The Impact of Selenium, Nano (SiO₂) and Organic Fertilization on growth and yield of Potato *Solanum tuberosum* L. under Salt Stress Conditions.

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Abstract

The experiment was conducted in the desert area of the extension center of the Karbala governorate for the agricultural season 2019-2020 to study the effect of spraying selenium fertilizer, SiO₂-NPs and organic fertilizers on growth and yield of potato plants under salt stress conditions. The experiment was carried out according to the split plot design of randomized complete block design (RCBD). The results of the study showed that irrigation water with salinity of 10 ds.m⁻¹ caused a decrease in all the characteristics of vegetative growth and yield, while the water quality 5.9 ds.m⁻¹ achieved the highest values in all the studied parameters, the results showed significant differences in the treatment combinations compared to control treatment, the treatment (corn cobs compost + Se) was achieved the highest results in all study parameters, which was significantly superior to most of the vegetative growth and yield characteristics.

1. Introduction

Potato *Solanum tuberosum* L. One of the most important vegetable crops in the world in terms of production and cultivated area it belongs to the Solanaceae family, which includes 90 genera and about a trace of 2000 species [1]. The salinity of water and soil is one of the main stresses that negatively effect on growth and productivity of plant species especially in dry areas, salinity greatly limits the production of many plant species. The world loses annually about ten million hectares of arable land due to salinization. The lands affected by salinity are about 954 million hectares, and researchers have been interested in studying the effect of salinity on plant growth and development. This interest comes in the context of the large increase in the population that requires a significant increase in plant production, being a "basic" source of human food, the study of the effect of salinity depends on exposing the plant to different salt levels by controlling the amount of salts added to the irrigation water, knowing that the effect of salinity in the plant depends on the severity of stress, the time of its occurrence and the length of time the plant is exposed to it, and also "according to the stage of growth [2,3].

Selenium is an important element associated with enhancing antioxidant activity in plants, and selenium is a activator of a protective mechanism that reduces oxidative stress in chloroplasts, and protects plants against free radicals [4]. The use of nano composites is one of the most promising methods to increase plant growth and production and reduce soil toxicity. Plant breeders aim to increase plant resistance to salinity by reducing the effect of salt stress destruction on plant growth and productivity through various strategies. One of these strategies for recent experiments is the applications of silicon, where it found its benefit. In increasing abiotic stress tolerance [5,6]. The aim of the study was to stimulate the salt stress tolerance of potato plants by using selenium and silicon dioxide nanoparticles (SiO₂-NPs) and organic fertilization and the interplay between them on the growth and yield of the potato plant under salt stress conditions.

2. Material and Methods

The experiment was carried out in the desert area of the extension center of the Karbala Governorate, which is located south of the Karbala Governorate, during the autumn 2019.
Soil samples were taken randomly from different locations of the experiment field at a depth (0-30 cm) to study some physical and chemical properties of field soil before planting table (1).

**Table 1.** some physical and chemical characteristics of the soil.

| Type of analysis | Result       |
|------------------|--------------|
| EC (1:1) ds/m    | 4.7          |
| pH               | 6.8          |
| HCO₃ ppm         | 30.5         |
| CO₃             | 0            |
| NH₄ ppm          | 63           |
| NO₃ ppm          | 45.5         |
| Ca²⁺ ppm         | 300.6        |
| Mg²⁺ ppm         | ppm Mg²⁺ 9.76|
| K⁺ ppm           | 288          |
| CL⁻ Mg/L         | 92.3         |
| P ppm            | 72           |
| O.M%             | 0.031        |
| Texture          | Sandy        |

The farm was prepared for planting, land was dressed into sectors in the form of meadows each sector was divided into experimental units, each experimental unit 3 m² (2 x 1.5 m), Class A Buren seeds cultivar were obtained from the refrigerated stores, and taken from the quotient of the previous spring season 2019, Which is planted with grade E and stored at a temperature of 4 °C, it is one of the Dutch varieties produced by the Dutch company Agrico. The seeds were received 15 days before planting and placed in a shaded place at room temperature, for the purpose of stimulating the tubers to sprout. The tubers were selected with a size of 30-55 mm, and the experimental unit included two meadows, the length of a meadow was 2 m and a width 0.5 m between the meadows, the rate of 8 tubers for each line, the area for the experimental unit 3 square m².

Potato tubers were treated directly before planting with the preventive fungicide (Hexaconazole 5% SC) by submerging the tubers in a water basin containing the pesticide for 5 minutes. Then the seed potatoes were planted on 9/16/2019 on meadows with a depth of 10-15 cm in the middle of the meadow. The distance between one tubers was 0.25 m, at a rate of 16 tubers for each experimental unit. The research was carried out using a split-plot design according to a randomized complete block design (RCBD). The experiment included two factors. The first factor is the quality of irrigation water with two qualities (5.9 dS.m⁻¹) and (10 dS.m⁻¹) as a main factor and fertilizer combinations (Selenium, SiO₂-NPs and corn cobs compost) Sub-Plots and the following parameters are included.

- F1 comparison transaction without adding.
- F2 Selenium (Se) 30 mg. L⁻¹.
- F3- SiO₂-NPs. 50 mg. L⁻¹.
- F4 Selenium (Se) 30 mg. L⁻¹ + SiO₂-NPs 50 mg. L⁻¹.
- F5 corn cobs compost 20 tons. h⁻¹ + SiO₂-NPs 50 mg. L⁻¹.
- F6 corn cobs compost 20 tons. h⁻¹ + Selenium Se 30 mg. L⁻¹.
- F7 corn cobs compost 20 tons. h⁻¹ + Selenium Se 30 mg. L⁻¹ + SiO₂-NPs 50 mg. L⁻¹.
- F8 corn cobs compost 20 tons. h⁻¹.
The treatments were (16) treatments each one with three replications, the total of the experimental units were (48) units. The averages were compared to the least significant difference (L.S.D), at the level of 0.05%.

Study parameters: Plant height (cm), Number of Aerial stems, Plant⁻¹, chlorophyll content in leaves with SPAD units [7], Proline content in leaves, Leaf area of the plant (cm², Plant⁻¹), Dry matter in the leaves, Marketing tuber weight (g), Total yield of tubers (tons. H⁻¹), Proline content in leaves.

3. Results and discussion

Table (2) show that there are significant differences between the averages of study parameters, The treatments which irrigated with (5.9 dS.m⁻¹) achieved the highest rates, with a significant difference with level of (10 dS.m⁻¹) in plant height, number of aerial branches, leaf area, marketing yield, number of total tubers, and the differences did not reach a significant degree in the chlorophyll content and the percentage of dry matter in the leaves, proline content in leaves. This can be attributed to the fact that the high salinity in the soil leads to the accumulation of sodium ions, and then their accumulation in the plant, which affects the various vital functions of plants, especially the process of photosynthesis and respiration [8]. The decline in the studied growth indicators is the result of the high salinity of irrigation water may be attributed to the osmotic effect caused by the increase in soil salinity and leads to a lack of water absorption by the plant, which in turn leads to Lack of entry of nutrients, which is reflected negatively on the cellular metabolism and vital activities inside the cell and thus affects the activities of photosynthesis and respiration [9], and this is confirmed [2,10]. Salinity also increases the production of active oxygen radicals, ROS, which causes an imbalance in cellular metabolism and oxidation of some internal components of the cell components such as the cell wall. The negative effects of salinity are the accumulation of toxic ions, causing a decrease in the activity of meristematic tissues and inhibiting cell division and elongation [11,12], [13], also indicated that the increase in salt concentration exceeds the ability of cells to distribute the salts in the vacuoles, then they accumulate rapidly in the cytoplasm of the cell, and it leads to inhibition of enzyme activity and a decrease in plant metabolism, which results in a decrease in growth and production.

Table 2 is shown that all the additions in the experimental treatments achieved a significant difference with the comparison treatment, which recorded the lowest rates. The combination treatment F6 (corn cobs compost 20 tons. h⁻¹ + Selenium Se 30 mg. L⁻¹) achieved the highest rates in all the studied parameters and did not differ with some combinations significantly like F7 (corn cobs compost 20 tons. h⁻¹ + Selenium Se 30 mg. L⁻¹ + SiO₂-NPs 50 mg. L⁻¹). Treatment F6 (corn cobs compost + Se) was the highest rates of vegetative growth and the absorption of water and nutrients upon decomposition, in addition to that the organic matter improves soil properties and increases fertility, which leads to an increase in the activity of living organisms, which increases the readiness of nutrients, and this is reflected Positively for improving plant nutrition and increasing yield. And consistent with their findings [2].

Also, the treatment with selenium or silicon alone achieved significant differences compared with the control treatment in all the studied indicators, This confirms the vital role of selenium and silicon, collectively or separately, in improving plant growth under conditions of salt stress, and increases the plant's ability to abiotic and biotic stresses, may be attributed to the antioxidant effect of selenium (Se), which led to an increase in the growth of the plants treated with Se, selenium mechanism related to the decrease in lipid oxidation which coincides with the increase in the activity of Glutathione peroxidase GSH-PX [14,15]. While silicon stimulates plant photosynthesis by positively exposing leaves to light. On the other hand, it has been shown that the role of the large macro is in response to various abiotic and biotic stresses, [16], pointed out that silicon increases the activity of the antioxidant system, especially enzymes, and this is positively reflected in preserving vital processes such as photosynthesis from oxidation under conditions of salt stress, These results are consistent with what [6], found that the addition of silicon and selenium has improved the vegetative growth and yield of Rocket (Eruca sativa M.). And they indicated that the plant content of chlorophyll and proline increased when treated with silicon and selenium under abiotic stress conditions. Table 3 shown the overlap results between the water quality and combination treatments which indicated significant differences in all study parameters with the exception of dry weight percentage in leaves, All combination treatments to which fertilizers were added made a significant differences with the control treatment, and irrigated with both water qualities (5.9 dS.m⁻¹) and (10 dS.m⁻¹)
Table 2. shows the effect of irrigation water quality, combination treatments, on vegetative and quantitative parameters.

| Treatments     | Plant higher | Number of aerial stems | Leaf area of the plant | Chlorophyll content in leaves | The matter of dry in the leaves | Average marketing tuber weight | Total tubers | Proline content mg·g dry weight |
|----------------|--------------|------------------------|------------------------|-------------------------------|-------------------------------|--------------------------------|--------------|---------------------------------|
| W.Q1           | 35.16        | 4.037                  | 3588                   | 34.67                         | 13.201                        | 100.04                         | 23.558       | 2.752                           |
| W.Q2           | 30.26        | 2.696                  | 2719                   | 32.61                         | 12.333                        | 81.84                          | 20.898       | 2.920                           |
| L.S.D(0.05)    | 0.093        | 0.5171                 | 336.0                  | N.S                           | N.S                           | 6.257                          | 1.3040       | 0.0368                          |
| F1             | 27.41        | 2.250                  | 2280                   | 29.87                         | 10.767                        | 72.38                          | 15.303       | 2.400                           |
| F2             | 31.03        | 3.117                  | 2832                   | 31.65                         | 12.378                        | 78.80                          | 18.777       | 2.928                           |
| F3             | 31.50        | 3.300                  | 2874                   | 32.73                         | 12.230                        | 81.38                          | 19.313       | 3.164                           |
| F4             | 33.30        | 3.533                  | 3156                   | 33.68                         | 13.205                        | 81.36                          | 20.680       | 2.540                           |
| F5             | 34.68        | 3.383                  | 3276                   | 35.05                         | 13.152                        | 104.51                         | 23.302       | 2.949                           |
| F6             | 35.30        | 3.867                  | 3636                   | 37.13                         | 13.922                        | 109.53                         | 25.952       | 3.010                           |
| F7             | 33.97        | 3.8                    | 3641                   | 36.33                         | 13.700                        | 101.16                         | 24.532       | 3.197                           |
| F8             | 33.50        | 3.683                  | 3537                   | 33.22                         | 12.843                        | 97.88                          | 23.276       | 2.507                           |
| L.S.D(0.05)    | 1.094        | 0.3812                 | 213.4                  | 1.332                         | 0.8192                        | 1.921                          | 0.7019       | 0.1679                          |

Table 3. The effect of the overlap between irrigation water quality and fertilizer combinations on vegetative yield and quantity characteristics.

| Treatments     | Plant higher | Number of aerial stems | Leaf area of the plant | Chlorophyll content in leaves | The matter of dry in the leaves | Average marketing tuber weight | Total tubers | Proline content |
|----------------|--------------|------------------------|------------------------|-------------------------------|-------------------------------|--------------------------------|--------------|-----------------|
| W.Q1F1         | 28.43        | 2.4                    | 2510                   | 30.70                         | 10.857                        | 81.62                          | 17.003       | 2.250           |
| W.Q1F2         | 33.77        | 3.633                  | 3163                   | 31.97                         | 12.613                        | 86.35                          | 20.977       | 2.560           |
| W.Q1F3         | 34.73        | 4.1                    | 3407                   | 33.73                         | 12.697                        | 88.58                          | 21.200       | 3.291           |
| W.Q1F4         | 36.30        | 4.2                    | 3548                   | 35.27                         | 13.427                        | 85.58                          | 22.693       | 2.430           |
| W.Q1F5         | 37.40        | 4.033                  | 3577                   | 36.33                         | 13.207                        | 112.02                         | 25.547       | 3.148           |
| W.Q1F6         | 37.20        | 4.767                  | 4275                   | 38.37                         | 14.660                        | 119.16                         | 28.807       | 3.167           |
| W.Q1F7         | 35.07        | 4.633                  | 4180                   | 38.27                         | 14.877                        | 115.26                         | 26.790       | 2.857           |
| W.Q1F8         | 34.91        | 4.533                  | 4051                   | 32.77                         | 13.273                        | 111.98                         | 25.450       | 2.320           |
| W.Q2F1         | 26.40        | 2.1                    | 2050                   | 29.03                         | 10.553                        | 63.15                          | 15.097       | 2.550           |
| W.Q2F2         | 28.27        | 2.6                    | 2501                   | 31.33                         | 12.143                        | 71.25                          | 18.290       | 3.296           |
| W.Q2F3         | 28.27        | 2.5                    | 2341                   | 31.73                         | 11.763                        | 74.40                          | 19.123       | 3.037           |
| W.Q2F4         | 30.30        | 2.86                   | 2763                   | 32.10                         | 12.983                        | 78.16                          | 20.333       | 2.650           |
| W.Q2F5         | 31.97        | 2.733                  | 2976                   | 33.77                         | 13.097                        | 97.00                          | 22.743       | 2.750           |
| W.Q2F6         | 33.40        | 2.965                  | 2997                   | 35.90                         | 13.183                        | 99.91                          | 24.830       | 2.853           |
| W.Q2F7         | 32.87        | 2.96                   | 3102                   | 34.40                         | 12.523                        | 87.07                          | 23.737       | 3.537           |
| W.Q2F8         | 30.60        | 2.833                  | 3024                   | 32.67                         | 12.413                        | 83.79                          | 23.037       | 2.693           |
| L.S.D(0.05)    | 1.448        | 0.5655                 | 330.4                  | 2.026                         | N.S                           | 4.726                          | 1.0919       | 0.2226          |

Conclusions

1. The water (5.9 ds·m⁻¹) achieved significant differences in all the studied traits according to the region conditions. The combination treatment (corn cobs compost 20 tons. h⁻¹ + Selenium Se 30 mg. L⁻¹), was superior in most of the vegetative growth parameters and yield especially with water quality (10 ds·m⁻¹).
2. The use of selenium and silicon, individually or collectively in combination, led to a significant increase in all the studied parameters, compared to the control treatment.
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