.00 cpad), Leaf Nitrogen Content (2.66 %), Leaf Phosphorus Content (0.60 %), Potassium content of leaves (3.07 %), Leaf Silicon Content (0.22 mg L^{-1}).

Keywords: humic acid, soil application. Silicon, foliar application

INTRODUCTION

Pomegranate is a deciduous fruit bearing shrub belong to the family of Punicaceae. Iran considered the place of origin from where it spread to subtropical countries such as Morocco, Egypt, India and Spain (Mirjalili and Poorazizi, 2015). The fruit has been garnered special attention due to its attractive appearance and numerous benefits including its high content of vitamins, minerals and medicinal compounds such as tannins in addition the plant tolerance to both high and low temperature stress (Hussain et al., 2021).

Humic acids result from the decomposition of animal and plant remains and contain substances such as lignin and cellulose (Hayes & Swift, 2020). These organic compounds positively influence soil properties by enhancing its structure, water holding capacity, cation exchange potential, acidity, microbial dynamics and the accessibility of essential nutrients (Nardi et al., 2021; Sible et al., 2021). It is worth noting that the level of humic substances in soils has generally decreased due to increased livestock and biogas production, forcing farmers to resort to external application of these substances (Gerke, 2018). The effect of humic acids on soil and plants is influenced by the type of humic acid, the application rate, solubility, particle size, and the type of active group (Ampong et al., 2022; Wang et al., 2023; Khrbeet, 2021). Humic acids are produced commercially from soil, charcoal, and lignin (Yang et al., 2021). Many studies have indicated the role of humic acid in plant growth. Sharif et al. (2023) studied the effect of spraying humic acid on pomegranate cuttings “wonderful” variety at different concentrations (0, 100, and 150) mg L^{-1} on vegetative and root growth indicators. The results indicated an increase in the number of leaves, branches, roots, root dry weight, and root length as a result of the treatment.

Silicon is considered a semi-essential element in plant nutrition, as it is not classified

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as an essential element, but it plays a very important physiological and functional role in improving growth and increasing resistance to environmental and biological stresses. The plant absorbs it from the soil in the form of silicic acid and stores it mainly in plant tissues and cell walls in the form of silica, which enhances rigidity (Thorne et al., 2020; Bazgaou et al., 2023). Silicon has a prominent role similar to that of calcium in increasing the strength and rigidity of plant cell walls (Guerriero et al., 2016), in addition to physiological roles such as improving vegetative growth and production by increasing the efficiency of photosynthesis in the plant (Muneer et al., 2017). Silicone also has a role in the absorption and transport of elements through cell membranes (Sheng et al., 2018). The results of Salim and Joody (2019) confirmed that spraying apple trees with potassium silicate at concentrations increased the concentration of nitrogen, potassium, calcium, and phosphorus in the leaves. Nada (2020) also recorded an increase in plant height, number of leaves, leaf area and leaf chlorophyll content when strawberry plants were treated with potassium silicate fertilizer. Mohammed and Majeed (2023) also showed that treating strawberries with potassium silicate positively affected plant growth characteristics and yield.

This research aimed to support seedlings to achieve rapid and normal growth by adding Environmentally friendly fertilizers humic acid and silicon.

MATERIALS AND METHODS

The research was carried out in the lath house of department of Horticulture and Landscape Engineering, University of Baghdad, Al-Jadriya Campus. Station B, during the 2024 growing season. A two-factor experiment was implemented according to a completely randomized block design. The first factor involved adding three levels of humic acid (0, 5, and 10) g L^{-1} (H0, H1, and H2) to the soil in mid-February, March, and April, and spraying with three levels of potassium silicate (0, 2.5, and 5) mL^{-1} (S0, S1, and S2) at the beginning of April. The experiment conducted on two years old pomegranate saplings C.V. Yemeni green and the experiment consisted of nine treatments applied in three replicates resulting in a total of 27 pomegranate saplings. The results were analyzed using the least significant difference (LSD) test at a probability level of 5%. The seedlings were grown in 20 kg plastic pots with a 2:1 mixture of silage and peat moss, and sprayed using a 10-liter hand sprayer.

Measured characteristics

1- Increase in branch length (cm)
2- Estimation of leaf chlorophyll content (SPAD)
3- Estimation of leaf nitrogen content (%)
4- Estimation of leaf phosphorus content (%)
5- Estimation of leaf potassium content (%)
6- Estimation of leaf silicon content (mg L^{-1})

RESULTS AND DISCUSSION

Increase in Branch Length (cm)

The results presented in the table below indicate that the experimental factors affected significantly in studied trait. The application of humic acid significantly increased branch length treatment H2 (10 g L^{-1})producing the highest increase 77.42 cm, whereas treatment H0 recorded the lowest value 55.30 cm. Similarly foliar application of silicon on the plant also affected branch length treatment Si2 (5 mL^{-1}) resulted the highest value 69.38 cm. which did not differ significantly from Si1 but differed significantly from treatment Si0 which showed the lowest increase 62.49 cm. furthermore the interaction between humic acid and silicon exerted a significant effect on branch length. The interaction treatment H2Si2 (10 g L^{-1} and 5 mL^{-1}) resulted in the highest increase to 81.42 cm while the control treatment recorded the lowest value 52.37 cm.

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Table No. 1. Effect of adding humic acid and foliar spraying with silicon on the trait of increasing branch length (cm)

	H 0	H 1	H 2	mean
Si 0	52.37	62.77	72.33	62.49
Si 1	55.40	65.10	78.33	66.28
Si 2	58.13	68.42	81.60	69.38
mean	55.30	65.43	77.42	
LSD	H= 4.00	Si = 4.00	H*Si = 6.93	

Leaf Chlorophyll Content (SPAD)

The results of table2 confirmed that the experiment factors affected the leaf chlorophyll content characteristic, humic acid significantly increased the chlorophyl, H2 treatment gave the highest concentration reached 42.56, which differed significantly from the H0 treatment, while it did not differ significantly from the H1 treatment. Likewise, the addition of silicon affected chlorophyll in the leaves, as the Si2 treatment gave the highest chlorophyll rate in leaves reached 42.33, which differed significantly from the Si1 and Si0 treatments, while there was no significant difference between the Si1 treatment compared to the Si0 treatment. the interaction between the study factors produced a clear significant increase in leaves chlorophyll content, H2Si2 treatment gave the highest rate of the characteristic reached 42.56, while the control treatment, H0Si0, gave the lowest rate of the characteristic at 25.00.

Table No. 2. Effect of adding humic acid and foliar spraying with silicon on the characteristic of leaf chlorophyll content (SPAD)

	H 0	H 1	H 2	mean
Si 0	25.00	39.00	40.33	34.78
Si 1	30.00	41.33	42.33	37.89
Si 2	38.00	44.00	45.00	42.33
mean	31.00	41.44	42.56	
LSD	H= 4.04	Si = 4.04	H*Si = 7.01	

Leaf Nitrogen Content (%)

The table below summarizes the effects of the treatments on leaf nitrogen content (%). The results indicate a significant increase in the trait due to both individual and combined influences of the studied factors. humic acid treatment (H2) recorded the highest value at 2.42% which was significantly higher than H0 treatment that showed the lowest value at 1.36%. Silicon application also caused a significant increase in leaf nitrogen content, the Si2 treatment achieved the highest value of 1.99%, significantly different from Si0 1.63 %, but not significantly different from the Si1 treatment 1.80%. moreover, the interaction between the studied factors was significant, as the combined treatment H2Si2 produced the highest value of 2.66%, which was significantly higher than control treatment (H0Si0) that gaves the lowest mean for this trait 1.28%.

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Table 3. Effect of adding humic acid and foliar silicon spray on leaf nitrogen content (%)

	H 0	H 1	H 2	mean
Si 0	1.28	1.38	2.25	1.63
Si 1	1.38	1.64	2.37	1.80
Si 2	1.43	1.90	2.66	1.99
mean	1.36	1.64	2.42	
LSD	H= 0.22	Si = 0.22	H*Si = 0.39	

Leaf Phosphorus Content (%)

The results in Table 4 confirmed that the study factors affected the leaf phosphorus content. Humic acid significantly affected this characteristic, treatment with H2 gives the highest concentration at 0.56% which significantly different from treatment H0 which about 0.29% and treatment H1 which is 0.39%. Similarly, the addition of silicon increased the characteristic in the leaves with treatment Si2 yielding the highest rate at 0.47% which significantly different from treatment Si0 (0.34%), while no significant difference was observed. Furthermore, the interaction between the study factors resulted in a clear and significant increase with treatment H2Si2 yielding the highest rate at 0.60% while the control treatment H0Si0 yielded the lowest rate at 0.18%.

Table 4. Effect of adding humic acid and foliar spraying with silicon on the phosphorus content of leaves (%)

	H 0	H 1	H 2	mean
Si 0	0.18	0.34	0.52	0.34
Si 1	0.33	0.39	0.55	0.42
Si 2	0.37	0.43	0.60	0.47
mean	0.29	0.39	0.56	
LSD	H= 0.075	Si = 0.075	H*Si = 0.130	

Potassium content of leaves (%)

The results in the table below shows that the research factors affected the increase of the studied trait. The addition of the humic acid significantly increased the potassium content of the leaves, the treatment H2 produce the highest increase of 2.46%, which significantly different from treatment H0. Similarly, spraying silicon on the plant affected the measured trait, with treatment Si2 resulting in the highest increase of 2.28%, significantly different from treatment Si0, which resulted in the lowest single-factor effect of 1.16%. The interaction between both factors humic acid and silicon significantly increased the potassium content in the leaves. The interaction treatment H2Si2 resulted in the highest increase of 3.07%, while the control treatment resulted in the lowest increase of 0.92%.

Table 5. Effect of adding humic acid and foliar spraying with silicon on the potassium content (%) of leaves

	H 0	H 1	H 2	mean
Si 0	0.92	2.15	2.05	1.71
Si 1	1.17	1.90	2.27	1.78
Si 2	1.39	2.38	3.07	2.28
mean	1.16	2.14	2.46	
LSD	H= 0.58	Si = 0.58	H*Si = 1.016	

Leaf Silicon Content (mg L^{-1})

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The results in the Table below confirmed that the study factors affected the leaf silicon content. Humic acid significantly affected the silicone concentration in leaves with treatment H2 gave the highest concentration at 0.19 mg L^{-1} which significantly different from treatment H0 (0.13 mg L^{-1}) and treatment H1 (0.15 mg L^{-1}). Similarly the addition of silicon increased the characteristic with treatment Si2 gave the highest concentration at 0.19 mg L^{-1} which significantly different from treatment Si0 (0.14 mg L^{-1}). Furthermore, the interaction between the study factors resulted in a clear significant increase with treatment H2Si2 gave the highest concentration at 0.22 mg L^{-1}, while the control treatment H0Si0 yielded the lowest concentration at 0.12 mg L^{-1}.

Table No. 6. Effect of adding humic acid and foliar spraying with silicon on the characteristic of leaf silicon content (mg L^{-1})

	H 0	H 1	H 2	mean
Si 0	0.12	0.15	0.17	0.14
Si 1	0.13	0.14	0.19	0.15
Si 2	0.15	0.17	0.22	0.19
mean	0.13	0.15	0.19	
LSD	H= 0.027	Si = 0.027	H*Si = 0.048	

The results showed that adding humic acid and silicone improved all plants growth traits, this effect may be attributed to the role of humic acid in building and strengthening plant cell walls as well as in the function and structure of cell membranes and cytoplasm and in the synthesis and activity of plant hormones (Zandonadi et al., 2025). Humic acid also affects growth through its positive impact on the biological, chemical and physical properties of the soil and on increasing the soil's capacity for nutrient exchange (Maidan and Marai, 2019). Table 2 also shows that adding humic acid to the soil had a positive effect on increasing chlorophyll in the leaves thus increasing the efficiency of photosynthesis. This in turn positively impacts the division and elongation of plant cells in the shoot and root systems which in turn leads to longer branches and increased nutrient uptake, the increased uptake of plant nutrients influences by humic acid may also be attributed to the role of microorganisms in soil growth and their effect on increasing nutrient availability in the soil. Humic acid also affects soil acidity by increasing the release of sulfur an element known for its acidic effect in the soil thus increasing nutrient availability (Sible et al., 2021).

The addition of humic acid also promotes plant growth by increasing the production of growth-related plant hormones such as auxins and cytokinins, which also play a role in stress resistance, nutrient metabolism, and photosynthesis (Canellas et al., 2020; Laskosky et al., 2020; van Tol de Castro, 2021). This was reflected positively in increased branch length (Table 1) and increased chlorophyll concentration in leaves (Table 2).

Regarding the positive effect of silicon on vegetative growth characteristics and plant nutrient content, this may be attributed to silicon's role in increasing plant resistance to environmental and biological conditions through its effect on increasing the activity of the antioxidant enzymes peroxidase and superoxide dismutase, as well as increasing total phenols in the plant (Salim and Joody, 2024). Some studies have indicated that silicon may play a role similar to that of growth regulators indirectly, by stimulating the expression of Silicon plays an indirect role in the synthesis of hormones (Khan et al., 2020; Luyckx et al., 2017; Guerriero et al., 2016). It also plays a role in the synthesis of gibberellin, the hormone responsible for cell elongation, thus increasing branch and root

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growth and nutrient absorption. Furthermore, silicon contributes to plant growth by increasing the plant's mechanical strength through its role in cell wall construction. Silicon also helps maintain the plant's water balance by precipitating in leaf cells as silica, thereby preserving the plant's water content and increasing cell swelling, which in turn enhances the cells' ability to absorb nutrients, elongates, and improves photosynthetic efficiency (Abdelaal et al., 2020; Bhat et al., 2019; Debicz et al., 2016; Epstein, 2001; Kimiaei et al., 2022; Ma and Yamaji, 2006; Mikiciuk and Mikiciuk,2008; Parimala and Singh, 2022; Laane, 2018).

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