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The Effect of Spraying with Micronutrients using Different Types of Nozzles on the Growth and Yield of Corn (*Zea mays* L.)

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The Effect of Spraying with Micronutrients using Different Types of Nozzles on the Growth and Yield of Corn (*Zea mays* L.)

Madyan Shallal Radhi Al-Shaheen

Agricultural Machines and Equipment Department, College of Agriculture, University of Basrah, Iraq.

madyan.radhi@uobasrah.edu.iq

Abstract. A field experiment was conducted in the north of Basra Governorate during the fall season of 2019 to determine the effect of the nozzles type and spraying of zinc and iron on the growth, yield, and quality of maize (Al-Maha cultivar). The first factor was (spraying zinc 90 mg L^{-1} F1, iron 300 mg L^{-1} F2, and zinc 90 mg L^{-1} + iron 300 mg L^{-1} F3). The second factor (Nozzles type: Tip Nozzle N1, Flat fan Nozzle N2, Hollow Cone Nozzle N3). R. C. B.D design with three replications was utilized. The application of micronutrients through spraying yielded positive outcomes. Specifically, treatment F2 exhibited the tallest stem height, measuring 139.68 cm. Treatment F4 demonstrated the largest stem diameter, measuring 1.91 cm. Furthermore, treatment F4 resulted in the highest mean values for grain yield (5.44 tonne ha-1), chlorophyll content (31.73 spad), and protein content (11.039%). Regarding the second factor, it was observed that N1 exhibited superior performance in stem diameter, measuring 1.889 cm. The F2N2 treatment demonstrated superior performance in stem height, with an average measurement of 148.05 cm. Conversely, the F4N2 treatment exhibited excellence in stem diameter, with an average measurement of 1.94 cm.

Keywords. Knapsack sprayer, Nozzles, Micronutrients, Maize.

1. Introduction

Corn (*Zea maya* L.) is one of the oldest agricultural crops with a high yield, and its grains have a high nutritional value, containing 72% starches, 10% protein, 4.8% oils, 8.5% fibers, in addition to 3.0% sugars and 1.7% ash, respectively [1].

[2] The cultivated areas of corn in Iraq are still below the minimum level. Therefore, it was necessary for specialists to invest in methods to increase the yield and quality of this crop. These techniques include foliar feeding due to its important role in enhancing plant growth and yield [3]. Corn crop is considered to be sensitive to the deficiency of micronutrients due to its effective and critical role within the plant during the various growth stages; consequently, it is affected by these elements and their availability, which is evident in vegetative growth and yield [4]

Zinc is one of the essential elements for carbohydrate metabolism and the majority of chloroplast and cytoplasmic enzymes. It is also an essential nutrient for plant protein synthesis and a major component of ribosomes [5, 6]. Iron is also a micronutrient of great importance in the metabolic processes of plants, playing a crucial role in metabolic processes such as DNA synthesis, respiration, and

photosynthesis, as well as the activation of numerous metabolic pathways. In addition, it participates in numerous physiological and biochemical pathways and is a component of numerous essential enzymes. Participates in the oxidation process that releases energy from starches and sugars [7].
And one of the factors influencing the effectiveness of the spraying process is the type of nozzle installed on the sprinkler, as it determines the amount of spraying solution and the pattern of its distribution on the plant. The nozzles also vary in terms of their impact on the number of drops deposited on the plant's leaves, the size of these drops, and the percentage coverage. Therefore, the spraying procedure's technology is crucial. The success of the foliar feeding process affects its effectiveness, according to [8]
Due to the lack of studies that explain the relationship between certain technological characteristics of the agricultural sprinkler, represented by the type of nozzle, and the vegetative growth and production characteristics of the maize crop, this study aimed to: Determine the merit of the type of nozzle used in the agricultural spraying process to improve growth, production, and quality, and determine the response of the maize crop. Spraying the shoots with zinc, iron, or both, and observing the impact on the growth characteristics, yield, and quality of maize.

2. Materials and Methods

During the fall season of 2019, a field experiment was conducted in the northern Basra Governorate - Qurna district - with the objective of determining the impact of the Nozzle Type on knapsack sprayer and zinc and iron spraying on the growth, yield, and quality of maize (Al-Maha cultivar) (approved by the Agricultural Research Department of the Ministry of Agriculture - Qurna).

Table 1. The chemical and physical properties exhibited by the soil sample prior to the commencement of planting.

Chemical properties	PH	ECe ds m^{-1}	Fe mg kg^{-1}	O.G	N mg kg^{-1}	P mg kg^{-1}	K mg kg^{-1}	Zn $mgkg^{-1}$
	8.12	8.20	2.26	1.03	31.02	15.32	76.46	0.32
physical properties	Sand	silt	clay			Soil texture		
	214.20	325.10	459.11			loam		

2.1. Study Variables

First, zinc, iron, and both sprayed:

- Control F1 spray versus distilled water
- Zinc F2 at 90 mg L^{-1} and aqueous zinc sulfate $ZnSo_4.7H_2O$ (22.7% Zn) were utilized.
- Iron F3 at a concentration of 300 mg L^{-1} and aqueous ferrous sulfate $FeSo_4.7H_2O$ containing 20.08% Fe were utilized.
- Zinc +iron F4 (Zinc 90 mg L^{-1} + Iron 300 mg L^{-1})

Spraying was carried out in two stages (half of the concentrations were used for spraying in each stage): 1-stage of vegetative growth (the emergence of 8 leaves), 2- stage of female flowering.
Type of nozzle used during the spraying process:
1-Tip Nozzle N1 2 - Flat fan Nozzle N2 3 - Hollow Cone Nozzle N3
The manufacturer of these nozzles is Albuz®

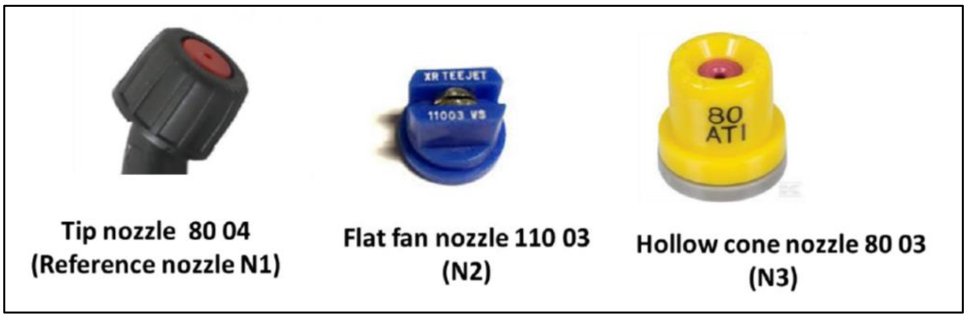

Figure 1. The RCBD design.

After the land had been plowed, smoothed, and leveled, it was plotted and divided into experimental units. The RCBD design was implemented with three replications, 36 experimental units, and a 2 m separation between units. It was planted on 01/08/2019, the field was irrigated according to the plant's needs, and bushes were removed through hoeing and weeding. The soil was treated with the recommended amount of fertilizer, which included 240 kg of nitrogen, 100 kg of potassium, and 120 kg of phosphorus [9].

2.2. Studied Traits

Stem height (cm)**,** stem diameter (cm)**,** leaf area (cm^2)**,** Weight of 500 grain (g), number of grains per cob**,** grain yield (ton ha^{-1}),
chlorophyll (spad) It was estimated one week after the third spray using the CCM-200 plus (Chlorophyll Content Meter) produced by the American company (OPTI-SCIENCES).
, protein (%) It was estimated using the Near Infrared Radiation (NIR) device produced by the American company Dickey-John.

3. Results and Discussion

3.1. Stem Height

Table (2) reveals that spraying and the interaction between the two factors have a significant effect, while the (type of nozzle) has no significant effect.
F2 had the highest average, measuring (139.68) cm, while F1 had the lowest, measuring (125.60) cm.
As for overlap, F2N2 had the highest average (148.05 cm), while treatment F1N3 had the lowest average (115.87 cm).
The reason can be attributed to zinc's effect on the formation of the amino acid tryptophan, which is the main component of the hormone auxin. Auxin is required for cell division and elongation, as well as increasing photosynthesis, which increases plant height [10].
In addition, the significant difference between the nozzles may be a result of their differing designs, which affect the spray solution's properties when it is deposited on plant leaves [11]. In addition, the spraying angle of the different droplet types results in different coverage percentages, and these findings are consistent with those of [12].

Table 2. The impact of zinc and iron spraying, nozzle type, and their interaction on the stem height.

	1 N	**2 N**	**3 N**	**Average**
F1	122.68	138.25	115.87	125.60
F2	134.95	148.05	136.05	139.68
F3	127.08	128.02	131.13	128.74
F4	131.85	128.27	143.53	134.55
average	129.14	135.65	131.65	
L.S.D	N= N.S	F=8.30	N*F=14.38	

3.2. Stem Diameter

According to Table (3), there is a significant effect of spraying, nozzle type, and interaction between the two workers, as the highest average was recorded in F4 (1,910 cm) and the lowest average was recorded in F1 (1,744 cm).
N1 nozzles produced the highest average of (1.889), while N2 nozzles produced the lowest average of (1.768).
As for the overlap, F4N2 had the highest average (1,940), while treatment F1N3 had the lowest average (1,647).
The superiority of the mixing treatment may be attributed to the fact that foliar feeding led to the activation of physiological processes in which zinc and iron play a significant role, whether photosynthesis or building and activating enzymes, which contributed to enhancing the plant's ability to grow and increase its biomass, and then increase the diameter of the stem, and this result is consistent with the hypothesis. What Discovered [13].

The size, number, and percentage of droplet coverage on maize leaves achieved with this nozzle increased nutrient absorption and vegetative growth rates as a result of the speed of absorption and penetration through leaf tissue and stomata, and as a result increased the stem diameter [14].

Table 3. The impact of zinc and iron spraying, nozzle type, and their interaction on the Stem diameter.

	1 N	**2 N**	**3 N**	**Average**
F1	1.840	1.747	1.647	1.744
F2	1.927	1.653	1.813	1.798
F3	1.900	1.733	1.920	1.851
F4	1.890	1.940	1.900	1.910
average	1.889	1.768	1.820	
L.S.D	N=0.0678	F=0.0783	N*F=0.1355	

3.3. Leaf Area

The results presented in Table (4) indicated that spraying, the type of nozzle used, and their interaction had no significant effect on the leaf area characteristic.

Table 4. The impact of zinc and iron spraying, nozzle type, and their interaction on the leaf area.

	1 N	**2 N**	**3 N**	**Average**
F1	3558.30	3548.90	3748.00	3618.40
F2	3774.20	3956.33	3844.67	3858.40
F3	3594.30	4010.90	4188.00	3931.07
F4	4108.80	4040.50	3900.67	4016.66
average	3758.90	3889.16	3920.33	
L.S.D	N= N.S	F= N.S	N*F= N.S	

3.4. Weight of 500 grains

The results indicated in the Table (5) that spraying, nozzle type, and the interaction between the two factors had no significant effect on the weight of 500 grains.

Table 5. The impact of zinc and iron spraying, nozzle type, and their interaction on Weight of 500 grains.

	1 N	**2 N**	**3 N**	**Average**
F1	146.18	156.21	149.26	150.55
F2	153.62	158.56	153.79	155.32
F3	144.63	142.38	163.68	150.23
F4	157.91	155.24	162.12	158.42
average	150.58	153.10	157.21	
L.S.D	N= N.S	F= N.S	N*F= N.S	

3.5. The Amount of Grains Per Corn Cob

According to Table (6), there is no statistically significant relationship between the type of nozzle used and the interaction between the two factors in The amount of grains per corn cob

While the F4 spray treatment yielded the highest average (340.61 grains ear^{-1}), the F1 treatment yielded the lowest average (266.34 grains ear^{-1}).

Adding iron and zinc together increased the number of grains per ear due to the role of these two elements in building chlorophyll and increasing the efficiency of the photosynthesis process in processing the emerging grains with their requirements of processed food necessary for their perpetuation. In addition, the addition of zinc and iron makes the compound stronger. It contributed to the regularization of the action of the hormones affecting flower production and the increase in fertility, as indicated by the increase in the number of grains in the cocoon. The outcomes were consistent with [3] and [15].

Table 6. The impact of zinc and iron spraying, nozzle type, and their interaction on The amount of grains.

	1 N	2 N	3 N	Average
F1	285.65	265.92	247.44	266.34
F2	252.33	282.51	292.82	275.89
F3	354.14	276.36	280.07	303.52
F4	323.52	341.67	356.63	340.61
average	303.91	291.62	294.24	
L.S.D	N= N.S	F=51.84	N*F= N.S	

3.6. Grain Yield

Table (7) reveals that spraying has a significant effect on the characteristic of grain yield, whereas the type of nozzle used and the interaction between the two factors have no significant effect.
The F4 treatment resulted in the highest average of (5.44 ton ha^{-1}) while the F1 treatment resulted in the lowest average of (4.16 ton ha^{-1}).
The reason for the increase in grain yield when zinc and iron were sprayed together is the increase in the yield component, which is the number of grains per cob (Table 5), which was reflected positively in the increase in grain yield per unit area. Consistent with the findings of numerous researchers, [16] found that an increase in grain weight leads to an increase in crop yield.

Table 7. The impact of zinc and iron spraying, nozzle type, and their interaction on the Grain yield.

	1 N	2 N	3 N	Average
F1	4.10	4.30	4.08	4.16
F2	4.35	5.06	4.77	4.73
F3	4.72	5.22	4.74	4.89
F4	5.26	5.53	5.54	5.44
average	4.61	5.03	4.78	
L.S.D	N= N.S	F=0.5375	N*F= N.S	

3.7. Chlorophyll

Table (8) reveals that spraying has a significant effect on the characteristic of chlorophyll content, whereas the type of nozzle used and the interaction between the two factors have no significant effect.
The treatment with the highest average was F4 (31.73 SPAD), while the treatment with the lowest average was F1 (22.73 SPAD).
Iron contributes to the formation of two compounds, Laevulinic and Protochlorophytic, which are essential to the chlorophyll synthesis pathway, as [17] explains. Additionally, zinc acts as a catalyst in plant cell oxidation processes, regulating sugar consumption and increasing the energy required to produce chlorophyll. In addition, it regulates the pH of chloroplasts and releases them from CO_2 [18], which increases chlorophyll production. This result is consistent with the findings to which it corresponds [19, 20].

Table 8. The impact of zinc and iron spraying, nozzle type, and their interaction on the Chlorophyll.

	1 N	2 N	3 N	Average
F1	24.19	20.60	23.40	22.73
F2	32.72	28.14	32.89	31.25
F3	31.96	26.42	33.79	30.72
F4	28.14	32.60	34.47	31.73
average	29.25	26.94	31.14	
L.S.D	N= N.S	F=4.774	N*F= N.S	

3.8. Protein

Table (9) reveals that spraying has a significant effect on protein characterization, whereas the type of nozzle used and the interaction between the two factors have no significant effect.

F4 had the highest average, which was (11.039%), while F1 had the lowest average, which was (9.690%).
The superiority of spraying zinc and iron together may be due to the indirect iron relationship through increased photosynthesis and nitrogen metabolism, and the role of zinc participating in the process of refining nitrate to tetra and then to ammonium and the formation of amino acids, which is the foundation of the process of forming proteins and increasing the proportion of protein in grains [21]. Zinc is primarily involved in the synthesis and maturation of ribosomes, which are responsible for the production of the amino acids that compose proteins [5].

Table 9. The impact of zinc and iron spraying, nozzle type, and their interaction on the Protein.

	1 N	2 N	3 N	Average
F1	9.683	9.660	9.727	9.690
F2	10.027	10.077	10.270	10.124
F3	10.403	10.260	10.663	10.442
F4	11.000	10.787	11.330	11.039
average	10.278	10.196	10.497	
L.S.D	N=N.S	F= 0.5681	N*F= N.S	

Conclusions

The present study has revealed a significant association between the application of foliar spraying and the type of nozzle, and their beneficial impact on the growth and yield attributes of the maize crop. The application of zinc and iron through foliar spraying using a Flat fan Nozzle has been identified as a promising method for improving plant growth and increasing crop yield. The selection of an appropriate nozzle type for foliar spraying is expected to yield outcomes that will enhance the quality of the maize crop.

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