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EFFECT OF THE NUMBER OF FOLIAR SPRAYING TIMES WITH GLUTATHIONE FOR DIFFERENT STAGES IN SOME TRAITS OF GROWTH AND YIELD OF CORN (*ZEA MAYS* L.)

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Abstract

A field experiment was conducted during the spring season of 2017 in Al-Mahnawia region, Babylon Province with the aim of determining the best concentration of Glutathione, the best response stage for spraying and the best interaction between the concentration of Glutathione and the spraying stage which give the best traits for the growth and yield of maize. Randomized Complete Block Design (RCBD) was used. The experiment included two factors: the first factor is spraying of Glutathione with concentrations of (50, 100 mg.L^{-1}) in addition to the control treatment (without spraying) and the second factor is response of seven combinations of different growth stages from the emergence of corn leaves, which are (6, 9, 12, 6 + 9, 6 + 12, 9 + 12, 6 + 9 + 12 leaf. $plant^{-1}$). The results showed that there were significant differences in the concentrations of Glutathione spraying, The concentration of (100 mg.L^{-1}) was excelled by giving it the highest averages in the traits of plant height (242.81 cm), the length of the cob (22.34 cm), the grains number in the cob (459.61 grain.cob^{-1}) and Weight of 1000 grains (322.83 g), respectively. The concentration of (50 mg.L^{-1}) was excelled by giving it the highest averages in the traits of the leaf area (5453 cm^2), the grain yield of the plant (159.19 g.$plant^{-1}$) and the total grain yield (11.06 tons.ha^{-1}), respectively. The interaction of Glutathione spraying (6 + 12 leaf.$plant^{-1}$) was excelled in all the above mentioned traits, respectively. The bi-interaction between the concentration of Glutathione and the spraying stage has excelled where the concentration of (50 mg.L^{-1}) and a spraying combination of (6 leaves +9 leaves) gave the highest average of plant yield was (168.66 g. $plant^{-1}$) and the total grain yield was (11.75 ton.ha^{-1}), respectively and did not differ significantly from the Spraying combination (6 leaves + 12 leaves). We conclude from this study that the best concentration for Glutathione spraying of (50 mg.L^{-1}) in a spraying combination of (6 leaves + 12 leaves) to excelling it in most of the studied traits and did not differ significantly from the spraying combination of (6 leaves + 9 leaves).

Key words: Number of grains, plant yield, growth stage, concentration, foliar spraying.

Introduction

corn (*Zea mays* L.) is one of the field grain crops belonging to the Poaceae family, which has economic value for its many uses. The vegetative parts are suitable as green feed for animal or in the form of silage (Singhal, 1999). Their grains (cobs) are used for human nutrition after grinding and mixing with wheat flour. Industrially, paper can be made from the stem of its plants (Ibrahim *et al.,* 1986). The cultivation of yellow corn Spreads in most parts of the world and in different environments, for this reason we call it a highly adaptable crop. Its main habitat is America, where it was first discovered. It is considered one of the most important crops in the world and Iraqbecause it is from grain crops. It occupies second place after wheat in the world in terms of cultivated area for 2015, where the cultivated area was approximately 182 million hectares and produced about 824 million tons (F.A.O., 2015), despite the importance of the crop in Iraq, the rate of production in the unit area is still low, and there are reasons behind the decline of productivity in unit area, including the deterioration of agricultural land due to the high pH in Iraqi soil. These studies focus on finding the means by which to reduce the pH, reduce the effect of calcium, and these means are spraying the Glutathione on the leaves of the corn (Al-Maha cultivar) at various stages of plant life, which reduces the calcium effect and improve the properties of physical and chemical soil. Tripeptide Glutathione is the most abundant in plant

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tissue, plays multiple roles in cellular metabolism and is a major compound in sulfur metabolism. It is also one of the main forms of Sulfur reductase. The Sulfur reductase pathway is linked to the protein structure, in addition to which it is regulator for reducted sulfur, On the other hand, it is a strong reducted of ROS (Tausz and Grill, 2000). The study aims to determine the best concentration of Glutathione, the best response stage according to spraying, and the best interaction between the concentration of Glutathione and the spraying stage, which gives the best traits for growth and yield of corn.

Materials And Methods

Experiment location

A field experiment was conducted during the spring season of 2017 in Al-Mahnawia region, Babylon Province with the aim of determining the best concentration of Glutathione, the best response stage for spraying and the best interaction between the concentration of Glutathione and the spraying stage which give the best describes for the growth and yield of corn (Al-Maha cultivar). The seeds were obtained from Abu Ghraib Research Station.

Experiment design

The experiment was conducted according to Randomized Complete Block Design (RCBD) in a factorial experiment. (The experiment included two factors: the first factor is spraying of Glutathione with concentrations of (50, 100 mg.L^{-1}) in addition to the control treatment (without spraying) and the second factor is response of seven combinations of different growth stages from the emergence of corn leaves, which are (6, 9, 12, 6 + 9, 6 + 12, 9 + 12, 6 + 9 + 12 leaf), with three replicates, where a total experimental units were (63 experimental unit). The soil of the field was analyzed before cultivating to study some of its chemical and physical traits in the laboratories of the Technical Institute of Kufa by taking samples at a depth of 30 cm as shown in Table 1. The soil was prepared for agriculture where settled, smoothing and divided into experimental units with dimensions of (3 × 4 m). Seeds were cultivated on the lines, the distance between the line and another is 75 cm and between plant and another is 25cm. Phosphate fertilizer (P20%) was added before the cultivating with rate of (100 kg.ha^{-1}) and the addition of urea (46% N) fertilizer with rate of (320 kg N.ha^{-1}) and in two batches at cultivating and after one month of cultivation Shuwailiya, (2000) by fertilizing the fertilizer on a line at 5 cm away from the agriculture line and on one side only (Al-Dulaimi, 1984). The seeds (Al-Maha cultivar) were cultivated manually on 23/3/2017 by placing 3 grains in pit and then cut into one plant when the plants reached a height of 15-20 cm. The field was sprayed with Atrazine pesticide (80% active ingredient) with amount of (4 kg.ha^{-1}) after cultivating and before the appearance of seedlings, to combat the annual thicket and continue to remove the thicket whenever needed. Sesamiacretica was combated by spraying the apical meristem of the plants with the herbicide Diazinon (10% GR), with 6 kg.ha^{-1}, in the two batches, the first after 20 days of germination and the other after 15 days from the first batch (Ali, 1980). The crop was harvested on 23/7/2017.

Preparation of Glutathione concentration

Glutathione was prepared with concentrations of (50, 100 mg.L^{-1}), it was sprayed immediately after the preparation it at the early morning by a 20L Backpack Sprayer on the plants and until the total wetness in three stages of plant life (6, 9, 12 leaf.$plant^{-1}$), their interaction, and the control treatment was sprayed with distilled water only.

Studied traits

1. Plant height (cm): it was calculated By measuring five plants from the intermediate lines of the experimental unit from the soil surface to the lower node of the inflorescences (Odongo and Bacholt, 1995).

2. Leaf area (cm^2): It was measured by taking five plants from each experimental unit and the leaf area was measured for each plant through the following equation

(Length of leaf under cob leaf)^2 × 0.75 (EL-Sahookie, 1985).

3. Length of the cob (cm): It was measured by taking ten cobs and extracted the average.

4. The number of grains in cob (grain.cob^{-1}): It was calculated by taking ten cobs and spread its grain and extracted the average.

5. The weight of 1000 grains (g): It was measured by a sensitive balance.

6. The grain yield of the plant (g): It was measured by taking ten plants from each experimental unit and the average yield of one plant was extracted.

7. Total yield (ton.ha^{-1}): The average of the plant yield × determined plant density Al-Sahuki (1990) after adjusting the weight to a moisture content of 15.5% for all traits related to weight according to the following equation

$$\text{Factor}=\frac{(\text{moist}-100\%)}{(15.5\,\text{moist}-100\%)}\times\text{sample weight}$$

Statistical analysis

The experimental data were analyzed according to

the variance analysis and for all the studied traits. The average were compared for the treatments using the least significant difference (L.S.D) at level of 0.05 Steel and Torrie, (1960) and using the Genestat program.

Results And Discussion

Plant Height (cm)

Table 2 indicates a significant effect of Glutathione concentration and spraying stages and their interaction in this traits. The concentration of Glutathione (100 mg.L^{-1}) gave the highest average for this trait was 242.81 cm. While the treatment of distilled water gave the lowest average for this trait of (219.10 cm). These results were consistent with (Klapheck *et al.,* 1992; Gullner *et al.,* 1999) indicated that the spraying of Glutathione with different concentrations on yellow corn and white corn led to increase the plant height compared to the control treatment, the table also showed no significant difference between the concentrations of (50, 100 mg.L-1). The spraying stage to the emergence of (6 leaves + 12 leaves) gave the highest average of this trait was (239.78 cm), while the stage of 6 leaves gave the lowest average of this trait (227.67 cm). The reason for the increase may be due to the fact that Glutathione is an antioxidant that has a role in plant development, cell division and elongation (15, 16 m). The results agree with Aziz *et al.,* (2014) indicated that a significant increase in plant height of the yellow corn plants when sprayed with Glutathione at the stage of six leaves on the plant compared to the control treatment. Table 2 showed a significant interaction between the Glutathione concentrations and the spraying stages. The concentration (50 mg.L^{-1}) and spraying stage of (9 leaves +12 leaves) gave the highest average for this traits amounted to (259.00).

Leaf area (cm^2)

Table 3 shows a significant effect on Glutathione concentrations and spraying stages and their interaction in this trait. The Glutathione concentration (50 mg.L^{-1}) gave the highest average of this trait was 5453 cm^2, While the treatment of distilled water gave the lowest average of this trait was (5177 cm^2), The results agree with Romero-Puertas *et al.,* (2006) that spraying the Poaceae family plants with Glutathione led to a significant increase in the leaf area (Hussein *et al.,* 2014). The spraying of yellow corn plants with Glutathione led to a significant increase in the leaf area compared to control treatment. The spraying stage (6 leaves +12 leaves) (S4) gave the highest average of this trait was (5513 cm^2), While the 6 leaves stage gave the lowest average of this trait (5270 cm^2), The reason for the increase may be due to the fact that the Glutathione is composed of three amino acids glycine, glutamic and cysteine, and that the physiologic role of the acids is a change in the negative of the Osmotic pressure, The increase in amino acids leads to a decrease in the Osmotic pressure, which in turn reduces the water stress of the cell and increases the cell's ability to withdraw dissolved nutrients and water and thus increase vegetative growth (Amini and Ehsanpour, 2005). Results agree with Gao *et al.,* (2015) that indicated to a significant increase in the leaf area of the plant when sprayed with Glutathione after 12 days of emergence of yellow corn plants. The results of Table 3 indicate a significant interaction between the Glutathione concentrations and the spraying stages. The concentration (50 mg.L^{-1}) and spraying stage (6 leaves + 9 leaves + 12 leaves) gave

Table 1: Some chemical and physical traits of soil model used prior to cultivating.

Trait		Soil components	
PH	7.2	Sand (g.kg^{-1} soil)	208
Electrical conductivity Ec (ds.m^{-1})	1.5	Clay (g.kg^{-1} soil)	318
Nitrogen availability (mg.kg^{-1} soil)	55	Silt (g.kg^{-1} soil)	474
Phosphorus availability (mg.kg^{-1} soil)	19.0	Soil Texture	sandy clay loam
Potassium availability (mg.kg^{-1} soil)	150		
Organic matter (g.kg^{-1} soil)	0.53		

Table 2 : Effect of Glutathione concentrations and spraying stages and their interaction in plant height (cm).

Glutathione / Spraying stages	0 mg.L^{-1}	50 mg.L^{-1}	100 mg.L^{-1}	Average of growth stages
6 leaves	212.67	229.33	241.00	227.67
9 leaves	223.33	226.67	235.33	228.44
12 leaves	225.67	236.33	243.67	235.22
6 + 9 leaves	216.67	249.00	242.33	236.00
6 + 12 leaves	219.00	251.33	249.00	239.78
9 + 12 leaves	214.00	259.00	245.67	239.56
6 + 9 + 12 leaves	222.33	242.67	242.67	235.89
Average of Glutathione concentration	219.10	242.05	242.81	
L.S.Dconcentration	3.48			
L.S.D stages	5.32			
L.S.D interaction	9.21			

Table 3 : Effect of Glutathione concentrations and spraying stages and their interaction in leaf area (cm^2).

Glutathione / Spraying stages	0 mg.L^{-1}	50 mg.L^{-1}	100 mg.L^{-1}	Average of growth stages
6 leaves	5174	5266	5371	5270
9 leaves	5159	5335	5394	5296
12 leaves	5116	5374	5497	5329
6 + 9 leaves	5225	5507	5424	5385
6 + 12 leaves	5224	5775	5539	5513
9 + 12 leaves	5158	5368	5463	5330
6 + 9 + 12 leaves	5181	5547	5337	5355
Average of Glutathione concentration	5177	5453	5432	
L.S.Dconcentration	64.6			
L.S.D stages	98.7			
L.S.D interaction	170.9			

Table 4 : Effect of Glutathione concentrations and spraying stages and their interaction in the length of cob (cm).

Glutathione / Spraying stages	0 mg.L^{-1}	50 mg.L^{-1}	100 mg.L^{-1}	Average of growth stages
6 leaves	17.42	18.96	21.78	19.39
9 leaves	18.29	19.53	22.25	20.02
12 leaves	17.69	20.85	21.96	20.17
6 + 9 leaves	17.59	22.44	22.58	20.87
6 + 12 leaves	18.24	22.65	22.92	21.27
9 + 12 leaves	17.65	23.00	23.07	21.24
6 + 9 + 12 leaves	17.98	22.41	21.81	20.73
Average of Glutathione concentration	17.84	21.41	22.34	
L.S.Dconcentration	0.50			
L.S.D stages	0.78			
L.S.D interaction	1.34			

the highest average of this trait was (5775).

The length of cob (cm)

Table 4 indicates a significant effect of Glutathione concentrations and spraying stages and their interaction in this trait. The Glutathione concentration (100 mg.L^{-1}) gave the highest average of this trait was (22.34 cm), While the treatment of distilled water gave the lowest average of this trait (17.84 cm), The results agree with Fricker *et al.,* (2000) that found the spraying of Glutathione on the yellow corn plants at the 9 leaves stage led to a significant increase in the length of cob compared to the non-spraying. The spraying stage (6 leaves + 12 leaves) gave the highest average for this trait (21.27 cm), While the stage of 6 leaves gave less average for this trait (19.39 cm), The results agree with Xiang *et al.,* (2001) that found the foliar spraying with Glutathione at eight stage leaves significantly increased the length of the cob compared to the non-spray treatment. The results of Table 4 showed a significant interaction between the Glutathione concentrations and the spraying stages. The concentration (100 mg.L^{-1}) and spraying stage (9 leaves + 12 leaves) gave the highest average for this trait (23.07 cm).

The number of grains in cob

Table 5 indicates a significant effect of Glutathione concentration and spraying stages and their interaction in this trait. The Glutathione concentration of (100 mg.L^{-1}) gave the highest average of this trait was (459.61 grain.cob^{-1}), While the treatment of distilled water gave the lowest average of this trait amounted to (426.73 grain.cob^{-1}), The results agree with Hartmann *et al.,* (2003) mentioned that spraying the yellow corn plants with Glutathione led to a significant increase in the number of grains in the cob. The spraying stage (6 leaves + 12 leaves) gave the highest average of this trait was (455.67 grain.cob^{-1}) While the stage of 6 leaves gave less average of this trait amounted to (435.57 grain.cob^{-1}). The reason for the increase in the number of grains in cob may be due to the fact that Glutathione has multiple functions during the development of grains where It represents a role in the stages of grain growth and cells division involved in their composition and protection from oxidation. The moisture content varies in grains, as well as metabolic activity and grain growth. As a result, ROS sources vary significantly in the growth stages of grains (25), The grains develop in photosynthesis and respiration, making photosynthesis and the electron transport chain in Mitochondria a source of (ROS) (26). In addition, Glutathione has a role in the defense of cells against oxidation and is contributed in plant growth and control of the cell cycle (15). The results agree with (27) that Glutathione spraying on leaf after 40 days of the emergence of seedling of yellow corn plant led to a significant increase in the number of grains in cob compared to the control treatment. The results of table 5 showed a significant interaction between the Glutathione

Table 5 : Effect of Glutathione concentrations and spraying stages and their interaction in the number of grains in cob (grain.cob^{-1})

Glutathione / Spraying stages	0 mg.L^{-1}	50 mg.L^{-1}	100 mg.L^{-1}	Average of growth stages
6 leaves	422.7	437.7	446.3	435.57
9 leaves	430.7	437.7	452.0	440.13
12 leaves	428.0	456.0	461.0	448.33
6 + 9 leaves	426.0	472.7	464.7	454.47
6 + 12 leaves	423.3	477.7	466.0	455.67
9 + 12 leaves	426.7	464.3	470.0	453.67
6 + 9 + 12 leaves	429.7	459.3	457.3	448.77
Average of Glutathione concentration	426.73	457.91	459.61	
L.S.Dconcentration	6.56			
L.S.D stages	10.02			
L.S.D interaction	17.36			

Table 6 : Effect of Glutathione concentrations and spraying stages and their interaction in the weight of 1000 grain (g).

Glutathione / Spraying stages	0 mg.L^{-1}	50 mg.L^{-1}	100 mg.L^{-1}	Average of growth stages
6 leaves	321.7	311.3	321.3	318.10
9 leaves	318.0	323.2	326.0	322.40
12 leaves	303.0	325.7	320.0	316.23
6 + 9 leaves	321.0	312.3	325.7	319.67
6 + 12 leaves	322.5	324.8	326.5	324.60
9 + 12 leaves	301.0	313.5	323.0	312.50
6 + 9 + 12 leaves	312.3	314.0	317.3	314.53
Average of Glutathione concentration	314.21	317.83	322.83	
L.S.Dconcentration	5.38			
L.S.D stages	8.22			
L.S.D interaction	14.23			

concentrations and the spraying stages. The concentration (50 mg.L^{-1}) and spraying stage (6 leaves + 12 leaves) gave the highest average for this trait was (477.7 grain.cob^{-1}).

Weight of 1000 grain (g)

The results shown in table 6 showed a significant effect of Glutathione concentrations and spraying stages and their interaction in this trait. The Glutathione concentration of (100 mg.L^{-1}) gave the highest average for this trait amounted to (322.83 g), While the treatment of distilled water gave the lowest average for this trait (314.21 g), the results agree with Mendoza-Cózatl *et al.,* (2008) indicated that spraying the Glutathione with different concentrations on the yellow corn plant led to a significant increase in the weight of 500 grains. The spraying stage (6 leaves + 12 leaves) gave the highest average of this trait reached (324.60 g). The reason for the increase in the average of 1000 grain is probably due to the increased Glutathione concentration of where Glutathione is a small, oxidizing and reducing molecules which plays a role in the formation of flowers and Salicylic acid. The latter is thought to increase CO_2 representation and dry matter production and regulate its distribution from source to downstream. The results agree with Soltan pour *et al.,* (2015) that the foliar spraying of the Glutathione in 6 leaves on the plant led to a significant increase in the weight of 300 grains of yellow corn. The results of table 6 indicate a significant interaction between Glutathione concentrations and spraying stages. The Glutathione concentration of (100 mg.L^{-1}) and the spray stage(6 leaves + 12 leaves) gave the highest average for this trait of 326.5g.

Grain yield for plant (g)

Table 7 shows a significant effect of Glutathione concentration and spraying stages and their interaction in this trait. The Glutathione concentration of (50 mg.L^{-1}) gave the highest average of this trait was (159.19 g), While the treatment of distilled water gave the lowest average of this trait amounted to (138.24 g), The results agree with Mahgouh *et al.,* (2015) indicated that spraying the yellow corn plants with Glutathione at different stages of growth led to a significant increase in plant yield. The spraying stage of (6 leaves + 12 leaves) gave the highest average for this trait reached (154.11 g), While the spraying stage of 6 leaves gave a lower average for this trait 148.11 g. The reason for the increase in the grains yield of the plant to the role of cl Glutathione in the increase the components of the crop are the length of the cob as shown in Table 4, the number of grains in the cob as shown in Table 5 and the weight of 1000 grain as shown in Table 6. Glutathione has an important role in controlling and maintaining the intracellular oxidation system as it is important in the process of photosynthesis (Hell and Bergmann, 1990). The reason for the increase may be due to the fact that glutathione is an antioxidant that works

Table 7 : Effect of Glutathione concentrations and spraying stages and their interaction in the plant yield of grain (g).

Glutathione / Spraying stages	0 mg.L^{-1}	50 mg.L^{-1}	100 mg.L^{-1}	Average of growth stages
6 leaves	136.33	153.67	154.33	148.11
9 leaves	140.00	153.33	161.33	151.55
12 leaves	140.33	160.00	160.67	153.67
6 + 9 leaves	133.33	168.66	155.40	152.46
6 + 12 leaves	141.33	166.00	155.00	154.11
9 + 12 leaves	136.00	158.67	158.65	151.11
6 + 9 + 12 leaves	140.33	154.00	153.33	149.22
Average of Glutathione concentration	138.24	159.19	156.96	
L.S.Dconcentration	3.41			
L.S.D stages	5.21			
L.S.D interaction	9.02			

Table 8 : Effect of Glutathione concentrations and spraying stages and their interaction in the total plant yield (tons.ha^{-1}).

Glutathione / Spraying stages	0 mg.L^{-1}	50 mg.L^{-1}	100 mg.L^{-1}	Average of growth stages
6 leaves	9.70	10.65	10.45	10.27
9 leaves	9.43	10.63	10.81	10.29
12 leaves	9.75	11.33	10.70	10.59
6 + 9 leaves	9.33	11.75	10.59	10.56
6 + 12 leaves	9.55	11.37	11.12	10.68
9 + 12 leaves	9.59	10.94	10.96	10.50
6 + 9 + 12 leaves	9.52	10.77	10.69	10.33
Average of Glutathione concentration	9.55	11.06	10.76	
L.S.Dconcentration	0.25			
L.S.D stages	0.38			
L.S.D interaction	0.65			

to protect cells from destruction by free radicals. It also helps to keep cells active, as well as to increase enzymatic activity Mamdouh, (1995) as well as the formation of Salicylic acid, which has a role in improving plant growth, enhancing photosynthesis, CO_2 and increasing dry matter accumulation. The results agree with Bair *et al.,* (2015) that the foliar spraying with glutathione at different stages of yellow corn growth led to a significant increase in the plant yield of the grain, The stage of 9 leaves has excelled compared to the non-spraying. The results of table 7 indicate a significant interaction between the concentrations of glutathione and the spraying stages. The concentration of (50 mg.L^{-1}) and spraying stage (6 leaves + 9 leaves) gave the highest average of this trait (168.66 g).

Total plant yield (tons.ha^{-1})

The results in table 8 indicated a significant effect of Glutathione concentrations and spraying stages and their interaction in this trait. The glutathione concentration (50 mg. L^{-1}) gave the highest average of this trait was (11.06), While the treatment of distilled water gave the lowest average of this trait (9.55 tons.ha^{-1}), These results agree with Broadbent *et al.,* (1995) that the treatment of yellow corn plants with Glutathione and different stages of growth led to a significant increase in total plant yield. The table showed no significant difference between the concentrations (50, 100 mg.L^{-1}). The spraying stage of (6 leaves + 12 leaves) gave the highest average for the trait of (10.68 tons.ha^{-1}), While the stage of 6 leaves gave less average for the trait (10.27 tons.ha^{-1}). The increase in total yield may be due to the increase in grain yield of plant as shown in table 7, These results agree with Skipsey *et al.,* (2005) that The foliar spraying of the plutonium at the 10 stage gave a significant increase in the length of the cob, the grain yield of the plant and the total yield compared to the non-spraying. The results of table 8 showed a significant interaction between the concentrations of glutathione and the spraying stages. The concentration (50 mg.L^{-1}) and spraying stage of (6 leaves + 9 leaves) gave the highest average for this trait of (11.75 tons.ha^{-1}).

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