Response Broccoli to Chemical Fertilizers and Zinc Sulfate Spraying on Growth and Yield

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Abstract. Field experiment was conducted in the vegetable field / Department of Horticulture and Landscape / College of Agriculture and Forestry / University of Mosul during 2019-2020 agricultural season to study the effect of two factors. First: Spraying with zinc sulfate at a concentration of 300 mg. L⁻¹ and without spraying (control). Second factor: Four levels of chemical fertilizer N15P15K15 (0, 150, 300 and 450) kg. ha⁻¹ on broccoli plants Hot Bro variety. The experiment conducted in a Split–plot system arranged in Randomized Complete Block Design (RCBD). Main plots included fertilization levels while sub plots included zinc spraying treatments. The results can be summarized as follows: The zinc spraying and level 450 kg. ha⁻¹ fertilization kg. ha⁻¹ was significantly superior in the plant height, number of leaves per plant, leaf area, circumference and weight of head, number of lateral heads, plant yield and total yield of heads, as compared to control treatment. The interaction between 450 kg. ha⁻¹ of NPK chemical fertilizer and zinc spraying was superior in all above studied traits.

1. Introduction:
Broccoli is an important vegetable crop that belongs to the Brassicaceae family, which is sparsely planted in Iraq. It has a high nutritional value, as it contains many 1- mineral elements 2- vitamins 3- protein 4-beta-carotene5- niacin 6-fulvic acid and is low in 1- free fats 2- sodium 3- calories [1]. It is considered a powerful regulator and antibiotic for many common diseases, as it lowers high blood pressure, helps to regulate blood sugar, build bones, protect against heart disease, urinary and reproductive diseases, reduce cancer, reduce the level of cholesterol in the blood, and is a rich source of Glucosinolates that have been shown to reduce disease cancer as well as helps prevent retinal diseases [2]. Chemical fertilizers have an effective and important role in plant growth and increase yield due to the speed of decomposition, readiness and absorption by the plant and their effect on vegetative growth and yield compared to organic fertilizers [3]. [4] reported that fertilizing broccoli plants with chemical fertilizer 42.7 kg N (urea), 317 kg P₂O₅, and 269 kg K₂O per hectare caused a significant increase in the number of leaves.Plant⁻¹, weight and yield of head compared to control treatment. [5] were found a significant increase in the weight of head and total yield when adding N₂₅P₂O₅K₂O at 300 kg.ha⁻¹ level. [6] found that fertilizing broccoli with different sources of nitrogen fertilizers significantly increased plant height, number of leaves per plant, leaf area, head circumference, head weight, and total head yield. [7] indicated that broccoli plants were fertilized with NPK 300 kg. ha⁻¹, caused a significant in the circumference of the head.

Micro-nutrients such as zinc are of no less importance than macronutrients such as N, P and K, because zinc is an important and essential nutrient for plant growth and is involved in many vital processes such as stimulating oxidative processes in plant cells and is necessary in
the formation of the amino acid tryptophan which consists of auxin IAA. Deficiency of zinc component leads to decreased stem elongation, lower auxin activity, and low levels of the amino acid [8]. Iraqi soils have a more than 7 pH and have a low content of organic matter, this leads to a reduction in the readiness of the micro-nutrients, including zinc in the soil solution, so foliar spraying with zinc is the effective way to treat the deficiency of this element. [9] note that the addition of zinc sulfate at levels 20 and 30 kg.ha⁻¹ of cauliflower plants caused a significant increase in the number of leaves per plant and the yield of head. [10] indicated that spraying broccoli plants with zinc at a concentration of 1% gave highest significant value in the number of lateral head. [11] found when adding zinc at a rate of 2.5 kg.ha⁻¹ of broccoli plants resulted a significant increase in the weight of the head. [12] reported when adding zinc at levels 0, 10, 20 and 30 kg.ha⁻¹ on broccoli plants, level of 30 kg. Ha⁻¹ caused a significant increase in the weight of the head and the total yield of the head. [13 a] observed that broccoli plants which sprayed with zinc sulfate at a concentration of 300 mg.L⁻¹ led to a significant increase in the number of leaves.plant⁻¹ and leaf area. [14 b] found that spraying broccoli plants with zinc sulfate at a concentration of 300 mg.L⁻¹ cause significant increase in the head circumference and the number of lateral heads and the percentage of dry matter in the main head.

The aim of study: to find the best levels of zinc sulfate and compound fertilizer N₁₅P₁₅K₁₅ and show interaction effect between them on some growth and yield characteristics of broccoli plants.

2. Materials and Methods:
This study was carried out at vegetables field of Horticulture and landscape department, College of Agriculture and Forestry, Mosul University, Iraq., during 2019-2020 agricultural season to study the effect of compound chemical fertilizers N₁₅P₁₅K₁₅ and zinc sulfate spraying on growth and yield of broccoli. Land of experiment was divided into experimental units which included 3 ridges of 1.2 m length and 0.75 m width per experimental unit. according to the need of the plant. Hot bro cultivar of broccoli seeds were planted in terraces using peat moss on 26/8/2019, and after the seedlings reached the stage of 3-5 real leaves, they were transferred to the field on 6/10/2019 and planted on distance between seedling and others 0.4 m, and after two weeks the patching process was performed for the failed seedlings. The number of plants in the experimental unit 10 plants. Drip irrigation system in the experiment used.

The following factors were studied in the experiment:

The first factor: adding the NPK 15-15-15 compound chemical fertilizer at four levels:
1- Without fertilizer (control).
2- 150 Kg.ha⁻¹ of N₁₅P₁₅K₁₅
3- 300 Kg.ha⁻¹ of N₁₅P₁₅K₁₅
4- 450 Kg.ha⁻¹ of N₁₅P₁₅K₁₅

The compound chemical fertilizer was added to soil once before planting the seedlings while preparing the soil for planting.

The second factor: spraying plants with 100 ml per plant of zinc sulfate at concentrations:
1- 0 mg. L⁻¹.
2- 300 mg. L⁻¹.

Plants were sprayed with zinc sulfate in two batches, the first after a month of transplanting and the second after a month from the first. The experiment conducted in a Split – plot system arranged in Randomized Complete Block Design (RCBD). Main plots included fertilization levels while sub plots included zinc spraying treatments. After the plants reached the reaping stage, and on 26/1/2020, the main head were harvested for all treatments, and after a month, the lateral heads were harvested. Statistical analysis was conducted using [15]. Analysis of variance and Duncan’s multiple range test at 0.05 were applied for all research data [16].

2.1 Studied Traits
1- Number of leaves (leaf. Plant⁻¹).
2- Leaf area of the plant (cm². Plants⁻¹): Three plants were taken randomly from each experimental unit and separated all the leaves and then take 10 tablets with an area of 1 cm² per disk of 10 sheets and then dried discs and leaves in an oven at 68 degrees - 70 °C and for weight stability and then calculated the leaf area of the plant proportionally on the basis of dry weight of tablets and leaves. [17].
3- Head circumference (cm).
4- Weight of the main head(g).
5- Number of lateral heads.
6- Yield of one plant (main head + lateral heads).
7- Total yield of heads (ton. ha⁻¹).
8- The percentage of dry matter in the main head.

3. Results and Discussion:
It is noted from the results of Table 1 that the treatment of spraying with zinc at a concentration of 300 mg. L⁻¹ was significant on plant height, number of leaves, leaf area and head circumference. The values were 38.44 cm and 15.36 leaves. Plant⁻¹ and 3577 cm². Plant⁻¹ and 35.94 cm respectively compared to a treatment without zinc spray. 450 kg. ha⁻¹ treatment of N15P15K15 fertilization showed significant superior in all characteristics above compared to other treatments which gives 41.07 cm, 15.78 leaves. Plant⁻¹, 4245 cm².Plant⁻¹ and 37.45 cm respectively, the comparison treatment (without fertilization) gave the lowest values in these traits.

Table (1) Effect of zinc sulfate spraying and chemical fertilization on some traits of broccoli plant.

| Zinc sulfate (mg.L⁻¹) | Plant height (cm) | No. of leaves (leaf.plant⁻¹) | Leaf area (cm².plant⁻¹) | Head circumference(cm) |
|-----------------------|-------------------|-----------------------------|------------------------|------------------------|
| 0                     | 36.20 b           | 13.89 b                     | 3089 b                 | 30.62 b                |
| 300                   | 38.44 a           | 15.36 a                     | 3577 a                 | 35.94 a                |
| N15P15K15 (kg. ha⁻¹):|                   |                             |                        |                        |
| Control (0)           | 32.53 c           | 13.39 c                     | 2407 d                 | 28.31 d                |
| 150                   | 37.22 b           | 14.39 b                     | 3128 c                 | 32.47 c                |
| 300                   | 38.45 b           | 14.94 b                     | 3551 b                 | 34.90 b                |
| 450                   | 41.07 a           | 15.78 a                     | 4245 a                 | 37.45 a                |

N15P15K15: 300 kg. ha⁻¹.

The results of Table 2 illustrate the interaction between the two treatments of spraying with zinc and chemical fertilization N15P15K15. It is noticed that spraying with zinc at a concentration of 300 mg.L⁻¹ with fertilization at level of 450 kg. ha⁻¹ gave the highest significant values in all traits so it was significantly different with most treatments.

Table (2) Effect of introduction between zinc sulfate spraying and chemical fertilization on some vegetative traits of broccoli plant.

| Zinc sulfate (mg.L⁻¹) | N15P15K15 (kg. ha⁻¹) | Plant height (cm) | No. of leaves (leaf.plant⁻¹) | Leaf area (cm².plant⁻¹) | Head circumference(cm) |
|-----------------------|----------------------|-------------------|-----------------------------|------------------------|------------------------|
| Control               | 31.26 d              | 12.56 e           | 2294 f                      | 23.83 d                |
| 150                   | 36.56 bc             | 13.56 d           | 2853 ed                     | 30.22 c                |
| 300                   | 37.69 b              | 14.33 c           | 3181 cd                     | 32.58 bc               |
| Control               | 39.29 ab             | 15.11 b           | 4028 ab                     | 35.86 ab               |
| 150                   | 33.81 c              | 14.22 c           | 2520 ef                     | 32.30 bc               |
| 300                   | 37.89 b              | 15.22 b           | 3403 f                      | 34.72 abc              |
| 450                   | 39.21 ab             | 15.56 b           | 3922 b                      | 37.22 ab               |
| Control               | 42.86 a              | 16.45 a           | 4463 a                      | 39.05 a                |

The results of Table 3 show that spraying with zinc at a concentration of 300 mg.L⁻¹ gave the highest significant values in the weight of the main head, lateral heads number, yield of one
plant and the total yield of the main heads the percentage of increase in these characteristics was 36.74%, 91.86%, 56.78% and 57.41%, respectively compared to treatment without zinc spraying. N15P15K15 at 450 kg. ha⁻¹ gave the highest significant values in above characteristics with an increase of 71.12% in the weight of main head, 220.19% in the number of lateral heads, 129.74% in the plant yield, and 130.74% in the total yield of main heads as compared to the comparison treatment.

Table (3) Effect of zinc sulfate spraying and chemical fertilization on some yield traits of broccoli plant.

| Zinc sulfate (mg.L⁻¹) | Main head weight (gm) | No. of lateral (heads. plant⁻¹) | Plant yield (gm. plant⁻¹) | Total yield (ton. ha⁻¹) |
|----------------------|----------------------|---------------------------------|--------------------------|------------------------|
| 0                    | 166 b                | 2.93 b                          | 199 b                    | 8.278 b                |
| 300                  | 227 a                | 5.66 a                          | 312 a                    | 13.031 a               |
| N15P15K15 (kg. ha⁻¹): |                      |                                 |                          |                        |
| Control (0)          | 142 d                | 2.08 d                          | 158 d                    | 6.558 d                |
| 150                  | 182 c                | 3.58 c                          | 221 c                    | 9.225 c                |
| 300                  | 207 b                | 4.91 b                          | 280 b                    | 11.705 b               |
| 450                  | 243 a                | 6.66 a                          | 363 a                    | 15.132 a               |

a, b, c: means in the same rows with different superscripts differ significantly at probability value 0.01 and 0.05.

The results of Table 4 illustrate the interaction between spraying with zinc and fertilizing with N15P15K15. It is noted that spraying with zinc at a concentration of 300 mg.L⁻¹ with fertilization of 450 kg.ha⁻¹ gave the highest significant values in main head weight of 280 g and the number of lateral heads was 9.16 per Plant, plant yield 422 g, and total 17.604 ton.ha⁻¹ and significant difference with all treatments except for treatment without zinc spraying with fertilization of 450 kg.ha⁻¹ in the weight of main head, and the lowest values in these characteristics were found in the treatment without zinc spraying in comparison plants.

Table (4) Effect of introduction between zinc sulfate spraying and chemical fertilization on some vegetative traits of broccoli plant.

| Zinc sulfate (mg.L⁻¹) | N15P15K15 (kg. ha⁻¹) | Main head weight (gm) | No. of lateral (heads. plant⁻¹) | Plant yield (gm. plant⁻¹) | Total yield (ton. ha⁻¹) |
|----------------------|----------------------|----------------------|---------------------------------|--------------------------|------------------------|
| 0                    | Control 94 d         | 1.33 f               | 100 f                           | 4.160 f                  |
| 150                  | 153 cd               | 2.83 e               | 171 e                           | 7.116 e                  |
| 300                  | 185 bc               | 3.50 d               | 220 ed                          | 9.177 ed                 |
| 450                  | 231 ab               | 4.16 c               | 304 bc                          | 12.661 bc                |
| Control 190 bc       | 2.83 e               | 215 e                | 8.956 e                         |
| 300                  | 181 bc               | 4.33 c               | 272 cd                          | 11.334 cd                |
| 450                  | 229 ab               | 6.33 b               | 341 b                           | 14.233 b                 |
| 280 a                | 9.16 a               | 422 a                | 17.604 a                        |

a, b, c: means in the same rows with different superscripts differ significantly at probability value 0.01 and 0.05.

The significant superiority as a result of spraying zinc sulfate in the studied characteristics may be due to the fact that sulfur and zinc are among the nutrients that the plant needs for growth. Zinc is one of the elements that work on the transfer of active substances in the plant such as sugars from the manufacturing areas to the areas of consumption Sinks which work to elongate cells, It is also included in the formation of the amino acid tryptophan which acts on the formation of the IAA hormone and also works to stimulate the enzyme carbonic anhydrase and cytochrome and thus elongate cells [18] and the increased leaf area as a result of increasing the number of leaves per plant (Table 1). The reason for the significant superiority as a result of spraying with zinc sulfate in the yield and its components is due to its superiority in the vegetative growth characteristics represented by plant height, number of leaves and leaf area (Table 1), which caused an increase in the manufacture of carbohydrate materials as a result of the photosynthesis process and thus the accumulation of these substances in the plant, which caused an increase in the circumference and weight of main head, plant yield, and total yield of main heads (Table 3). These are consistent with what [19]
report on broccoli. The significant superiority as a result of adding the N\textsubscript{15}P\textsubscript{15}K\textsubscript{15} fertilizer may be due to the availability of the necessary nutrients in the fertilizer added to the soil, their absorption by the roots, their transfer to the vegetative system and their exploitation in the biological and physiological processes inside the plant such as photosynthesis, respiration, and the processes involved in the synthesis of the necessary nucleic acids in cell and tissue division [20] as the nitrogen component has an important role in encouraging the process of cell division and elongation of cells [21] and then increasing the height of the plant, which has a positive effect on increasing the number of leaves and leaf area in the plant (Table 1). Also, phosphorous has an important role in plant growth as it contributes to the formation of energy-rich compounds that the plant needs to form other compounds such as phospholipids, carbohydrates and enzymatic compounds that contribute to activating the vital activities of the plant, which leads to an increase in vegetative growth as the increase in plant height may be attributed to the role the significant role played by this element in plant growth, Potassium also has an important role in photosynthesis by activating the enzymes associated with the process of energy transfer and building (ATP) the main energy carrier inside the plant [22] and it also speeds up the transfer of all manufactured materials to the storage sites in addition to its important role by effective in dividing and elongating cells and then increasing vegetative growth, as increasing the nitrogen and potassium content in the plant has an effect on improving the vegetative growth characteristics, plant height, number of leaves and leaf area (Table 1). The increase in the yield components may be due to the increase in the vegetative growth indicators represented by the plant height, number of leaves and leaf area (Table 1), which was positively reflected in the increase in the outcome indicators (Table 3).

4. Conclusion

Spray zinc sulfate at a concentration of 300 mg.L\textsuperscript{-1} and chemical fertilization N\textsubscript{15}P\textsubscript{15}K\textsubscript{15} at 450 kg. Ha\textsuperscript{-1} level caused a significant increase in all studied traits.

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