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ORIGINAL ARTICLE

EFFECT OF SPRAYING GIBBERELLIN AND THIAMINE ON THE GROWTH AND YIELD OF CORN (*ZEA MAYS* L.)

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Abstract: The field experiment was conducted on one of the private farms located in Al- Musauib project area, 40 km north of Babylon Governorate, during the spring and autumn seasons of 2022. To know the effect of spraying gibberellin and thiamine and spraying stages on the growth and yield of corn. The experiment was implemented according to the split plots arrangement, and the treatments were distributed using the Randomized complete block design (R.C.B.D) with three replicates. The data were analyzed statistically according to the analysis of variance method, and the arithmetic means were compared using the least significant difference test (L.S.D) at a probability level of 0.05. Where the main plot included three stages of addition and they were (the stage of formation of 4 leaves, the stage of formation of 8 leaves, the stage of flowering) and symbolized by the symbols (A1, A2, A3). The subplot included spray concentrations and were as follows: spraying with distilled water only, gibberellin at a concentration of 100 mg.L^{-1} and thiamine (vitamin B1) at a concentration of 100 mg.L^{-1} and the interaction between gibberellin at a concentration of 100 mg.L^{-1} and thiamine 100 mg.L^{-1}, and symbolized by (B0, B1, B2, B3) and the results were as follows :The stage of formation of 8 leaves (A2) excelled significantly and gave the highest average for most of the studied traits and for both season, respectively. Total plant yield (181.07 and 175.01) kg.ha^{-1}, biological yield (548.81 and 529.83). 3 treatments were significantly excelled on the rest of the other treatments and gave the highest mean of the two roots, respectively, for the traits of plant height (141.97 and 146.26) cm, leaf area (6778.96 and 6718.31) cm^2, stem diameter (2.55 and 2.41) cm, total plant yield (201.56 and 195.49) kg.ha^{-1}, biological yield (625.71 and 605.90). The results also showed that the interaction between the study factors had a significant effect. The interaction treatments (A2 + B3) excelled and gave the highest values for most growth, yield and qualitative traits.

***Key words*:** Gibberellin, Thiamine, Growth, Corn, *Zea mays* L.

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1. Introduction

Corn crop (*Zea mays* L.), which belongs to the Poaceae family, is one of the most important grain crops that are grown on a very large scale in the world, where it comes in importance after wheat and rice in terms of area and production, because of its multiple uses in human and animal nutrition and its entry into many industrial fields [Al-Sahoki (1990), Al-Maliki *et al.* (2021)] and it was found that the enzymatic system falls under the influence of plant hormones, especially gibberellic acid [Atiyah (1999)], where the physiological effect of gibberellins is due to its control of enzymatic activity and its activation of metabolic processes such as increasing soluble carbohydrates through it activates enzymes such as amylase α-amylase, protease, peroxidase, the manufacture of carboxylase and gibberellins activate the formation of nucleic acids and treatment with gibberellins contributes to the transfer of manufactured nutrients to a greater degree towards the growth site its expansion [Al-Wahsh (2008), AL-Taey (2018)]. As for thiamine (vitamin B_1), one of the important vitamins for growth, and it is one of the water-soluble vitamins. Vitamin B_1 was considered a growth hormone because it moves from

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one part of the plant to other parts, that is, it is synthesized in the leaves and then transmitted to the root [Youssef and Talaat (2003)]. In view of the foregoing, the research aims

1. To know the effect of spraying stages on the growth and yield of corn.

2. To know the effect of gibberellin concentration on the growth and yield of maize.

3. To know the effect of thiamine concentration on the growth and yield of maize.

4. To know the effect of the interaction between the concentrations of Gibberellin and Thiamine on the growth and yield of corn

2. Materials and Methods

2.1 Implementation of the experiment

A field experiment was conducted during the spring and fall season of 2022. In one of the private farms located in Al-Musayyib project area, 40 km north of Babylon province, to study the effect of spraying gibberellin and thiamine and the spraying stages on the growth and yield of corn. The experiment was conducted according to the split plots arrangement, and the treatments were distributed using the Randomized complete block design (R.C.B.D) with three replicates. Where the main plot included three stages of addition, and they were (the stage of forming 4 leaves, the stage of forming 8 leaves, the stage of flowering) and symbolized by the symbols (A1, A2, A3). As for the secondary plot, they included spray concentrations and were (spraying with distilled water only, gibberellin at a concentration of 100 mg.L^{-1} and thiamine (vitamin B1) at a concentration of 100 mg.L^{-1} and the interaction between gibberellin at a concentration of 100 mg.L^{-1} and thiamine 100 mg.L^{-1} and denoted by (B0, B1, B2, B3). The experimental land was plowed with two perpendicular tillage, then smoothed and leveled, and then divided into experimental units measuring 4m× 4m. The grains of the cultivar (Sorour) were planted in rows, the distance between one line and another was 75 cm and the length was 4 m and between one pit and another 25 cm, the number of lines per experimental unit was 5 lines and three seeds were planted in one jar and the experiment was fertilized at a rate of 120 kg N and 132 kg phosphorus/h. Where, the used urea (46% N) as a source of nitrogen and triple superphosphate (46% P_2O_5) as a source of phosphorus. And the first batch of nitrogen fertilizer was added with all the amount of phosphorus when seedlings appeared. The second batch of nitrogen fertilizer was added one month after planting, and the weeds were controlled three days after planting using the atrazine pesticide (80% effective substance) at a rate of 4 kg/h. The grafts were done two weeks after planting for both pit. The plants were thinned to one plant in each pot after reaching a height of 15-20 cm. The plants were watered as needed. The granular diazinon pesticide (10%) was used as an effective substance to control the corn stem borer Sesamia critica at an amount of 6 kg/ha and in two batches, the first at the stage of (4 to 5) leaves, and the other after 15 days from the first batch, sowing was done for the spring season on 15/ 3/2022 and the autumn season on 7/12/2022.

Gibberellin and thiamine (vitamin B_1) were prepared at a concentration of (100 mg / L^{-1}) from the acid, and it was prepared by taking 1 g containing 1 gm of active substance and dissolving it in a liter of distilled water to obtain a stock solution and keeping the solution in a vial dark place and take 100 ml of the base solution and complete the volume to 1000 ml in order to obtain a concentration of 100 mg/L^{-1}. Each level of gibberellin and thiamine is sprayed until complete wetness on the leaves of plants in the early morning using a knapsack sprinkler with a capacity of 16 liters with the use of a dispersant material for the spray solution at a rate of 3 cm 3 per 20 liters to reduce the surface tension of the water and to ensure complete wetness for both season to increase the efficiency. The spray solution penetrates the outer surface of the leaf. The soil of the experiment was analyzed before planting by taking random samples from it to a depth of (0-30 cm) to conduct an analysis of the soil's physical and chemical traits in the

Table 1: Physical and chemical traits of the experimental field soil.

	Traits	**Units**	**Values**
	pH	–	7.8
Soil electrical conductivity EC		Ds.m^{-1}	2.77
Macro elements	Nitrogen	ppm	30.35
	Phosphorous		6
	Potassium		205
Texture	Sand	g/kg	148.40
	Silt		51.01
	Clay		341.30
		Clay loam	

laboratories of the College of Agriculture, Al-Qasim Green University, as shown in Table 1.

2.2 Studies traits

2.2.1 Plant height (cm): The stem height was measured from the soil surface to the end of the plant, at the rate of five plants taken randomly from each experimental unit.

2.2.2 Leaf area cm²: Calculated from the measurement of the maximum leaf length × maximum width × 0.75, which is located under the top leaf and for ten plants randomly taken from each treatment after flowering is complete.

2.2.3 Stem Diameter (mm): The stem diameter was measured using a micrometer varnier device from the middle of the stem of ten plants of the central marzine at full flowering [Al-Sahoki (1990)].

2.2.4 Plant yield: After extracting the average plant yield from dry grains (with a moisture content of 15.5%), the rate was multiplied by the plant density to obtain the grain yield per unit area (ton/ha) for each genotype in the experiment.

2.2.5 Biological Yield (tons.ha^{-1}): It represents the vegetative total (stems, leaves and stalks).

2.2.6 Harvest Index %: According to the following equation

$$\text{Harvest index} = \frac{Grain\ yield}{Biological\ yield} \times 100 .$$

3. Results and Discussion

3.1 Plant height

Table 2 showed that the stages of spraying gibberellin and thiamine had a significant effect on the plant height and for both season .This was followed by the formation of 4 leaves (A1), which gave a plant height of 160.51, 156.17 cm for both season, respectively, while the flowering stage (A3) gave the lowest plant height of 155.50 and 150.58 cm for both season, respectively. Also, spraying gibberellin and thiamine had a significant effect on plant height. The treatment of spraying thiamine and gibberellin (B3) excelled and gave the highest average plant height and 168.62 cm for both season, followed by the gibberellin spray treatment with a concentration of 100 mg.L^{-1} and gave an average height of 165.02 and 1159.96 cm for both season, respectively. While the control treatment (B0) gave the lowest plant height of (146.26 and 141.97) cm for both season, respectively. The results of the same table also showed that the interaction between spraying stages and spraying concentrations had a significant effect on plant height, respectively for the two arrows, while the control treatment gave the lowest average plant height for both season, which reached 140.67 and 136.83 cm. The excelled spraying treatment of gibberellins and thiamine at a concentration of 100 mg.L^{-1} may be due to, as the gibberellins activate the formation of nucleic acids, and the treatment with gibberellins contributes to the conversion of processed nutrients to a greater degree towards the growth site. Gibberellin also has a role in cell division and increasing their water absorption by increasing the flexibility and plasticity of cell walls and increasing their expansion [Al-Wahsh (2008)] or is attributed to the role of thiamine and its contribution to activating cellular activities, including the synthesis of amino acids and proteins, and thus the synthesis of nucleic acids, DNA and RNA, which are the materials. The genetics of the body and thus increase the rate of growth and improve the performance of the plant and that spraying at the stage of 8 leaves encouraged the plant to continue growing and supported by the products of photosynthesis and this is consistent with what was reached by Al-Jubouri *et al*. (2018) on yellow corn.

3.2 Leaf area (cm²)

Table 3 showed that the stages of spraying gibberellin and thiamine had a significant effect on the leaf area for both season, the stage of formation of 8 leaves (A2) excelled and gave the highest average of the leaf area amounted to 6343.34 and 79175 cm² for both season, respectively, followed by the stage of grain formation (A1) average. The leaf area is 5968.18 and 6066.60 cm² for both season, respectively. The flowering stage (A3) was recorded and it gave the lowest mean of the leaf area of the two hairs, which reached 5810.40 and 5757.35 cm², respectively. Also, the spraying of gibberellin and thiamine had a significant effect on the leaf area. The treatments of spraying thiamin and gibberellin (B3) was excelled and gave the highest mean for the leaf area and for both season, which reached 6778.96 and 6718.31 cm², respectively. This was followed by the treatment of gibberellin spraying with a concentration of 100 mg.L^{-1} and it gave an average of the leaf area of 6307.19 and 6246.63 cm ^{2} for the two loops, respectively, while the comparison treatment (B0) gave the lowest average of the leaf area

Table 2: Effect of spraying concentrations of gibberellin and thiamine, spraying stages and the interaction between them on the height of yellow corn plant (cm) for both season.

Spray stages (A)	Spring season				Average (A)	Autumn season				Average (A)
	Gibberellin and thiamine spray (mg.L^{-1}) (B)					Gibberellin and thiamine spray (mg.L^{-1}) (B)				
	B0	B1	B2	B3		B0	B1	B2	B3	
A1	140.67	164.21	163.98	173.17	160.51	136.83	159.70	159.47	168.66	156.17
A2	149.74	174.94	154.20	179.58	164.62	145.23	170.43	149.70	175.08	160.11
A3	148.36	155.91	151.09	166.64	155.50	143.85	149.74	146.59	162.13	150.58
Average (B)	146.26	165.02	156.42	173.13		141.97	159.96	151.92	168.62	
L.S.D 0.05		A=2.11	B = 1.64	A*B =2.92		A = 2.00	B = 1.25		A*B =2.42	

Table 3: Effect of spraying concentrations of gibberellin and thiamine, spraying stages, and the interaction between them on the leaf area cm2 of yellow corn for both season.

Spray stages (A)	Spring season				Average (A)	Autumn season				Average (A)
	Gibberellin and thiamine spray (mg.L^{-1}) (B)					Gibberellin and thiamine spray (mg.L^{-1}) (B)				
	B0	B1	B2	B3		B0	B1	B2	B3	
A1	4978.64	6203.12	6333.10	6790.60	6076.37	4918.76	6142.57	6472.55	6729.74	6065.91
A2	5358.43	6916.40	6067.92	7030.60	6343.34	5297.89	6855.85	6007.37	6970.06	6282.79
A3	5142.09	5802.04	5781.79	6515.67	5810.40	5111.54	5741.49	5721.24	6455.12	5757.35
Average (B)	5159.72	6307.19	6060.94	6778.96		5109.40	6246.63	6067.05	6718.31	
L.S.D 0.05		A=94.9	B = 90.6	A*B=151.8		A=152.9	B = 125.7		A*B =219.1	

of 5159.72 and 5109.40 cm^2 for both season, respectively. The results of the same table also showed that the interaction between spraying stages and spraying concentrations had a significant effect on the leaf area. The interaction treatment composed of (8 leaf formation stage + spraying of gibberellin and thiamine at a concentration of 100 mg.L^{-1}) excelled and gave the highest mean of the leaf area amounted to 7030.60 and 6970.06 cm^2 for both season, respectively, while the comparison treatment gave the lowest mean of the yield for both season amounted to 4978.64 and 4918.76 cm^2 and that the increase in the leaf area as a result of spraying gibberellin and thiamine can be due to the fact that thiamine is formed in the leaves and depends on the light in its formation [Muhammed and El-Younes (1991)] and has a role in activating cellular activities, including the synthesis of amino acids and proteins, and thus the synthesis of nucleic acids, DNA and RNA, which are the materials. The genetics of the body and thus increase the growth average and improve the performance of the plant. This may be due to the action of auxins induced by the addition of gibberellins, which has a role in cell growth. On the other hand, auxins induced by gibberellins play an important role in stimulating the softness of cell walls and by breaking the bonds of the cell walls and rearranging them in new locations under the influence of bulging pressure, which contributes to an increase in cell size and breadth by increasing its protoplasmic content, reflected on the surface area of the plant.

3.3 Stem diameter (cm)

Table 4 showed that the stages of spraying gibberellin and thiamine had a significant effect on the stem diameter. The stage of formation of 8 leaves (A2) excelled and gave the highest mean for the stem diameter which reached 2.27 and 2.16 cm, respectively, while it gave the stage of formation of 4 leaves (A1), the minimum diameter of the stem reached 1.88 cm, as for the autumn season, the flowering stage (A3) recorded the lowest diameter of the stem at 1.87 cm. Also, spraying gibberellin and thiamine had a significant effect on the stem diameter. Then the treatment of gibberellin spraying (B3) gave an average of 2.27 and 2.09 cm for the stem diameter for both season, while the control treatment (B0) gave the lowest average for

Table 4: Effect of spraying concentrations of gibberellin and thiamine, and the spraying stages and their interactions, on the stem diameter of the yellow corn plant for both season.

Spray stages (A)	Spring season				Average (A)	Autumn season				Average (A)
	Gibberellin and thiamine spray (mg.L^{-1}) (B)					Gibberellin and thiamine spray (mg.L^{-1}) (B)				
	B0	B1	B2	B3		B0	B1	B2	B3	
A1	1.38	2.29	1.45	2.40	1.88	1.21	2.08	2.03	2.23	1.89
A2	1.76	2.38	1.99	2.95	2.27	1.63	2.29	1.88	2.83	2.16
A3	1.78	2.15	1.99	2.31	2.06	1.64	1.90	1.77	2.16	1.87
Average (B)	1.64	2.27	1.81	2.55		1.49	2.09	1.89	2.41	
L.S.D 0.05		A=N.S	=B 0.20	A*B =0.38		A=0.17	=B 0.07		A*B =0.18	

Table 5: Effect of spraying the concentrations of gibberellin and thiamine and the spraying stages and the interaction between them on the total plant yield of yellow corn for both season.

Spray stages (A)	Spring season				Average (A)	Autumn season				Average (A)
	Gibberellin and thiamine spray (mg.L^{-1}) (B)					Gibberellin and thiamine spray (mg.L^{-1}) (B)				
	B0	B1	B2	B3		B0	B1	B2	B3	
A1	106.66	185.55	180.20	197.51	167.48	100.60	179.49	175.47	191.45	161.75
A2	128.76	208.27	166.47	220.78	181.07	122.70	202.21	160.41	214.71	175.01
A3	131.82	156.58	153.60	186.38	157.09	125.75	150.51	147.54	180.32	151.03
Average (B)	122.41	183.47	166.76	201.56		116.35	177.40	161.14	195.49	
L.S.D 0.05		A=11.233	B=5.672	A*B =12.357		A=6.053	B = 4.924		A*B =8.610	

the stem diameter of 1.64 and 1.49 cm for both, respectively. The results of the same table also showed that the interaction between the spraying stages and spraying concentrations had a significant effect on the stem diameter. The interaction treatment composed of (8 leaf formation stage + spraying gibberellin and thiamine at a concentration of 100 mg.L^{-1}) excelled and gave the highest mean for the stem diameter of 2.95 and 2.83 cm for both season, respectively, while the comparison treatment gave the lowest mean for the stem diameter for both season, which amounted to 1.38 and 1.21 cm, respectively. This may be due to the addition of gibberellins having an important role in influencing the enzymes that make up the cell walls, especially cellulase, which in turn weakens the fiber systems and in building the components of the cell walls and their decomposition, which may come through activating the pumping of hydrogen ions (protons) and reducing the cell pH, which causes an increase in the acidity of the cell wall and a change the bonds and thus increase the plasticity of the cell wall and thus increase the diameter of the stem. Table 4 and this agrees with Al-Maleki *et al*. (2020), when spraying gibberellin on yellow corn, Al-Jubouri *et al*. (2018) on corn.

3.4 Total plant yield

Table 5 showed that the stages of spraying gibberellin and thiamine had a significant effect on the plant yield for both season. The stage of formation of 8 leaves (A2) excelled and gave the highest average yield of 181.07 and 175.01 for both season, respectively, followed by the stage of formation of 4 leaves (A1), which gave an average yield for both season. 167.48 and 161.75, respectively, while the flowering stage (A3) gave the lowest average yield of 157.09 and 151.03 for grapevines, respectively. Also, spraying gibberellin and thiamine had a significant effect on plant yield. The treatment of thiamine and gibberellin (B3) was excelled and gave the highest rate of yield for both season 167.48 and 161.75, respectively. 201.56 and 195.49, respectively, followed by the treatment of gibberellin at a concentration of 100 mg.L^{-1}, which gave an average yield of 183.47 and 177.40 for the two loops, respectively, while the control treatment (B0) gave the lowest

Table 6: Effect of spraying concentrations of gibberellin and thiamine and the spraying stages and their interactions on the biological yield of yellow corn for both season.

Spray stages (A)	Spring season				Average (A)	Autumn season				Average (A)
	Gibberellin and thiamine spray (mg.L^{-1}) (B)					Gibberellin and thiamine spray (mg.L^{-1}) (B)				
	B0	B1	B2	B3		B0	B1	B2	B3	
A1	269.62	537.29	516.43	616.14	484.87	254.80	522.48	501.62	601.33	470.06
A2	344.12	633.01	502.75	715.36	548.81	329.31	618.20	487.94	683.88	529.83
A3	315.38	434.73	420.36	545.65	429.03	300.57	421.58	407.21	532.50	415.47
Average (B)	309.70	535.01	479.84	625.71		294.89	520.75	465.59	605.90	
L.S.D 0.05		A=21.52	B=19.90	A*B =33.60		A=8.37	B= 20.29		A*B =30.93	

average yield of 122.41 and 116.35 for the two loops, respectively. The results of the same table also showed that the interaction between spraying stages and spraying concentrations had a significant effect on plant yield. Whereas, the control treatment gave the lowest mean for both season, which was 106.66 and 100.60, respectively. The reason for the excelled of spraying gibberellin and thiamine can be attributed to the fact that the yield of grain is a complex quantitative traits that is controlled by a large number of genetic factors as well as environmental factors such as temperature, humidity and other factors. The production of one plant of grain depends on two necessary concomitant steps, namely the occurrence of pollination and fertilization and the amount of building photosynthesis in the period between fertilization and crop maturity to store nutrients in grains, and since gibberellins have an important role in improving plant growth.and increasing fertilization and flowering, and thus increasing yield (Table 5).

3.5 Biological yield

Table 6 showed that the stages of spraying gibberellin and thiamine had a significant effect on the biological yield and for both season, the stage of formation of 8 leaves (A2) excelled and gave the highest mean for the biological yield, which reached 548.81, 529.83, respectively. Followed by the stage of formation of 4 leaves (A1), which gave an average of the biological yield for both season of 484.87 and 470.06, respectively, while the flowering stage (A3) gave the lowest average of the biological yield of 429.03 and 415.47 for both season, respectively. Also, the spraying of gibberellin and thiamine had a significant effect on the biological yield. The coefficient of spraying thiamine and gibberellin (B3) was excelled and gave the highest mean for the biological yield and for both season, which reached 625.71, 605.90. This was followed by the treatment of gibberellin spraying with a concentration of 100 mg.L^{-1} and it gave a high average of 534.87 and 520.78 for the two grapes, respectively, while the comparison treatment (B0) gave the lowest average of the biological yield, which reached (269.62, 254.80) for both season, respectively. The results of the same table also showed that the interaction between spraying stages and spraying concentrations had a significant effect on the biological yield. The combination treatment (the stage of formation of 8 leaves + spraying gibberellin and thiamine at a concentration of 100 mg.L^{-1}) excelled and gave the highest average biological yield of 715.36, 683.88 for the two grapes, respectively, while the control treatment gave the lowest average of the biological yield for both season amounted to 269.62 and 254.80 cm.

3.6 Harvest index

Table 7 showed that the stages of spraying gibberellin and thiamine had a significant effect on the harvest index of grapevines. The flowering stage (A3) excelled and gave the highest average of the harvest index of 37.16 and 36.94 for both season. While, the stage of formation of 8 leaves (A2) gave the lowest mean for the harvest index, which reached 33.66 and 34.28 for the two grapes, respectively. Also, spraying gibberellin and thiamine had a significant effect on the harvest index. The results of the same table also showed that the interaction between spraying stages and spraying concentrations had a significant effect on the harvest index. The interaction treatment composed of (4 leaf formation stage + without spraying) excelled and gave the highest mean for the harvest index of 39.65 and 39.67 for both season, respectively, while the treatment of 4 leaf formation stage (A1) + spraying gibberellin and thiamine at a concentration of 100 mg.L^{-}

Table 7: The effect of spraying concentrations of gibberellin and thiamine and the spraying stages and the interaction between them on the harvest index of corn plant for both season.

Spray stages (A)	Spring season				Average (A)	Autumn season				Average (A)
	Gibberellin and thiamine spray (mg.L^{-1}) (B)					Gibberellin and thiamine spray (mg.L^{-1}) (B)				
	B0	B1	B2	B3		B0	B1	B2	B3	
A1	39.65	34.60	35.16	32.06	35.37	39.67	34.34	33.64	31.84	34.87
A2	37.64	32.89	33.26	30.86	33.66	37.44	32.70	33.04	33.93	34.28
A3	41.83	36.09	36.56	34.16	37.16	41.89	35.74	36.27	33.87	36.94
Average (B)	39.71	34.53	34.99	32.36		39.67	34.26	34.32	33.22	
L.S.D 0.05		A=N.S.	B= 2.025	A*B =4.126		A=N .S	B= 2.584		A*B =4.552	

[1]) excelled. The lowest average for the harvest index is 30.86. The reason for the increase in the yield index when spraying with gibberellin and thiamine is due to the effect of gibberellin in increasing the grain yield significantly more than its effect on the biological yield, and this is consistent with the findings of Al-Jubouri *et al*. (2018) on yellow corn.

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