Role of Humic Acid and Chemical Fertilizer in NPK Concentration, Growth and Yield of Broccoli Under Salinity Conditions

Khaleel J. Al-Issawi¹, Kamal H. AL-Dulaimi² and Bassam A.A.H Alkhateb³

¹,²,³Department of Soil and Water Resource, College of Agriculture, University of Anbar, Iraq.

Email: khaleelalissawi@gmail.com

Abstract

A field experiment was conducted during the winter agricultural season 2020. To study the effect of humic acid and fertilizer recommendation, humic acid was supplied with irrigation water at two levels i.e., 0 and 0.25 gm L⁻¹. Nine levels of the fertilizer recommendation were applied according to the fertilizer recommendation of 92kg N.h⁻¹, 200 kg P.h⁻¹ and 150 kg K.h⁻¹ taking the symbols of F1 to F9. The results showed the superiority of the treatments of humic acid application (0.25 gm L⁻¹) in the traits of plant height, Weight of broccoli head, total yield, nitrogen, phosphorous and potassium concentrations, by giving 32.64 cm, 246.5 gm plant⁻¹, 8.215 tons ha⁻¹, 5.541%, 0.3816%, and 3.641% respectively, the treatment of adding chemical fertilizer at a level of 125% N + 125% P + % K 125 of the fertilizer recommendation (F2) gave the highest plant height of 36.60 cm, Weight of broccoli head of 269.2 g plant⁻¹, total yield of 8.972 tons H⁻¹, nitrogen concentration 5.817% and concentration Phosphorous 0.3141% compared to treatment F9, while treatment F5 gave the highest potassium concentration 3.893% compared to treatment F9 (1.914%).

Keywords: Humic Acid, NPK fertilizer, Broccoli.

1. Introduction

Broccoli (Brassica oleracea var. Italic) is a winter vegetable that belongs to Brassicaceae family. The growth and yield of broccoli are affected by many factors including the regional appropriateness of the hybrids. Broccoli is an excellent source of nutrients, including provitamin A (b-carotene), vitamin C (ascorbate) and vitamin E (tocopherol). It is also a source of phytochemicals associated with health benefits including Glucosinolate, carotenoids, tocopherols and flavonoids [1]. The agricultural land in central and southern Iraq regions suffer from soil salinity, the level of ground water may go down and the root zone may not get sufficient water when using improper agricultural methods [2], due to which the saline water’s level may increase. This in turn increases the dominance of a saline species resulting in the deterioration of chemical, physical and mineral soil properties and accordingly the fertility too [3,4].

Humic acid is one of the humic substances resulting from the decay of terrestrial plant and animal matter. Humic substances play an important role in soil fertility and crop production directly and indirectly. The indirect effects include soil fertility indicators, namely increasing the soil microbial population, enhancing the soil [5,6]. Moreover, increasing the cation exchange capacity (CEC) and regulating the buffering capacity of the pH soil. While the direct effects of humic substances may include the vital processes such as respiration, the rate of photosynthesis and, because it contains chemical compounds, which include phenols [7], amino acids and some hormones that stimulate plant growth, as well as it has great effect in increasing the availability of some soil nutrients under salt stress conditions [8], in the agriculture sector, humic acid is attaining popularity as low-cost organic fertilizer. Previous studies showed that humic acid plays crucial role in uptake of minerals such as N, P, K [9]. Macro nutrients play a crucial role in plant growth and development, where nitrogen stimulates vegetative growth [10], while phosphorus promotes healthy root development and also contributes by providing the energy through forming ATP and potassium play a vital for carbohydrate metabolism, enzyme activation and osmotic regulation [11,12].

Achieving the food security for the rapid population growth is a big challenge and can be accomplished by increasing crop productions, the use of inorganic fertilizers individually may cause an environmental problem such as soil acidification, eutrophication, nutrient losses, reduced biological diversity and increasing the greenhouse gas (GHG) emissions from agricultural farms [13,14], humic acid has important role in plant growth by promoting the bioavailability of nutrients through rectify the soil environment of the roots zone [15], therefore this study aimed to find out the role of humic acid and...
inorganic fertilizers in the availability of nitrogen, phosphorous, potassium, growth and yield of broccoli cultivated in saline soil.

2. Materials and Methods

A field experiment was carried out during winter season of 2020. Where five disturbed samples were randomly chosen from soil at depth (0-30cm) and the soil chemical and physical properties was measured according to [16], (Table 1). The field was divided into three blocks. A distance of 2 m was left between blocks, each block was divided into 18 experimental units, with dimensions of 3 x 2 meters (length and width respectively).

Two rows of broccoli were planted in each experimental unit (plot), where each plot included 16 plants. The distance between plants 40cm. The experiment was conducted based on a randomized complete block design with three replications. Humic acid was mixed with the used irrigation water at two levels, Symbols as follow: H0 without application (control treatment) and H1 received 0.25 g/l. The chemical fertilizer was applied according to the fertilizer recommendation of 92 kg N.h⁻¹, 200 kg P.h⁻¹ and 150 kg K. h⁻¹ [17], as the following:

- F1(100% N +100%P+100%K as for fertilizer recommendation).
- F2(125% N +125%P+125%K as for fertilizer recommendation).
- F3(125% N +125%P+100%K as for fertilizer recommendation).
- F4(125% N +125%P+75%K as for fertilizer recommendation).
- F5(100% N +100%P+125%K as for fertilizer recommendation).
- F6(100% N +100%P+75%K as for fertilizer recommendation).
- F7(75% N +75%P+125%K as for fertilizer recommendation).
- F8(75% N +75%P+100%K as for fertilizer recommendation).
- F9(75% N +75%P+75%K as for fertilizer recommendation).

Irrigation was performed at 40% depletion of available water content (AWC) using field Scout Soil Sensor Reader after being calibrated in the soil of the experiment.

2.1 Study parameters

Plant height (cm).

Head weight (g.plant⁻¹).

Total yield:

The yield obtained from randomly 10 plants and weighted (yield per plant divided by yield of 10 selected plants). The yield of each experimental unit (plot) was calculated using the following equation:

\[ \text{yield} = \text{yield per plant} \times \text{number of plants per plot} \]  \hspace{1cm} (1)

While the total yield was determined according to the equation:

\[ \text{Total yield} = \frac{\text{yield of plot} \times \text{hectare area}}{\text{plot area}} \]  \hspace{1cm} (2)

The volume of supplied water was calculated according to the equation:

\[ d = \left( \theta_{w.p} - \theta_{f.c} \right) dw D \]

Where:

- \( d \) is the depth of supplied water
- \( \theta_{f.c} \) soil volumetric water content at field capacity
- \( \theta_{w.p} \) soil volumetric water content at irrigation event (determined using Field Scout Soil Sensor Reader).
- \( Dw \) is soil moisture depletion.
- \( D \) depth of root(determined according to witness).

Nitrogen was estimated using the Kjeldahl method, while phosphorous was estimated by the method of ammonium molybdate at a wavelength of 820 nm, potassium was estimated using a flame photometer, according to the methods given in [18].
Table 1. Some Chemical and Physical properties before planting.

| Parameter                        | Value | Unit   |
|----------------------------------|-------|--------|
| pH                               | 7.60  | -      |
| Sodium Adsorption Ratio (SAR)    | 3.02  | -      |
| EC                               | 6.12  | dS.m⁻¹ |
| Organic matter                   | 1.50  | g.kg⁻¹ |
| Carbonates                       | 236   |        |
| Lime (CaCO₃)                     | 224   |        |
| Calcium sulfate (CaSO₄)           | 1.33  |        |
| Ca²⁺                              | 15    | Mmol.L⁻¹ |
| Mg²⁺                             | 16.31 |        |
| Na¹⁺                             | 17    |        |
| K⁺                               | 0.59  |        |
| SO₄²⁻                            | 26.10 |        |
| HCO₃⁻                             | 4.50  |        |
| Cl⁻                              | 22.50 |        |
| Nitrogen (N)                     | 110.30| mg.kg⁻¹ |
| Phosphorous (P)                  | 69    |        |
| Potassium (K)                    | 117.40|        |
| Exchange Capacity (CEC) Cation   | 16.65 | cmolc/kg |
| Soil Particles                    |       |        |
| Sand                             | 590   | g.kg⁻¹ |
| Silt                             | 120   |        |
| Clay                             | 290   |        |
| Soil Texture                     | Sandy clay loam |        |
| Bulk Density                     | 1.38  | Mg/m³  |

3. Results and Discussion

3.1 Plant height (cm)

There were significant effects of mineral fertilizers application and humic acid on the average height of broccoli plant (Table 2). The treatment of mineral fertilizers application F₂ (125% N + 125% P + % K 125 from the fertilizer recommendation) was characterized by achieved the highest average of plant height reached 36.6 cm compared to all levels of application with an increase of 35.6%. Humic acid application (H₁ with rate of 0.25 g. L⁻¹) was significantly achieved the best values of plant height reached 32.64 cm.

The effect of interaction between the mineral fertilizers and humic acid showed recorded significant effect F₂H₁ of plant height reached 38.60 cm, followed by the treatment of F₃H₁, which record 34.47 cm.
The role of humic acid and fertilizer recommendation in plant height (cm).

| Levels of humic acid | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F | Average |
|---------------------|----|----|----|----|----|----|----|----|----|----|---------|
| H0                  | 120.0 | 171.8 | 157.9 | 135.4 | 130.7 | 93.5 | 85.7 | 74.3 | 73.8 | 116.0 | 115.7 |
| H1                  | 230.0 | 366.5 | 348.7 | 302.3 | 247.2 | 193.9 | 184.7 | 176.8 | 165.1 | 246.5 | 234.6 |
| Average             | 176.7 | 269.2 | 253.3 | 218.9 | 189.0 | 143.7 | 135.2 | 125.6 | 119.5 | 245.5 | 237.1 |
| LSD(0.05)           | H = 6.47 | F = 13.73 | F = 19.42 x H |

3.2 Weight of broccoli head (g. plant⁻¹)

Table 3 showed that there were significant effects of mineral fertilizers application in the in the weight of head, where the treatment F₂ (125% N + 125% P + % K 125) achieved the highest values in the weight of head, which amounted 269.2 g plant⁻¹. The treatment of humic application H₁ (0.25 g L⁻¹) achieved significant superiority in the average of weight of head amounted 246.2 gm plant⁻¹. The interaction between mineral fertilizer and humic acid achieved the best values in the weight of head, the best treatment was F₂H₁ recorded 366.5 gm plant⁻¹.

| Levels of humic acid | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F | Average |
|---------------------|----|----|----|----|----|----|----|----|----|----|---------|
| H0                  | 120.0 | 171.8 | 157.9 | 135.4 | 130.7 | 93.5 | 85.7 | 74.3 | 73.8 | 116.0 | 115.7 |
| H1                  | 230.0 | 366.5 | 348.7 | 302.3 | 247.2 | 193.9 | 184.7 | 176.8 | 165.1 | 246.5 | 234.6 |
| Average             | 176.7 | 269.2 | 253.3 | 218.9 | 189.0 | 143.7 | 135.2 | 125.6 | 119.5 | 245.5 | 237.1 |
| LSD(0.05)           | H = 6.47 | F = 13.73 | F = 19.42 x H |

3.3 Total yield

Table 4 shows that the treatment F₂ (125% N + 125% P + % K 125 of the fertilizer recommendation) was significantly achieved the highest value of total yield of broccoli (ton ha⁻¹) reached 8.972 ton h⁻¹ compared to other levels of application. The treatment of humic application (H₁) 0.25 g. L⁻¹ recorded the highest average of total yield amounted to 8.215 tons ha⁻¹. Regarding the interaction effect of mineral fertilizer and humic acid, the treatment F₂H₁ achieved the highest average of total yield reached 12.21 tons ha⁻¹.

| Levels of humic acid | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F | Average |
|---------------------|----|----|----|----|----|----|----|----|----|----|---------|
| H0                  | 4.011 | 5.728 | 5.262 | 4.514 | 4.356 | 3.117 | 2.855 | 2.478 | 2.460 | 3.865 | 3.845 |
| H₁                  | 7.766 | 12.21 | 11.62 | 10.07 | 8.241 | 6.462 | 6.157 | 5.892 | 5.504 | 8.215 | 8.345 |
| Average             | 5.888 | 8.972 | 8.442 | 7.295 | 6.298 | 4.790 | 5.888 | 4.185 | 3.982 | 7.815 | 7.825 |
| LSD(0.05)           | H = 0.2158 | F = 0.4578 | F × H = 0.6475 |

The results of tables 2, 3 and 4 showed that the mineral fertilizers application led to a significant increase in all yield traits, probably due to the role of mineral fertilizers in terms of their rapid decomposition and release in the soil, which led to high availability, absorption by the plant, and the nutritional balance in the soil, consequently, increase the total vegetative part as a result of plant absorption of basic nutrients and the increase in the vital activities of the plant, which was positively reflected on the weight of the flower head, the height of the plant and the total yield of the plant, these findings are consistent with [19]. The increases occurred due to humic acid application attributed to the role of humic acid in increasing the availability of nitrogen for absorption by the plant. Consequently, gives the plant the ability to form a larger number of meristematic cells and increase their size, which is positively reflected on the vegetative growth of the plant resulting from the increased formation of proteins and nucleic acids [20]. Increasing the growth indicators due to humic acid application attributed to its effect on various vital processes such as respiration, photosynthesis and protein formation, as well as containing mineral compounds such as phenols and amino acids, and increases the absorption of nutrients in saline soils [21].

3.4 Nitrogen concentration in the fruits

The results of Table 5 show the significant effects of the mineral fertilizers application on the percent of nitrogen in the broccoli heads (%), the treatment F₂ (125% N + 125% P + % K 125) achieved the highest value of nitrogen percent in the broccoli heads, reached 5.81% , humic acid application (H₁) achieved the highest value of Nitrogen percent, reached 5.541% compared to the control treatment (H₀) which record 3.20% with an increase of 73.10%. The effect of the interaction
between the levels of mineral fertilizers and humic acid recorded significant effect of nitrogen percent in the broccoli heads, where the treatment $F_5H_9$ had the highest average nitrogen percent reached 7.333%, while the $F_4H_0$ treatment gave the lowest percent of nitrogen in the broccoli heads amounted to 2.267%.

### Table 5. Role of humic acid and fertilizer recommendation in the concentration of nitrogen in the fruits (%).

| Levels of Humic Acid | Levels of mineral fertilizers | Average |
|----------------------|--------------------------------|---------|
| $H_0$                | $F_1$ $F_2$ $F_3$ $F_4$ $F_5$ $F_6$ $F_7$ $F_8$ $F_9$ | 3.307 4.300 4.200 3.800 3.200 3.000 2.333 2.400 2.267 3.201 |
| $H_1$                | $F_1$ $F_2$ $F_3$ $F_4$ $F_5$ $F_6$ $F_7$ $F_8$ $F_9$ | 5.733 7.333 7.033 6.767 5.533 5.500 4.133 4.033 3.800 5.541 |
| Average              | $H = 0.0961$ $F = 0.2039$ | 4.520 5.817 5.617 5.283 4.367 4.250 3.233 3.217 3.033 |
| LSD(0.05)            | $F \times H = 0.2884$ |  |

#### 3.5 Phosphorous concentration in the fruits

Table 6 indicated that humic acid and mineral fertilizers recorded significant effect on the phosphorous percent in the broccoli heads (%), where the treatment $F_5$ (100% N + 100% P + 125% K) achieved the highest values of phosphorous percent in the broccoli heads reached 0.3143% which did not differ significantly from the treatments $F_1$, $F_3$, $F_5$, $F_6$, $F_7$, $F_8$ and $F_9$. However, the treatment $F_2$ significantly differ from the treatment $F_9$.

The treatment of humic acid application ($H_1$ 0.25 g. L$^{-1}$) achieved the heist value of phosphorous percent of broccoli heads, which amounted to 0.3816%.

The interaction between mineral fertilizers and humic acid achieved significant differences of phosphorous percent in broccoli heads. Where the treatment $F_5H_1$ recorded the highest value of phosphorous in the broccoli heads reached 0.4460%.

### Table 6. Role of humic acid and fertilizer recommendation in phosphorous concentration in the fruits (%).

| Levels of Humic Acid | Levels of mineral fertilizers | Average |
|----------------------|--------------------------------|---------|
| $H_0$                | $F_1$ $F_2$ $F_3$ $F_4$ $F_5$ $F_6$ $F_7$ $F_8$ $F_9$ | 0.1333 0.1933 0.1900 0.1733 0.1450 0.1430 0.1153 0.1040 0.1153 0.1459 |
| $H_1$                | $F_1$ $F_2$ $F_3$ $F_4$ $F_5$ $F_6$ $F_7$ $F_8$ $F_9$ | 0.3897 0.4353 0.4113 0.4083 0.4107 0.3607 0.2820 0.4460 0.2877 0.3816 |
| Average              | $H = 0.03869$ $F = n.s$ | 0.2615 0.3143 0.3007 0.2908 0.2778 0.2530 0.1987 0.2750 0.2015 |
| LSD(0.05)            | $F \times H = n.s$ |  |

#### 3.6 Potassium concentration in the fruits (%)

Table 7 indicated that there significant effects of the treatments of humic acid and mineral fertilizers on the potassium percent of broccoli heads (%), where treatment $F_5$ (100% N + 100% P + 125% K) achieved the highest value of potassium percent in broccoli heads reached 3.893%. Humic acid with treatment of $H_1$ (0.25 g. L$^{-1}$) achieved highest value in the potassium percent of broccoli heads, reached 3.641% with an increase of 161.54% compared to the treatment of $H_0$ (control). The treatment $F_5H_1$ achieved the highest potassium percent of broccoli heads reached 4.747%.

### Table 7. Role of humic acid and the fertilizer recommendation in potassium concentration in the fruits (%).

| Levels of Humic Acid | Levels of mineral fertilizers | Average |
|----------------------|--------------------------------|---------|
| $H_0$                | $F_1$ $F_2$ $F_3$ $F_4$ $F_5$ $F_6$ $F_7$ $F_8$ $F_9$ | 1.147 2.520 1.476 1.360 3.249 2.375 2.459 1.769 1.399 1.973 |
| $H_1$                | $F_1$ $F_2$ $F_3$ $F_4$ $F_5$ $F_6$ $F_7$ $F_8$ $F_9$ | 3.565 4.747 3.753 3.226 4.537 3.078 4.437 2.997 2.430 3.641 |
| Average              | $H = 0.1538$ $F = 0.3263$ | 2.356 3.633 2.615 2.293 3.893 2.726 3.448 2.383 1.914 |
| LSD(0.05)            | $F \times H = 0.4615$ |  |

The obtained results indicate increasing in the percentage of nitrogen in the heads with increasing the level of the mineral fertilizers application probably due to the fact that the mineral fertilization increased vegetative growth and thus increased the process of absorption and accumulation of elements in the tissues of the broccoli plant. Also, the superiority of the $F_2$ fertilizer treatment in the proportion of potassium in the heads was due to the nitrogen application, which caused an improvement in plant growth and root distributed and branching, which led to the absorption of a greater amount of potassium, this result is consistent with [22]. Also the increased of phosphorous percent of heads as a result of phosphate fertilizers application, which led to an increase in the phosphorous content in the soil, and leads to an increase the phosphor amount in the plant [23]. The results of the showed that mineral fertilizer $F_2$ treatment (125% N + 125% P + 125% K), Where the high level of mineral fertilizer stimulate the plant growth and biological activity in the plant.

The addition of organic fertilizer (Humic acid) might stimulate the production of auxin, which encouraged the process of cell division and elongation to perform various vital activities. The increase in the concentrations of the nutrients nitrogen, phosphorous and potassium when supplying the humic acid to broccoli, which reflects positively on the growth of the crop.
In addition, humic acid contains nitrogen and some other compounds and increases the availability of nutrients that contribute to increasing the vegetative growth of the plant and reducing the negative effects of salinity.

Conclusion

the addition of humic acid at a concentration of 0.25 g l^{-1} and The treatment of mineral fertilization F₂ improved the growth characteristics and yield of broccoli, where it achieved the highest plant height, Weight of broccoli heads (g, plant^{-1}), total yield, nitrogen, phosphorous and potassium. while the interaction treatments between humic acid and mineral fertilizer F₂H₁ achieved the highest values in growth and yield of study parameters.

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