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Response of Three Maize (*Zea mays* L.) Varieties to Spraying with Pyridoxine

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Abstract. A field experiment was carried out during the spring season of 2022 with the aim of determining the effects of spraying four concentrations of pyridoxine (0, 1500, 3000, 4500) mg/L on some growth characteristics and yield of three maize varieties (Al-Rabi', Sarah, Baghdad3). The experiment was conducted at the research station of the College of Agriculture - University of Anbar using a randomized complete block design (RCBD) with three replications. The results of the study indicated a significant effect of pyridoxine on plant growth characteristics, and yield and its components. The concentration 4500 mg/L gave the highest average for leaf area, number of grains per ear, weight of 300 grains, and grains yield. The varieties differed significantly in most of the studied traits, as variety (Baghdad3) was distinguished by the shortest period of male and female flowering, the number of grains per ear, and the grain yield; while variety (Al-Rabi') exceeded in the traits of leaf area and weight of 300 grains. The interaction between the varieties and the concentrations of pyridoxine also had a significant effect on most of the studied traits, as variety (Al-Rabi') was superior in grain yield at concentration (4500 mg/L).

Keywords. *Zea mays* L., Pyridoxine, Maize genotypes.

1. Introduction

Maize (*Zea mays* L.) is one of the important grain crops in the world. America, Russia, India, China and South Africa are among the most important countries that produce this crop. Maize is of interest plant for many researchers due to the importance of its multiple uses, as it is used in human and animal nutrition, and is also used in various industries such as the manufacture of starch, oil, alcohol, and secondary wastes from them are included in the plastic and paper industry. Maize has also been used in the production of biofuel, and some countries have become self-sufficient for this crop, including Brazil and America [1].

Although maize is one of the main ancient crops in Iraq, its production rate per unit area is still low due to salt stresses, which exposed from soil and extensive water irrigation; in addition, because of the environmental fluctuations such as high temperatures, high hot winds, and use improper soil and crop management in terms of excessive fertilization and soil salinization. Therefore, attention has turned for studying these obstacles and developing appropriate solutions for them, including using of improved and environmentally friendly varieties for Iraqi regions that could help increasing the productivity rate per unit area. However, choosing the variety alone is not sufficient to raise the crop productivity for the above mentioned reasons, so it is preferable to be accompanied by the use of environmentally safe materials that have the ability to stimulate vegetative growth to increase the plants tolerance to

drought, high temperature, soil salinity, and irrigation water; this may stimulate the plant to exploit its functional and genetic capabilities to obtain high production and good quality without leaving side or negative effects on plants, humans or animals. One of these compounds is vitamins, because they are manufactured within living organisms [2], and also growth regulators such as kinetin [3].
It has been observed through several studies that external application of these organic compounds had a positive effect on plant growth and protein synthesis [4,5]. Among these substances is pyridoxine (vitamin B6), which contributes in activating cellular vital activities such as synthesis of amino acids like tryptophan, which is the basic building block for proteins formation, as well as increasing interactions within living cells, and increasing the growth rate and improving plant performance [6]. The active form of pyridoxine, pyridoxal 5-phosphate, can act as a coenzyme for many metabolic enzymes [7], and has been shown to be a powerful antioxidant [8,9]. For the above mentioned reasons, this research was carried out with the aim of studying the effect of spraying four different concentrations of pyridoxine on productivity and some growth characteristics of three different Iraqi varieties of maize.

2. Materials and Methods

The experiment was conducted at the research station of the College of Agriculture- University of Anbar by applying two factors, the first one included three varieties of maize (Al-Rabi', Sarah, and Baghdad 3), while the second factor included four concentrations (0, 1500, 3000, 4500 mg/L) of pyridoxine (vitamin B6) that sprayed on the plants of the three varieties. The treatment (0 mg/L) represents control treatment (distilled water only). The factorial experiment was achieved according to a randomized complete block design (RCBD) with three replications.
The field was prepared for planting, where two perpendicular plowing was carried out, and then the soil was smoothed and leveled. Random samples of soil were taken from different places at a depth of (0-30 cm) to determine some of their physical and chemical characteristics, as shown in Table (1). The field was divided into twelve experimental units with dimensions of (3×3 m) in three replicates. Each experimental unit contained five rows, the distance between one row and another was 70 cm, and between one hole and another was 25 cm. Nitrogen fertilizer (N 46%) was added at a rate of 200 kg nitrogen/ha in the form of urea in two stages; the first one was after appearing of four leaves and the second was at the flowering stage. Triple superphosphate fertilizer (P_2O_5 46%) was also added at a rate of 200 Kg phosphate/ha.

Table 1. Some chemical and physical characteristics of the soil before planting of the spring season (2022).

Characteristics	Value
pH	8.1
Ec	ds/m2.2
Available N	56.0 PPM
Available P	12.5 PPM
Available K	280.0 PPM
Organic matter	%0.74
Sand	%7.30
Silt	%39.2
Clay	%53.5
Texture	Silt Clay Soil

The seeds were planted during April, 2022, by placing 3 seeds in each hole. The field was irrigated quietly whenever necessary, relying on soil moisture. The plants were thinned out and only one was kept in each hole obtaining a plant density of 5714 plants/ha. Weeding was carried out manually during the growing season whenever necessary. The aqueous solution of pyridoxine was sprayed during the vegetative growth stage and at the beginning of flowering according to the concentrations under study, using a 16-litre backpack sprinkler to which Tween-20 was added as a spreading agent to increase the complete wetness of the plant. The granular pesticide (10% diazinon) was added in the vegetative growth stage to control the corn stem borer (*Sasamia Cretica* L.) in two stages, the first after 20 days of emergence (growth stage of 4-5 leaves), and the second after 15 days from the first

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one [10]. The experimental units were harvested when the plants reached physiological maturity. The studied characters were as follow:

- Number of days from planting until 75% of male flowering: Calculated when 75% of the male anthers appeared on plants of each experimental unit.
- Number of days from planting until 75% of female flowering: Calculated when 75% of the silks appeared on plants of each experimental unit.
- Leaf area (cm^2): Measured during male flowering stage for ten random plants from each experimental unit and according to the following equation [11]:

$$\text{Leaf area} = (\text{Leaf length under the upper leaf petiole})^2 \times (75.0)$$

- Number of grains per ear: It was calculated as an average number of grains per ear for the ten random plants harvested from each experimental unit.
- Weight of 300 grains (g): Calculated as an average of 300 grains taken from the ten random plants harvested from each experimental unit, then weight based on 14% moisture.
- Grain yield (tons/ha): Calculate from the average weight of grains for all ears harvested from the ten random plants from each experimental unit, then calculate the average yield per plant and multiply it by the plant density to obtain the grain yield (tons/ha) based on 14% moisture [11].

3. Results and Discussion

3.1. Number of Days up to 75% of Male Flowering

The averages in Table (2) show that time required to reach 75% of male flowering decreased with increasing pyridoxine concentrations, as the concentration (4500 mg/L) recorded the shortest period, reaching 74.98 days, and the decrease was significant; while plants of the control treatment recorded the longest period (85.00 days) to reach this stage. The reason for the short period required to reach 75% of male flowering may be due to the role of pyridoxine in stimulating vital reactions within plant cells and activating the meristematic activity of the root and shoot systems, which increases the efficiency of absorption of nutrients and their accumulation in the leaves that may leads to enhance the flowering of plant [12], this is consistent with the results of [13]. The varieties differed significantly in this trait, as the plants of the (Baghdad3) recorded the lowest average (78.78 days), while variety (Al-Rabi') recorded the highest average for the trait, reaching 81.91 days.

Table 2. The effect of pyridoxine and corn varieties and their interaction on the number of days from planting to 75% of male flowering of the spring season (2022).

Varieties	Pyridoxine concentrations (mg/L)				Averages
	0	1500	3000	4500	
Al-Rabi'	86.67	83.00	81.00	77.00	81.91
Sara	86.33	81.07	76.80	74.83	79.75
Baghdad3	82.00	81.67	78.33	73.13	78.78
-	85.00	81.91	78.71	74.98	-

Variety LSD (0.05) = 1.56; pyridoxine conc. LSD (0.05) = 2.25; interaction LSD (0.05) = 3.98

The difference between the varieties may be due to their different genetic makeup, and this is in agreement with [14]. The results of Table (2) also indicated a significant effect on the interaction between the two factors of the study, as the plants of variety (Baghdad3) at the concentration of 4500 mg/L recorded the shortest period (73.13 days), while the plants of variety (Al-Rabi') with the control treatment recorded the longest period (86. 67 days).

3.2. Number of Days Up to 75% of Female Flowering

Table (3) indicates that the averages for the number of days decreased significantly with increasing the concentrations of pyridoxine, as the concentration of 4500 mg/L gave the lowest average (80.93 days), while the control treatment recorded the highest average for this trait (89.75 days). The varieties also differed significantly, as the plants of cultivar (Baghdad3) recorded the lowest number (83.89 days), while cultivar (Sara) recorded the highest average (86.75 days). The differences in varieties may be

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due to their different genetic makeup, and this is consistent with the results of [14]. It is clear from the same table that there is a significant interaction between the varieties and concentrations of pyridoxine, as the plants of variety (Al-Rabi') at concentration 4500 mg/L gave the shortest period (80.00 days), while the plants of variety (Sara) with the control treatment showed longest period (90.67 days).

Table 3. The effect of pyridoxine and corn varieties and their interaction on the number of days from planting to 75% of female flowering of the spring season (2022).

Varieties	Pyridoxine concentrations (mg/L)				Averages
	0	1500	3000	4500	
Al-Rabi'	90.00	89.37	81.00	80.00	85.09
Sara	90.67	88.67	85.00	82.67	86.75
Baghdad3	88.60	84.61	82.23	80.13	83.89
-	89.75	87.55	82.74	80.93	-

Variety LSD (0.05) = 1.34; pyridoxine conc. LSD (0.05) = 1.58; ; interaction LSD (0.05) = 2.73.

3.3. Leaf Area (cm^2)

Table (4) indicates that the concentration of 4500 mg/L was significantly superior to the others and recorded the highest average (4899.7 cm^2), while the control treatment plants gave the lowest average (4424.7cm^2). The reason for the increase in leaf area with high concentration of pyridoxine may be due to the positive effect of this substance in improving metabolic processes and thus increasing manufactured materials. It may also be due to the role of pyridoxine in increasing the effectiveness of superoxide dismutase (SOD) and catalase (CAT) enzymes, and this leads to an increase in the biological reactions within the plant cell and thus an increase in cell division. The cells expand causing an increase in the size of the shoot of which the leaf is an important part, and this is consistent with [15].

Table 4. The effect of pyridoxine and corn varieties and their interaction on the leaf area (cm^2) of the spring season (2022).

Varieties	Pyridoxine concentrations (mg/L)				Averages
	0	1500	3000	4500	
Al-Rabi'	4676	4612	4770	5122	4795
Sara	4222	4531	4426	4697	4469
Baghdad3	4376	4609	4868	4880	4683.25
-	4424.7	4584	4688	4899.7	-

Variety LSD (0.05) = 189.5; pyridoxine conc. LSD (0.05) = 217.4; ; interaction LSD (0.05) = NS.

The results of the same table also indicate that variety (Al-Rabi') recorded the highest average of leaf area (4795cm^2) comparing to the plants of variety (Sara), which recorded the lowest average (4469cm^2). The reason for the difference in leaf area of the varieties may be due to their difference in the genetic composition and their ability to exploit growth requirements and this is reflected in this trait; this is in line with the results of [14] as well as [16].

3.4. Number of Grains Per Ear

Table (5) indicates that highest average number of grains per ear was 523.13 with the concentration of 4500 mg/L pyridoxine, this was significantly different from the other concentrations; the control treatment gave the lowest average number, which amounted to 425.83 grains/ear. The reason may be due to the role of pyridoxine in improving vegetative growth and leaf area that increasing the manufacturing processes and increasing the efficiency of the carbon assimilation process. Pyridoxine also effect on the length of the root, which increases the absorption of nutrients and their transfer and accumulation in the leaves; also increase flowering and fertility and thus increasing the number of grains in the ear.

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Table 5. The effect of pyridoxine and corn varieties and their interaction on the average number of grains per ear of the spring season (2022).

Varieties	Pyridoxine concentrations (mg/L)				Averages
	0	1500	3000	4500	
Al-Rabi'	411.0	431.0	456.3	473.1	442.85
Sara	432.2	441.0	475.3	519.7	467.05
Baghdad3	434.3	456.6	471.4	576.6	484.72
-	425.83	442.86	467.66	523.13	-

Variety LSD (0.05) = 27.74; pyridoxine conc. LSD (0.05) = 32.07; ; interaction LSD (0.05) = 60.53.

The results of the same table indicate a significant differences between the averages of the varieties, as variety (Baghdad3) showed the highest average (484.72 grains/ ear) compared to the lowest average (442.85 grains/ ear) that recorded by variety (Al-Rabi'). This may be attributed to the genetic difference between the genotypes; this result is consistent with the findings of [17] and [18]. The interaction between pyridoxine concentrations and the varieties led to a significant effect on the averages of this trait, as plants of variety (Baghdad3) at a concentration of 4500 mg/L gave the highest average (576.6 grains/ ear), while variety (Al-Rabi') with the control treatment gave the lowest average (411.0 grains/ ear).

3.5. Weight of 300 Grains (g)

The results of Table (6) indicate significant differences among the means concentrations of pyridoxine. The concentration 4500 mg/L gave the highest average reaching 48.11 grams, while the control treatment recorded 41.23 grams. The reason may be attributed to the role of pyridoxine in improving vegetative and root growth, improving metabolic processes, accumulating dry matter in the leaves, increasing the leaf area, and absorbing nutrients. Transferring these synthetic substances into the leaves and accumulating in the grains may increase their weight.

Table 6. The effect of pyridoxine and corn varieties and their interaction on the weight of 300 grains (g) of the spring season (2022).

Varieties	Pyridoxine concentrations (mg/L)				Averages
	0	1500	3000	4500	
Al-Rabi'	45.62	43.51	49.97	52.45	47.88
Sara	41.75	44.67	46.66	49.12	45.55
Baghdad3	36.33	35.18	44.08	42.78	39.59
-	41.23	41.12	46.90	48.11	-

Variety LSD (0.05) = 1.04; pyridoxine conc. LSD (0.05) = 1.41; ; interaction LSD (0.05) = 3.09.

The results of the varieties in Table (6) indicate significant differences, as variety (Al-Rabi') gave the highest average (47.88 grams) compared to variety (Baghdad3) that recorded the lowest average (39.59 grams). The reason for the superiority of variety (Al-Rabi') may be due to its superiority in leaf area (Table 4) and its high efficiency in distributing the products of photosynthesis; in addition to the differences between the varieties in their genetic composition and the efficiency of each variety to redistribute nutritional components and prepare the flowers for completing the fertilization process. The effect of interaction between the varieties and pyridoxine concentrations was significant, as the plants of variety (Al-Rabi') at the concentration 4500 mg/L gave the highest average (52.45 grams), while the plants of variety (Baghdad3) at concentration 1500 mg/L gave the lowest average (35.18 grams).

3.6. Grains Yield (tons/ha)

Table (7) shows a significant effect of increasing pyridoxine concentrations on the grains yield. The concentration of 4500 mg/L significantly exceeded the others and recorded the highest average, reaching 5.81 tons/ha, while the control treatment recorded the lowest average (3.92 tons/ha). The reason for that may be due to the increase of the yield components, such as the number of grains per ear and the weight of 300 grains (Tables 5 and 6), respectively. This result was in consistent with [19] and with other researchers for different field crops [20].

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Table 7. The effect of pyridoxine and corn varieties, and the interaction between them on the of grains yield (ton per hectare) of the spring season (2022).

Varieties	Pyridoxine concentrations (mg/L)				Averages
	0	1500	3000	4500	
Al-Rabi'	3.79	4.43	4.59	6.33	4.78
Sara	3.87	4.54	4.67	5.12	4.55
Baghdad3	4.10	4.85	5.43	6.00	5.09
-	3.92	4.60	4.89	5.81	-

Variety LSD (0.05) = 0.48; pyridoxine conc. LSD (0.05) = 0.66; ; interaction LSD (0.05) = 0.87.

The results of the same table indicate significant differences among the varieties, as (Baghdad3) recorded the highest average of grains (5.09 tons/ha), while variety (Sara) recorded the lowest average (4.55 tons/ha). The reason for the superiority of variety (Baghdad3) may be due to its superiority in the number of seeds per ear (Table 5). This result is in agreement with the findings of [21] and [14]. Regarding the interaction, the same table shows that there is a significant effect of the interaction between the concentrations of pyridoxine and the varieties, where variety (Al-Rabi') had the highest average at a concentration of 4500 mg/L and reached 6.33 tons/ha, while the control treatment with variety (Al-Rabi') gave the lowest average (3.79 tons/ha).

Conclusions

The study was designed to explore the effects of four different pyridoxine concentrations on the response of three maize varieties. The concentration (4500 mg/L) caused reduction for the number of days required to reach 75% of male and female flowering; furthermore it caused enhancement for the leaf area, number of grains per ear, weight of 300 grains, and grains yield. Regarding varieties, Baghdad3 produced the highest grains yield followed by Al-Rabi' and then Sara.

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