Proceeding Paper

Effect of Humic Acid on Soil Properties and Productivity of Maize Irrigated with Saline Water †

Hassan Dergam * and Omar Abdulrazzak

The Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD), Damascus 96311, Syrian Arab Republic; omar354691@gmail.com
* Correspondence: hassandergam@hotmail.com
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Abstract: The aim of this search was to understand the effect of humic acid on soil properties and the growth and salinity tolerance of maize irrigated with saline water. The experiment was conducted in the Sabboura Research Station, Syria in 2019–2020. As treatments, humic acid was added to the soil at concentrations of 0, 1, and 2 g/L m², and the crop was irrigated using saline water with 0.5, 2, 4, and 6 ds/m salinity, measured by electrical conductivity (EC). The results showed that treatment with 2 ds/m irrigation water salinity and 2 g/L m² of humic acid achieved the highest fresh biomass production and plant height compared to the control and other treatments, while 4 ds/m irrigation water salinity and 0 g/L m² of humic acid gave the highest productivity measured by dry mass. In addition, the pH value increased up to 9.15 for the treatment with 6 ds/m irrigation water salinity and 2 g/L m² of humic acid, while the EC values increased with an increase in salinity in the irrigation water, and the highest value (2.59 ds/m) occurred in the treatment with 6 ds/m irrigation water salinity and 2 g/L m² of humic acid. The use of highly saline irrigation water (6 ds/m) led to an increase in EC and caused a noticeable decrease in plant height and fresh biomass accumulation in all treatments, indicating that maize cannot tolerate more than 6 ds/m irrigation water salinity.

Keywords: salinity; humic acid; maize; saline water; Sabboura

1. Introduction

The use of irrigation water with salinity below a threshold value is the key to meeting agricultural needs with economic and environmental sustainability [1]. Especially in the context of climate change, leading to increasing water demand for several purposes, freshwater needs to be used judiciously to preserve the soil, water, and climate [2–5]. At the same time, soil health is a key issue to consider for the long-term sustainability of crop production, especially in arid and saline drylands. The addition of organic matter or its extracts to the soil has a very important effect on the various physical, chemical, and biological properties of the soil, as it is an important source of many nutrients and an essential source of energy for soil organisms [5–9]. Some organic extracts (chelates) such as humic acid have a significant role in improving plant growth and increasing the efficiency of roots in absorbing water and dissolved nutrients, increasing the plant’s ability to tolerate salt stress, and improving various physical, chemical, and biological properties of the soil. Thus, this experiment was conducted to study the effect of humic acid with saline irrigation water application on soil properties, to determine their effect on the growth and productivity of maize, and to understand the maize plant’s tolerance for salinity.

2. Materials and Methods

The experiment was carried out in pots at ACSAD Research Center in Al-Saboura, Syria using a factorial randomized complete block design. Two factors, i.e., three levels of
irrigation water salinities, $A_0 = 0.5 \text{ ds/m}$, $A_1 = 2 \text{ ds/m}$, $A_2 = 4 \text{ ds/m}$, and $A_3 = 6 \text{ ds/m}$, and three rates of humic acid, $B_0 = 0 \text{ g/L} \cdot \text{m}^2$, $B_1 = 1 \text{ g/L} \cdot \text{m}^2$, and $B_2 = 2 \text{ g/L} \cdot \text{m}^2$ were applied as treatments. The data were analyzed as a factorial experiment and the significant differences were estimated using the F-test. The treatments’ mean separation was determined using the LSD test at the 5% level of significance for both main and interaction (A*B) effects.

3. Results and Discussion

Table 1 shows the measured results for the fresh weight, dry weight, and plant height. We found the superiority of all treatments with humic acid over the control treatment (No. 1) in producing fresh weight, whereas treatment No. 6 resulted in the highest production of vegetative mass.

Table 1. Fresh and dry weight and plant height as affected by the application at different rates.

| Treatment No. | Irrigation Water Salinity (ds/m) | Humic Acid Rates (g/L·m²) | Fresh Weight (g) | Increase Over Control % | Dry Weight (g) | Increase Over Control % | Plant Height (cm) | Increase Over Control % |
|---------------|---------------------------------|----------------------------|------------------|-------------------------|---------------|-------------------------|-------------------|-------------------------|
| 1             | 0.5                             | 0                          | 184              | 100                     | 43.18         | 100                     | 42.25             | 100                     |
| 2             | 0.5                             | 1                          | 305.66           | 166.77                  | 77.29         | 178.99                  | 70.5              | 166.86                  |
| 3             | 0.5                             | 2                          | 269.33           | 146.37                  | 74.43         | 172.37                  | 63.16             | 149.49                  |
| 4             | 2                               | 0                          | 308              | 167.88                  | 98.36         | 227.79                  | 65.75             | 155.62                  |
| 5             | 2                               | 1                          | 314.33           | 170.8                   | 86.84         | 201.11                  | 67.5              | 159.76                  |
| 6             | 2                               | 2                          | 335.6            | 182.42                  | 98.24         | 227.51                  | 74                | 175.14                  |
| 7             | 4                               | 0                          | 296.6            | 161.2                   | 111.77        | 258.84                  | 62                | 146.74                  |
| 8             | 4                               | 1                          | 251              | 136.41                  | 68.74         | 159.19                  | 58.75             | 139.05                  |
| 9             | 4                               | 2                          | 232              | 126.3                   | 57.7          | 133.76                  | 49                | 115.97                  |
| 10            | 6                               | 0                          | 240              | 130.43                  | 49.89         | 115.53                  | 60.75             | 143.78                  |
| 11            | 6                               | 1                          | 275              | 149.45                  | 105.88        | 245.20                  | 43.25             | 102.36                  |
| 12            | 6                               | 2                          | 201              | 109.23                  | 41.40         | 95.87                   | 42.55             | 100.7                   |
| LSD (5%) (A × B) |                          |                            | 12.3             |                         | 4.5           |                         | 3.6               |                         |

This was followed by the two treatments No. 5 and No. 4. Regarding the dry weights of plants, we note that the highest dry weight was recorded for plants with treatment No. 7, which amounted to 111.77 g per pot, compared to the control whose average dry weight did not exceed 43.18 g. Likewise, with regard to the average plant height, we find that treatment No. 6 resulted in the highest average height of plants (74 cm), with an increase over the height of the control plants of 75.14%. Humic acid has an important role in improving the physical, chemical, and biological properties of the soil as a store for many necessary nutrients for plant growth and has a role in maintaining the buffering capacity and improving the strength of plant growth [2,5,10,11].

In general, the differences were very significant between most of the treatments and the control, while we note that the use of water with high salinity (6 ds/m) led to a significant decrease in both the wet weight of the product and the height of the plant. The reason for this decrease is the negative impact of salts on plant growth, as well as the shortage of water absorbed as a result of osmotic stress [8–12].

Table 2 shows a decrease in the value of electrical conductivity with the use of non-saline water (0.5 ds/m) and an increase for the two treatments, i.e., 4 and 6 ds/m. The maximum value reached was in treatment No. 11, with a score of 2.597, compared to the control with a score of 0.255. Here, we note that in the treatment irrigated by water (0.5 ds/m), the value of the electrical conductivity decreased with an increase in the amount of humic acid used, with a value of 0.199 for treatment No. 3, compared to a value of 0.255 for treatment No. 1. The decreasing EC values are suspected to occur because humic acid exchanges H+ ions with soil Na+, so that the Na+ content decreases and the H+ levels...
increase, causing the soil EC to decrease \([2,5,10]\). From the table, we also note fluctuations in the values of organic matter, which decreased significantly in the humic acid treatments, regardless of the saline concentration of the irrigation water. \([5–8]\). We can also see that in the treatment irrigated by water (6 ds/m), the amount of organic matter remained close to the control in treatment No. 1, which is evidence of the effect of a high salt concentration on the activity of microorganisms, slowing down the decomposition of the organic matter. Regarding the changes in the concentration of elements N, P, and K, they were limited and to some extent correlated with the rate of organic decomposition and plant production.

Table 2. Soil chemical properties as affected by the application of different rates of humic acid and irrigation water salinity.

| Treatment No | Irrigation Water Salinity (ds/m) | Humic Acid Rates (g/L·m²) | pH (kcl) (1/5) | EC (ds/m) (1/5) | C-org (%) | OM (%) | N-NO₃ (mg/kg) | N (%) Total | P (mg/kg) | K (mg/kg) |
|--------------|----------------------------------|---------------------------|----------------|---------------|-----------|--------|--------------|------------|----------|----------|
| 1            | 0.5                              | 0                         | 8.50           | 0.255        | 0.508     | 0.876  | 11.50        | 0.057      | 7.85     | 314      |
| 2            | 0.5                              | 1                         | 8.59           | 0.214        | 0.536     | 0.924  | 5.13         | 0.082      | 7.60     | 312      |
| 3            | 0.5                              | 2                         | 8.37           | 0.199        | 0.438     | 0.755  | 5.70         | 0.053      | 6.03     | 308      |
| 4            | 2                                | 0                         | 8.80           | 0.537        | 0.464     | 0.800  | 3.26         | 0.055      | 7.73     | 297      |
| 5            | 2                                | 1                         | 8.76           | 0.675        | 0.431     | 0.743  | 5.03         | 0.063      | 5.90     | 288      |
| 6            | 2                                | 2                         | 8.83           | 0.858        | 0.417     | 0.719  | 5.13         | 0.068      | 5.90     | 285      |
| 7            | 4                                | 0                         | 8.78           | 1.597        | 0.483     | 0.833  | 5.96         | 0.059      | 5.56     | 306      |
| 8            | 4                                | 1                         | 8.88           | 1.861        | 0.457     | 0.788  | 7.10         | 0.083      | 6.40     | 311      |
| 9            | 4                                | 2                         | 8.95           | 1.258        | 0.411     | 0.709  | 14.7         | 0.069      | 5.90     | 322      |
| 10           | 6                                | 0                         | 9.04           | 1.989        | 0.588     | 1.014  | 14.8         | 0.070      | 7.80     | 355      |
| 11           | 6                                | 1                         | 8.94           | 2.597        | 0.582     | 1.003  | 13.4         | 0.074      | 7.80     | 386      |
| 12           | 6                                | 2                         | 9.15           | 1.758        | 0.598     | 1.031  | 11.35        | 0.075      | 6.40     | 387      |
| LSD (5%) (A × B) |                      |                            | 0.23           | 0.23          | n.s.    | 0.2   | 1.6          | n.s.      | 0.3      | 6.5      |

4. Conclusions

In conclusion, the results indicate that humic acid applications can improve growth, fresh and dry biomass accumulation, and plant height. A slight decrease in the EC value with an increase in the amount of humic acid was recorded. The amount of soil organic matter remained close to the control in treatments irrigated with highly saline water. This experiment shows the importance of using organic fertilizers in improving soil properties and increasing the tolerance of maize to salt stress when saline water is used for irrigation.

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