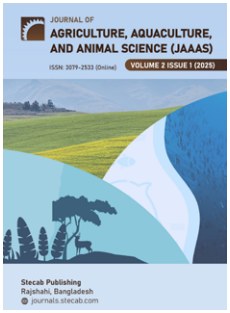

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Research Article

Growth Response of Two Broccoli Varieties to Zinc Sulfate Spray and Potassium Sulfate Soil Application

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About Article

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ABSTRACT

The experiment was carried out in the Mosul Forest Area field of the College of Agriculture and Forestry, University of Mosul, during autumn 2024 and winter 2025, to study the response of the vegetative growth characteristics of two varieties of broccoli (Naxos, Blue Finn) to the effect of three concentrations of zinc sulfate (0, 500,750 mg.L^{-1}) and three levels of potassium sulfate (0,200,400 ton.h^{-1}).The experiment was carried out in the field using a factorial experiment within split plots in the design of complete random segments (RCBD) with three replicates, where the varieties were placed in the main plots and the compatibility between the fertilization treatments by zinc and potassium sulfate in the secondary plots (Sub plots) was repeated for each treatment three times. The study showed that plants of the Blue Finn variety achieved the highest leaf chlorophyll content when sprayed with 750 mg. $liter^{-1}$ of zinc sulphate and add 200 ton.h^{-1} potassium sulfate reached 8.8467 mg. ml^{-1} suspension, and the highest plant height reached 78.893 cm.$plant^{-1}$ when sprayed with zinc sulphate at a concentration of 750 mg.L^{-1} and adding potassium sulfate at the level of 200 ton.h^{-1} highest number of leaves with 21.997 leave.$Plant^{-1}$ When not spraying zinc sulphate and adding 200 ton.h^{-1} Potassium sulphate The highest significant value of the foliar area reached 48179 cm^2.$Plant^{-1}$ when not spraying zinc sulphate and adding 400 ton. h^{-1} of potassium sulfate. Plants of the Naxos variety achieved the highest percentage of dry matter in the leaves when sprayed with 750 mg $liter^{-1}$ of zinc sulphate and 400 ton.h^{-1} of potassium sulphate amounted to 14.4533%.

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1. INTRODUCTION

Broccoli (*Brassica oleracea* var.italica) Broccoli, which belongs to the Brassicacea family, to which a large number of winter vegetable crops belong (Hassn, 2003). The broccoli plant is considered to have a high economic value in all governorates of Iraq due to its high prices, due to its limited productivity locally, in addition to the economic value of this crop, as it is the richest crop of the Cruciferous family in terms of the nutrients included in its composition and the most widely used in terms of Indication in many countries of the world as it contains vitamins (A, B1, B2, B5, B6, B17,E) and fiber, and contains calcium, manganese, zinc, and Iron. It also contains carotene, which turns into vitamin A in the human body (Thapa *et al.*, 2016) and prevents breast and colon cancer, and also enhances liver function (Nilaratanakul *et al.*, 2020).

2. LITERATURE REVIEW

Zinc is one of the micronutrients that is necessary for plant growth, as it is needed in small quantities and for its important role in many physiological plant processes such as protein and sugar synthesis, growth regulation, and photosynthesis. If it is not available or lacking, it hinders the functioning of these pathways, which negatively affects plant productivity, low yield and poor productivity (Alloway, 2008) Among its functions is that it helps in the process of photosynthesis, converting sugar into starch, resists vital stresses, reduces cell oxidation, and helps in the manufacture of the amino acid tryptophan, which contributes to the formation of indole acetic acid, which is important in cell elongation and is also involved in the processes of biological functions of cell membranes. Potassium is one of the main elements that plants need in relatively large quantities due to its important role in many vital physiological processes and stimulating many enzymatic reactions in the plant. It regulates the process of water absorption and opening and closing stomata, thus increasing the efficiency of water absorption and increasing the thickness of cell walls, which increases the tolerance of plants. Different environmental stresses and acts as a catalyst in the process of transferring nutrients from the roots to the upper parts of the plant or transporting them to grains or fruits (Ali *et al.*, 2014), Acknowledgments to the progress of plant breeding, it was possible to develop varieties that combine a set of good traits in one variety to suit their cultivation in a specific region.

3. METHODOLOGY

The experiment was carried out in the field of the Mosul Forest Area, affiliated with the College of Agriculture and Forestry, University of Mosul, during the Autumn 2024 and winter 2025 seasons. Seeds of two types of broccoli were used in the experiment, the first Blue Finn produced by KNOWN-YOU from Taiwan, the second Naxos produced by SOKATA from Chile, and three concentrations of sulfate. Zinc (0, 500, 750 $mg.L^{-1}$) and three levels of potassium sulfate (0,200,400 $ton.h^{-1}$), DAP fertilizer (18% nitrogen and 46% phosphorus) was added at a rate of 400 $kg.h^{-1}$, while urea fertilizer (46% nitrogen) was added at a rate of 200 $kg.h^{-1}$ is a complementary source of nitrogen and potassium sulfate (48%) Potassium) at the special addition rates for this agent used in the experiment. Potassium sulfate fertilizer was added at once after 14 days of seedling. According to the levels used in the experiment, fertilizers were added to the soil at the rate of one batch of DAP fertilizer 20 days after seedling and two batches of urea, the first 20 days after seedling and the second. At the beginning of the formation of heads (Muttalib *et al.*, 1989). The experiment was carried out in the field using a factorial experiment within split plots, and each treatment was repeated three times. The seeds were planted in plastic dishes containing 50 eyes using house moss as a planting medium on 1/8, and the dishes were placed in a seedling preparation house covered with saran Green, and after the seedlings reached the stage of three-four true leaves, they were sown in the morning in the permanent field on 20/8 With complete care, while keeping the house moss around the roots during seedling and maintaining soil moisture, the plants were treated with zinc sulphate during three stages of plant growth: the first two weeks after seedling, the second and third stages with an interval of 15 days between one addition and another. As for potassium sulphate, it was added all at once after seedling.14 days as a result of the overlap between the levels of the factors studied, the number of treatments reached 18 (3×3×2). The statistical analysis of the results was adopted according to the design used using the SAS system (2017) and the averages were compared using the Duncan polynomial test at a probability level of ≤ 0.05 (Al-Rawi & Khalafallah, 2000).

Characteristics studied:

i. Total chlorophyll content of leaves (mg ml^{-1} suspension)
ii. Plant height ($cm.Plant^{-1}$)
iii. Number of leaves ($leaf.Plant^{-1}$)
iv. Total leaf area of the plant (cm^2. $Plant^{-1}$)
v. Percentage of dry matter in the leaves

4. RESULTS AND DISCUSSION

4.1. Total chlorophyll content of leaves ($mg.ml^{-1}$ .suspension)

Table 1. The effect of zinc sulfate, potassium, and varieties and the overlap between them in the leaves content of total chlorophyll (mg ml^{-1} suspension)

Zinc sulphate concentrations ($mg. L^{-1}$)	potassium sulphate concentrations ($ton.h^{-1}$)	Verities		Zinc sulphate × potassium sulphate	Average Effect of Zinc sulphate
		Naxos	Blue Finn		
0	0	53.100 ef	6.3333 c-e	5.8217 b c	6.1339 b
	200	6.8467 b- e	7.7500 a-c	7.2983 a	
	400	3.0767 g	7.4867 a-d	5.2817 c	

500	0	3.0067 g	8.7267 a	5.8667 b c	6.5494 b
	200	5.3000 e f	8.2700 a b	6.7850 a b	
	400	6.0633 d e	7.9300 a-c	6.9967 a	
750	0	4.2800 f g	6.8300 b-e	5.5550 c	6.8639 a
	200	6.9500 b-e	8.846 7 a	7.8983 a	
	400	6.6667 b-e	7.6100 a-d	7.1382 a	
zinc sulphate X varieties	0	5.0778 d	7. 1900 b	Average effect of Potassium sulphate	
	500	4.7900 d	8. 3089 a		
	750	5.9656 c	7. 7622 a b		
Potassium sulphate X varieties	0	4.1989 e	7. 2967 b	5.7478 c	
	200	6.3656 c	8. 2889 a	7.3272 a	
	400	5.2689 d	7. 6756 a b	6.4722 b	
Average effect of varieties		5.2778 b	7.7537 a		

**Averages that share the same letter for each factor and for each overlap do not differ significantly from each other according to the Duncan polynomial test at the probability level ≤ (0.05)*

From the results of Table (1), it is clear that spraying with zinc sulphate at a concentration of 750 mg. L^{-1} achieved a significant superiority in the total chlorophyll content of the leaves, amounting to 6.8639 mg. ml^{-1}. suspension, as measured by non-spraying and spraying with 500 mg.L^{-1}, which did not differ significantly from each other, as the results show that adding potassium sulfate at the level of 200 ton.h^{-1} was significantly superior to the rest of the addition parameters, which differed significantly from each other, as the chlorophyll content of the leaves reached 7.3272 mg.ml^{-1} suspension, and the Blue Finn variety was significantly superior in this characteristic to the plants of the Naxos variety, reaching 7.7537 and 5.2778 mg.ml^{-1} .suspension respectively. As for the results of bi-interaction between zinc sulphate and potassium sulphate, the treatment of this interference recorded clear significant differences, and the highest value reached 7.8983 mg.ml^{-1}. suspension when sprayed at a concentration of 750 mg.L^{-1} of zinc sulphate with the addition of 200 ton.h^{-1} of potassium sulphate, thus significantly superior to most of the bi-interaction coefficients. The lowest value recorded in this bi-interaction was 5.2817 mg.ml^{-1}. suspension when zinc sulphate was not sprayed and 400 tons.h^{-1} were added potassium sulphate. As for the bi-interaction between zinc sulphate and the varieties, the spray treatment was recorded at a concentration of 500 mg.L^{-1} on plants of the Blue Finn variety had the highest significant increase compared to all other interference treatments, amounting to 8.3089 mg. ml^{-1}. suspension, and did not differ significantly from the spray treatment at a concentration of 750 mg.L^{-1} only for the same variety, and the lowest value achieved for the Naxos variety when spraying at a concentration of 750 mg.L^{-1}. In the overlap between the addition treatments for potassium sulfate and the varieties, there was a significant superiority when the addition treatment was 200 ton.h^{-1} potassium sulfate for the Blue Finn variety, measured by all bi-interaction factors, amounted to 8.2889 mg.ml^{-1}. suspension, except for the addition treatment of 400 ton.h^{-1} for the same variety did not differ significantly, while the lowest value amounted to 4.1989 mg. ml^{-1}. suspension in the comparison treatment for the variety Naxos. The effect of triple interference between the factors studied is noted in the same table that the highest chlorophyll content of the leaves was found when the interference treatment between a concentration of 750 mg.L^{-1} of zinc sulphate and the addition level is 200 ton.h^{-1} potassium sulfate on plants of the Blue Finn variety amounted to 8.8467 mg.ml^{-1}. suspension, and the lowest value for the chlorophyll content of the leaves was 3.0067 mg.ml^{-1}.suspension when spraying 500 mg.L^{-1} of zinc sulphate and not adding potassium sulphate to plants of the Naxos variety.

4.2. Plant height(cm.$Plant^{-1}$)

Table 2. The effect of zinc sulfate, potassium, and varieties and the interaction between them on plant height (cm.$Plant^{-1}$)

Zinc sulphate concentrations (mg. L^{-1})	potassium sulphate concentrations (ton.h^{-1})	Verities		Zinc sulphate × potassium sulphate	Average Effect of Zinc sulphate
		Naxos	Blue Finn		
0	0	55.687 d	73.200 b	64.443 c	67.0156 b
	200	60.440 c d	77.267 a b	68.853 a b	
	400	60.443 c d	75.067 a b	67.750 a-c	

500	0	57.143 c d	76.733 a b	66.938 a-c	66.6606 b
	200	59.177 c d	73.600 b	66. 338 b c	
	400	59.443 c d	73.867 b	66.655 a-c	
750	0	60.153 c d	78.067 a b	69.110 a b	69.1433 a
	200	61.330 c	78.893 a	70.112 a	
	400	61.883 c	74.533 a b	68.208 a b	
zinc sulphate X varieties	0	58.853 b	75.178 a	Average effect of Potassium sulphate	
	500	58.588 b	74.733 a		
	750	61.122 b	77.164 a		
Potassium sulphate X varieties	0	57.661 c	76.000 a	66.8306 a	
	200	60.316 b	76.587 a	68.4511 a	
	400	60.587 b	74.489 a	67.5378 a	
Average effect of varieties		59.5214 b	75.691 a		

**Averages that share the same letter for each factor and for each overlap do not differ significantly from each other according to the Duncan polynomial test at the probability level ≤ (0.05)*

The results of Table (2) indicate that spraying with zinc sulphate at a concentration of 750 mg.L^{-1} recorded the highest significant differences in plant height characteristic, reaching 69.1433 cm.$Plant^{-1}$, which differed significantly with the non-spraying and spraying treatments at a concentration of 500 mg.L^{-1}. We note from the same table that the addition of potassium sulphate at the level is 200 ton.h^{-1} gave the highest significant values for plant height, reaching 68.4511 cm.$Plant^{-1}$ and did not differ significantly from the treatment, non-addition and addition at the level of 400 ton.h^{-1} and the variety Blue Finn was significantly superior in this characteristic and recorded the highest significant values 75.691 cm.$Plant^{-1}$ compared to plants of the Naxos variety, which gave the lowest average plant height of 59.5214 cm.$plant^{-1}$. In the coefficients of bi- interaction between zinc sulphate and potassium sulphate, it is noted from the same table that highest significant value in the plant height characteristic reached 70,112 cm.$Plant^{-1}$ when sprayed with 750 mg.1 liter of zinc sulphate with the addition of 200 ton.h^{-1} potassium sulfate, while the average plant height decreased to 64443 cm.$Plant^{-1}$ in comparison treatment. In the results of the bi-interaction between zinc sulphate and the varieties, it was found that the Blue Finn variety was significantly superior when sprayed at a concentration of 750 mg.L^{-1} of zinc sulphate and on all spray treatments for the variety Naxos and amounted to 77.164 cm.$Plant^{-1}$ did not differ significantly from the rest of the spray treatments for the same variety, Naxos, and the lowest plant height value was for the variety Naxos when sprayed with 500 mg.L^{-1} and reached 58.558 cm.$Plant^{-1}$. As for the interaction between potassium sulphate and the varieties, the Blue Finn variety and all treatments were significantly superior in plant height characteristic to all treatments for the Naxos variety and did not differ significantly among them, and the highest value reached 76.587 cm.$Plant^{-1}$ when adding 200 ton.h^{-1} for plants of the Blue Finn variety, and the lowest value recorded when comparing plants of the Naxos variety was 57,661 cm.$Plant^{-1}$. To explain the effect of the triple interference coefficients between the factors studied (zinc sulphate, potassium sulphate, and other varieties), the results of the table indicate that spraying with zinc sulphate at a concentration of 750 mg.L^{-1} and adding potassium sulfate at the level of 200 ton.h^{-1} on plants of the variety Blue Finn recorded the highest significant values for plant height 78.893 cm.$Plant^{-1}$ The variety Naxos recorded the lowest average plant height when treated with the comparison, amounting to 55.687 cm.$Plant^{-1}$.

4.3. Number of leaves (leaf.$Plant^{-1}$)

Table 3. The effect of zinc and potassium sulphate and the varieties and the overlap between them in the number of leaves (leaf. $Plant^{-1}$)

Zinc sulphate concentrations (mg. L^{-1})	potassium sulphate concentrations (ton.h^{-1})	Verities		Zinc sulphate × potassium sulphate	Average Effect of Zinc sulphate
		Naxos	Blue Finn		
0	0	17.217 d	19.220 b	18.2183 d	20.0556 a
	200	20.590 a-c	21.997 a	21.2933 a	
	400	20.110 a-c	21.200 a b	20.6550 a b	

500	0	19.997 a-c	18.330 c d	19.1633 b-d	20.3672 a
	200	20.663 a-c	20.107 a-c	20. 3850 a b	
	400	21.887 a	21.220 a b	21.5533 a	
750	0	19.107 b-d	18.44 a b	18.7733 c d	20.0233 a
	200	21.200 a b	20.977 a b	21.0883 a	
	400	20.420 a-c	19.997 a-c	20.2083 a-c	
zinc sulphate X varieties	0	19.3056 b	20.8056 a	Average effect of Potassium sulphate	
	500	20.8489 a	19.8856 a b		
	750	20.2422 a b	19.8044 a b		
Potassium sulphate X varieties	0	18.7733 b	18.6633 b	18.7183 b	
	200	20.8178 a	21.0267 a	20.9222 a	
	400	20.8056 a	20.8056 a	20.8056 a	
Average effect of varieties		20.1652 a	20.1322 a		

**Averages that share the same letter for each factor and for each overlap do not differ significantly from each other according to the Duncan polynomial test at the probability level ≤ (0.05)*

The results of Table (3) show us that spraying zinc sulphate did not have any significant effect on the number of leaves, while the largest number of leaves reached 20.3672 leaf.Plant^{-1} when sprayed with zinc sulphate at a concentration of 500 mg.L^{-1}, and the addition of potassium sulfate had a significant effect on the character of the number of leaves at the levels of 200 and 400 ton.h^{-1}. The varieties grown in the experiment did not witness any significant effect on the number of leaves. The bi-interaction between zinc sulfate and potassium sulfate showed clear significant increases in most interference coefficients as measured by the comparison treatment and the highest number of leaves was recorded when spraying 500 mg.L^{-1} zinc sulphate and add 400 ton.h^{-1} potassium sulphate amounted to 21.5533 leaf.Plant^{-1} While the results of the bi-interaction between zinc sulphate and the varieties indicate that the Naxos variety gave the highest number of leaves when treated with a spray at a concentration of 500 mg.L^{-1} and this interference did not vary with all the interference coefficients and only varied with no spraying with zinc sulphate for the same variety. It was noted from the results of Table (3) regarding the bi-interaction coefficients between potassium sulphate and the varieties that there was a significant superiority in the number of leaves for plants of both varieties and for all levels of addition of potassium sulphate. The addition coefficients on both varieties did not differ significantly from each other compared to the comparison treatment, and that the highest value was recorded at the addition level of 200 ton.h^{-1} on plants of the Blue Finn variety and amounted to 21.0267 leaf.Plant^{-1}. In the triple interaction between the factors studied, the table indicates that the highest number of papers reached 21,997 leaf.Plant^{-1} When not spraying zinc sulphate and adding 200 ton.h^{-1} potassium sulfate on plants of the Blue Finn variety. The average number of leaves decreased to 17,217 leaf.Plant^{-1} when comparing plants of the Naxos variety.

4.4. leaves area (cm^2.Plant^{-1})

Table 4. The effect of zinc sulfate, potassium, and varieties and the overlap between them in leaf area (cm^2.Plant^{-1}).

Zinc sulphate concentrations (mg. L^{-1})	potassium sulphate concentrations (ton.h^{-1})	Verities		Zinc sulphate × potassium sulphate	Average Effect of Zinc sulphate
		Naxos	Blue Finn		
0	0	16010 j	36407 b c	26209 e f	31643.1 a
	200	23476 g h	39590 b c	31533 b c	
	400	26197 f g	48179 a	37188 a	
500	0	20506 i j	27884 e-g	24195 f	28588.3 b
	200	31198 d e	35102 c d	33150 b	
	400	20779 h i	36062 c	28420 c-e	
750	0	24810 f- h	28502 e f	26656 d-f	28560.0 b
	200	18481 i j	40754 b	29618 c d	
	400	20897 h i	37915 b c	29406 c-e	

zinc sulphate X varieties	0	21894 c	41392 a	Average effect of Potassium sulphate
	500	24161 c	33016 b	
	750	21396 c	35724 b	
Potassium sulphate X varieties	0	20442 d	30931 b	25686.4 b
	200	24385 c	38482 a	31433.4 a
	400	22624 c d	40719 a	31671.4 a
Average effect of varieties		36710.5 a	22483.7 b	

**Averages that share the same letter for each factor and for each overlap do not differ significantly from each other according to the Duncan polynomial test at the probability level ≤ (0.05)*

The results of Table (4) indicate that there is a significant superiority in the leaf area of the plant when treated with zinc sulphate at a concentration of 500 mg.L^{-1} and amounted to 31643.1 cm^2.$Plant^{-1}$ by analogy with the comparison treatment, while adding potassium sulfate affected the plant significantly, and the highest leaf area value was recorded at the level of 400 ton.h^{-1} and amounted to 31671.4 cm^2.$Plant^{-1}$, which did not differ significantly with the addition treatment of 200 ton.h^{-1} and differed with the comparison treatment and the Blue Finn variety was significantly superior to the Naxos variety in this characteristic, with 36,710.5 and 22,483.7 cm^2.$Plant^{-1}$ respectively. As regards the bilateral interference between zinc sulphate and potassium sulphate, the interference between 500 mg.L^{-1} sprays of zinc sulphate with an addition of 400 ton.h^{-1} potassium sulfate The highest significant differences in average leaf area amounted to 37188 cm^2.$Plant^{-1}$, compared to all interference coefficients, and the lowest value of leaf area recorded during the comparison treatment was 24195 cm^2. $Plant^{-1}$. The results of the bilateral interaction between zinc sulphate and the varieties are shown in the same table when spraying 500 mg.L^{-1} of zinc sulfate on plants of the Blue Finn variety recorded the highest significant differences in leaf area, amounting to 41,392 cm^2.$Plant^{-1}$, which differed significantly with all interference coefficients and with the variety Naxos. It was observed in the bi-interaction between the addition of potassium sulfate and the varieties, as clear significant differences were recorded between the treatments, and the highest value was when 400 ton.h^{-1} were added. on plants of the variety Blue Finn and had a value of 40719 cm^2.$Plant^{-1}$, which did not differ significantly with the addition treatment at the level of 200 ton.h^{-1} on the same variety and differed significantly with all the coefficients of bi-interaction and on plants of variety Naxos and that the lowest value of leaf area was when the comparison treatment of plants of variety Naxos was 20442 cm^2.$Plant^{-1}$. The three coefficients of interaction between the factors studied recorded the highest significant value for the paper area, amounting to 48,179 cm^2.$Plant^{-1}$ at 500 mg.L^{-1} of zinc sulphate and add 400 ton.h^{-1} of potassium sulfate on plants of the Blue Finn variety and the lowest leaf area rate recorded when spraying 500 mg.L^{-1} of zinc sulphate, without adding potassium sulphate, for plants of the Naxos variety, reaching 16,010 cm^2.$Plant^{-1}$.

4.5. Percentage of dry matter in the leaves

Table 5. The effect of zinc sulfate, potassium, and varieties and the interaction between them in the percentage of dry matter in the leaves (%)

Zinc sulphate concentrations (mg. L^{-1})	potassium sulphate concentrations (ton.h^{-1})	Verities		Zinc sulphate × potassium sulphate	Zinc sulphate × potassium sulphate
		Naxos	Blue Finn		
0	0	11.9567 c-e	10.3033 f g	11.1300 c	11.4877 b
	200	12.3033 b-d	9.6783 g	10.9908 c	
	400	12.9267 b-d	11.7580 d e	12.3423 a b	
500	0	12.6067 b-d	10.8210 b-d	11.7138 b c	12.3512 a
	200	12.8767 b-d	12.4290 b-d	12.6528 a	
	400	13.0733 b c	12.3003 b-d	12.6868 a	
750	0	13.4500 a b	10.9613 e f	12.1772 a b	12. 2465 a
	200	13.3633 a b	11.0207 e f	12.1920 a b	
	400	14.4533 a	10.2873 f g	12.3703 a b	

zinc sulphate X varieties	0	12.3956 b c	10. 5799 d	Average effect of Potassium sulphate
	500	12.8522 a	11. 8501 c	
	750	13.7556 a	11.7374 d	
Potassium sulphate X varieties	0	12.6711 b	10.6762 d	11.6737 b
	200	12.8478 b	11.0427 c d	11.9452 b
	400	13.4844 a	11.4486 c	12. 4665 a
Average effect of varieties		13.0011 a	11.0558 b	

**Averages that share the same letter for each factor and for each overlap do not differ significantly from each other according to the Duncan polynomial test at the probability level ≤ (0.05)*

The results of Table (5) show the superiority of the two spraying treatments with zinc sulphate at concentrations of 500 and 750 mg.L^{-1} significantly affected the non-spraying treatment, and the percentage of dry matter in the leaves was (12.3512 and 12.2465%), respectively. In explaining the effect of adding potassium sulphate, it is clear from the table that the treatment of adding potassium sulphate was superior at the level of 400 ton.h^{-1} by giving it the highest significant differences compared to the non-addition and addition treatments at the level of 200 ton.h^{-1}, The Naxos variety was significantly superior to the Blue Finn variety in the percentage of dry matter in the leaves, as the values reached (13.0011 and 11.0558%), respectively. As for the bi-interaction between zinc sulfate and potassium sulfate, it achieved a significant effect when spraying 500 mg.1 liter of zinc sulphate with the addition of 400 or 200 ton.h^{-1} of potassium sulphate was significantly superior, and the percentage of dry matter in the leaves reached 12.6528% and 12.6528 % and respectively and the lowest percentage of dry matter in the leaves reached 10.9908% when not spraying with zinc sulphate and adding 200 ton.h^{-1} potassium sulphate. In the coefficients of bi-interaction between zinc sulphate and the varieties, we note from the table that the Naxos variety was significantly superior to the Blue Finn variety in all concentrations used, and this variety achieved the highest percentage of dry matter in the leaves, amounting to 13.7556% when sprayed at a concentration of 750 mg.L^{-1} The percentage of dry matter in the leaves decreased to 10.5799% when not spraying Blue Finn plants. We also notice a moral superiority in the addition factor of 400 ton.h^{-1} potassium sulfate for plants of the Naxos variety, according to all coefficients of bi-interaction between the addition of potassium sulfate and the varieties, amounting to 13.4844%, and the lowest percentage of dry matter was 10.6762% in the leaves of plants of the Blue Finn variety when potassium sulfate was not added. From the results of the triple interaction between the factors studied, it is clear that the highest percentage of dry matter in the leaves reached 14.4533% when overlapping between spraying 750 mg.l^{-1} of zinc sulphate and 400 ton.h^{-1} of potassium sulphate on plants of the Naxos variety, and the lowest percentage of dry matter reached 9.6783% when plants of the Blue Finn variety were not sprayed with zinc sulphate, with potassium sulphate added only at the level of 200 ton.h^{-1}.

5. CONCLUSION

Zinc sulfate spray treatments exceed all spray treatments in all vegetative growth characteristics. The addition of potassium sulfate witnessed significant superiority in all characteristics of vegetative growth. The Blue Finn variety was significantly superior in all the characteristics studied, except for the percentage of dry matter in the leaves, at which the Naxos variety was superior. Bi-interactions between both fertilizing factors or triple interactions between fertilizing factors and varieties gave the best results compared to the effect of single factors or with comparison factors.

RECOMMENDATIONS

We recommend using an bi-interaction between foliar spraying of zinc sulphate and adding potassium sulphate and treating independently and sequentially for each one.We also recommend planting the Blue Finn variety because the variety has the ability to adapt to the climate of the city of Mosul.

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