MAIZE (ZEA MAYS L.) GROWTH REACTION TO SOWING DATES AND HUMIC FOLIAR APPLICATION

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Abstract

The growth response of the synthetic cultivar 5018 was investigated in the spring of 2024 in Iraq's Diyala Governorate using a randomized complete block design (R C B D) on soil with a mixture of clay and sandy , Maize (Zea mays L.) textures in the Abi Saida district which is situated 60 kilometers northeast of the governorate center (Baquba). during the Spring Season of 2024. The study three sowing dates (March 15, April 1, and April 15) and foliar application of humic at two concentrations (2 and 3 ml L^{-1}) in addition to a control treatment, Sowing Dates The sowing dates of April 15 and April 1 significantly outperformed the March 15 date regarding plant height, leaf number, leaf area, and leaf area index (LAI). These dates recorded averages of 210.91 and 193.16 cm for plant height; 15.00 and 15.22 leaves $plant^{-1}$; 65.69 and 63.22 dm^2 for leaf area; and 28.33 and 28.81 for LAI, respectively. In contrast, the March 15 date recorded the lowest averages for these traits (175.83 cm, 14.86 leaves $plant^{-1}$, 57.92 dm^2, and 24.79, respectively). However, the March 15 date was superior in stem diameter, reaching an average of 2.64 cm, compared to April 1 and April 15, which both recorded the lowest average of 2.19 cm. . Humic Acid Levels: concentrations of 3 and 2 ml L^{-1} showed significant superiority across all studied traits, particularly in leaf area index (LAI) and shoot dry weight. They achieved the highest averages of 30.23 and 27.82 for LAI, and 134.50 and 118.30 g $plant^{-1}$ for dry weight, respectively, compared to the control treatment .

Keywords: Sowing dates, Foliar Nutrition, Humic acid, Maize .

Introduction

Maize (Zea mays L.), a member of the grass family (Poaceae), is one of the most significant cereal crops cultivated extensively worldwide. It ranks third in importance after wheat and rice in terms of production and cultivated area, owing to its diverse applications in human nutrition, animal feed, and various industrial sectors **[1]**. Within the Arab world, maize occupies the third position after wheat and barley regarding cultivated area, and the second position after wheat in terms of production. In Iraq, the area planted with maize reached 264,121 dunums, yielding approximately

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240,244 tons, with an average productivity of 455.1 kg ha^{-1} **[2]** The average productivity per hectare in

Iraq reached approximately 2 tons ha^{-1}. The spring season is considered a crucial cropping cycle, comparable to the autumn season for crops grown in two cycles in Iraq, such as maize and sunflower. Both are classified as day-neutral crops. This season commences from mid-February to early March, characterized by low temperatures at night and suitable temperatures during the day. Subsequently, conditions become more favorable for many physiological processes during the mid-season, where cultivated plants exhibit their highest growth rates during that period. Despite fluctuations in temperature between day and night and from one day to another, temperatures begin to reach extreme levels (extremes) during the flowering stage **[3]** , This causes significant damage to the plants grown in the field, a phenomenon known as Chronic Heat Stress. Furthermore, fertility rates decline if temperatures exceed 35°C, especially when accompanied by low humidity levels. Agricultural productivity can be enhanced through various agronomic practices, including determining the optimal and most suitable planting date for crop growth; thus, planting dates are considered vital factors influencing plant development **[4]** found a significant effect of planting dates on most growth characteristics. Humic acid is a form of organic matter and the end product of organic matter decomposition. Studies have demonstrated that humic acid increases cell membrane permeability and promotes nutrient uptake (Kaya et al. **[5]**. Moreover, it improves nitrogen absorption from the soil and enhances the uptake of potassium, calcium, magnesium, and phosphorus, making them more bioavailable to the plant's root system Singer et al. **[6]** ; Pascual et al. **[7]**. Organic fertilizers, represented by Humic acid, are among the humic substance components resulting from organic matter decomposition **[8]** . Its chemical formula is represented as C_{75}H_{33}O_{17}N_{3}(COOH)_{3}(CO)_{2}. The impact of humic acid on plant growth depends on the organic source, concentration, and molecular weight of the humic molecule. Low molecular weight fractions easily reach the plasmalemma (plasma membrane) of higher plant cells and enter the cytosol. In contrast, high molecular weight fractions interact with the cell wall and do not penetrate into the cell (Nardi et al. **[9]** . Recent studies indicate the potential of using humic acid as a growth regulator by modulating endogenous hormone levels in plants, in addition to enhancing plant resistance to water stress (Nardi et al. **[9]**.

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This study aims to determine the effect of the best spring planting date and the best humic acid spray level on the growth of corn plants. *Zea mays* L. (cultivar 5018)

Materials and Methods:

An experiment was conducted in Diyala Governorate, Al-Muqdadiyah District (Abi Saida, located 60 km northeast of the governorate's capital (Baquba). The experiment was conducted outdoors, using a Randomized Complete Block Design RCBD with three replications in , during the spring of 2024 in sandy clay loam soil. The aim was to study the growth response of corn (Zea mays L., cultivar 5018) to planting dates of March 15, April 1, and April 15, 2024, and foliar feeding with two levels of humic acid (2 and 3 ml L^{-1}), as well as a control Treatment . Two applications of humic acid were administered: the first 21 days after germination and the second before flowering. The treatments were grown in plastic pots, with three planting dates and two humic acid levels. With a control group of three replicates, the number of experimental units became 27 pots. All pots were fertilized identically and simultaneously with nitrogen in the form of urea (46% N) and triple superphosphate (21% P) as the phosphorus source. 140 kg ha^{-1} of N and 120 kg ha^{-1} of P were added. Each application of phosphorus was one-third of the nitrogen, mixed into the soil before planting. The remaining two applications of nitrogen fertilizer were added 45 and 70 days after planting **[3]** . Yellow corn seeds of the synthetic variety 5018 were sown. Germination occurred on May 9, 2024. The seeds were sown in 10 kg plastic pots with a diameter of 30 cm at the top and a depth of 30 cm in holes 5 cm deep, with five seeds per pot. Light watering followed after sowing, and thinning was performed, leaving two plants per pot. Pots were planted 20 days after sowing. The corn stem borer, Sesamia cretica, was treated with a 10% diazinon granular solution applied as a mid-plant spray 20 days after sowing as a preventative control measure. A second treatment was applied 10 days after the first **[10] .** Data were measured for several important growth characteristics at harvest for two plants growing in the two midlines of each experimental unit, and the average was calculated as follows:

Studied Characteristics:

Stem Height (cm): A graduated tape measure was used to measure the plant height from the soil surface to the top of the plant **[11] .**

Stem Diameter (cm): A cloth measuring tape was used to measure the stem circumference from the center of the first internode above the soil surface. The mathematical relationship between circumference and diameter was used to calculate

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the diameter: Stem Circumference (cm) = Diameter x Constant Ratio 3.14 **[12]** .

Number of Leaves (leaf per plant): The number of leaves per plant is counted from the first green leaves closest to the soil surface to the top (apex), taking into account any leaves that die at the base of the stem or are buried due to field operations **[13]**.

Leaf Area (dm² per plant): (at full flowering) according to the equation: (leaf length below the ear leaf)² × 0.75 if the number of leaves is more than 13, and (leaf area)² Leaf length under the ear of corn × 0.65 if the number of leaves is less than 13 **[12]** .

Leaf area index: Estimate using the following equation:

$$\text{Leaf area index} = \frac{\text{Average leaf area}}{\text{Area occupied by the plantFrom the ground}}$$

Plant dry weight (g plant^{-1}): Based on the dry weight of the vegetative mass after physiological maturity, plants were cut 5 cm from the ground surface in each experimental unit et al **[14]** They were then cut into small pieces, placed in a perforated paper bag, and air-dried for two weeks. The weight was recorded, and the average of the plants was calculated. The dry weight was then estimated**[13]** .

Statistical Analysis:

The data were statistically analyzed using ANOVA as a factorial experiment within a randomized complete block design (RCB D), using SPSS software. The Least Significant Difference (LSD) method was used to compare the means of the studied treatments at a probability level of 0.05 **[15]** .

Results and Discussion

Stem height (cm)

The results in the table show (1) There were significant differences between planting dates and foliar feeding with humic acid. No significant differences were recorded in the interaction between them in the stem height trait (cm). The planting dates of April 15th and April 1st were superior, with average heights of 210.91 and 193.16 cm, respectively, compared to the March 15th date, which recorded the lowest average height of 175.83 cm, representing increases of 19.95% and 9.85%, respectively. This may be due to the variation in temperature between planting dates, or it may be attributed to the genetic makeup of the variety and its response to environmental conditions, as stem height is a trait related to the nature of the genetic makeup. Additionally, the efficiency of photosynthesis in this variety, and the utilization of necessary growth requirements, positively impact plant activity and growth, thus increasing yield and its components **[16]**. This result is consistent with what **[17,18]**

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found. and **[19]** reported that the humic acid application, at concentrations of 2 and 3 ml L^{-1}, resulted in higher average heights of 209.80 and 191.33 cm for the same trait, compared to the control treatment which recorded the lowest average height of 178.77 cm, representing increases of 18% and 8%, respectively. This is attributed to the positive effect of humic acid on plant growth through increased cell membrane permeability, stimulation of enzyme reactions,

promotion of cell division, cell elongation, increased production of plant enzymes, and stimulation of vitamin synthesis within cells. This is reflected in the increased stem height **[20]**. Table 1 shows the effect of planting dates and humic acid application on the plant height (cm) of yellow corn. Table 1 shows a non-significant interaction. However, the interaction between the 15/4 application date and the application of 3 ml L^{-1} resulted in a non-significant increase, with an average length of 231.50 cm, compared to the interaction with the 15/3 application date, which recorded the lowest average length of 166.75 cm. The interaction between the application dates and humic acid was less significant than the interaction between the application dates or humic acid alone.

Table 1. Effect of planting dates and spraying with Humic acid on plant height (cm) of Maize.

Average Dates	Humic acid concentrations ml L^{-1}			planting Dates
	3	2	0	
175.83	184.25	176.50	166.75	/ 3 /15
193.16	213.66	185.00	180.83	/ 4 / 1
210.91	231.50	212.50	188.75	/ 4 / 15
	209.80	191.33	178.77	Humic average
Interaction N.S.	Humic 16.06	Dates 16.06		L S D 0.05

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Stem diameter (cm)

Table 2 shows significant differences between the planting dates and foliar application of humic acid. No significant differences were observed in the interaction between them for stem diameter (cm). The 15/3 application date had an average length of 2.64 cm, compared to the 15/4 and 1/4 applications, which each recorded the lowest average length of 2.19 cm, representing an increase of 20.54%, respectively. This may be due to the shorter stem height of the 15/3 application date compared to the 15/4 and 1/4 applications. Others (15/4 and 1/4) (Table 1), and this may also be attributed

to the availability of a suitable temperature for the growth and development of the root and shoot systems during the early stages of the plant's life and the increased absorption of nutrients with the increase in the root system [21] . This is consistent with the results of [22, 17] and [23] . Different planting dates have an effect on the stem diameter. However, when humic acid was added, the 3 ml L^{-1} concentration was superior for the same trait. The average height increase was 2.54 cm compared to the 2 ml L^{-1} concentration and the control treatment, which recorded the lowest average heights of 2.30 and 2.15 cm, respectively, representing increases of 16% and 19%.

This may be attributed to the effect of humic acid in addressing nutrient deficiencies in the plant resulting from physical or chemical problems in the soil,

or to its promotion of vegetative growth and increased dry matter accumulation in the plant through spraying on the vegetative parts. This method of fertilization is faster-acting compared to soil fertilization, and this may be reflected in an increase in stem diameter **[24]** .

As for the interaction, the interaction between the application date of March 15th (3 ml L^{-1}) and the control treatment resulted in a non-significant increase of an average height of 2.78 cm, compared to the interaction between the application date of April 15th and the control treatment, which recorded the lowest average height. 1.91 cm. The interaction between planting dates and humic acid had a lesser effect than the effect of planting date or humic acid alone.

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Table 2. Effect of planting dates and humic acid spraying on the stem diameter (cm) of yellow corn plants

Average Dates	Humic acid concentrations ml L^{-1}			planting Dates
	3	2	0	
2.64	2.78	2.62	2.54	/ 3 /15
2.19	2.38	2.14	2.06	/ 4 / 1
2.19	2.46	2.22	1.91	/ 4 / 15
	2.54	2.32	2.17	Humic average
Interaction N.S.	Humic 0.15	0.15 Dates		L S D 0.05

Number of leaves (plant^{-1}):

The results in Table 3 showed significant differences between the different concentrations of humic acid. No significant differences were observed between planting dates and the interaction between planting dates and humic acid application in the trait of number of leaves (plant^{-1}). The concentrations of 3 and 2 ml/L were superior, with averages of 16.00 and 15.38 leaves/L, respectively, compared to the control treatment, which recorded the lowest average of 13.69 leaves/L, representing an increase of 16.87% and 12.34%, respectively. This may be due to the fact that both concentrations recorded

the highest stem height (Table 1), which helps increase the number of leaves. This is called plant geometry, which is the correct and appropriate distribution of

plant shape, including plant height and number of leaves **[25]** . Or it may also be attributed to the effect of humic acid spray concentrations on producing higher dry matter by increasing the efficiency of photosynthesis and thus increasing plant growth indicators represented by stem height and number of leaves Ebrahimzadeh et al. **[26 , 27]** . Although no significant differences were found between planting dates, the April 1st date showed a non-significant increase in the same trait, with an average of 15.22 leaves per plant, compared to the other two dates, April 15th and March 15th, which recorded the lowest averages of 15.00 and 14.86 leaves per plant, respectively.

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As for the interaction, the April 1st date combined with the application of 3 ml L^{-1} resulted in a non-significant increase, with an average of 16.25 leaves per plant, compared to the April 15th date, which recorded the lowest average of 13.50 leaves per plant. The interaction between planting dates and humic acid had a lesser effect than the effect of humic acid alone.

Table 3. The effect of planting dates and spraying with humic acid on the number of leaves (leaf-1) of maize plants.

Average Dates	Humic Acid concentrations ml L^{-1}			Planting Dates
	3	2	0	
14.86	15.75	15.00	13.83	/ 3 /15
15.22	16.25	15.66	13.75	/ 4 / 1
15.00	16.00	15.50	13.50	/ 4 / 15
	16.00	15.38	13.69	Humic average
Interaction N.S.	Humic 0.78	N.S. Dates		L S D 0.05

Leaf Area (dm^2):

The results in Table 4 show significant differences between planting and humic acid application dates. No significant differences were observed in the interaction between these dates for leaf area (dm^2). The April 15th date showed the highest average leaf area at 65.69 dm^2, compared to the March 15th date, which recorded the lowest average at 57.92 dm^2, representing a 13.41% increase. This may be attributed to the significant increase in stem height (Table 1) recorded on the aforementioned date, which contributed to the increase in leaf area. Alternatively, it may be due to the variety's response to the environmental conditions during this date, such as temperature, light, and humidity, which resulted in an increase in the number and size of leaves, and consequently, an increase in leaf area. This

result confirms that leaf area is significantly related to the number of leaves in the plant, their duration of greenness, and the area of a single leaf. This result is consistent with the findings obtained by **[21, 27 ,18]** and **[19]**. No

significant differences were observed between the 1/4 date and the other two dates. This result is consistent with the result of **[28]** ,

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who did not find significant differences in leaf area with the change in planting dates. Regarding the addition of humic acid, the concentrations of 3 and 2 ml L^{-1} were superior for the same trait, with averages of 67.73 and 63.49 dm^2, respectively, compared to the control treatment, which recorded the lowest average of 55.61 dm^2, representing increases of 21.79% and 14.17%, respectively. This may be due to both concentrations showing a significant increase in stem height and number of leaves (Tables 1 and 2), or perhaps because humic acid increases cell membrane permeability, thus increasing water and nutrient absorption. This is because humic acid provides major and minor nutrients, especially nitrogen, phosphorus, and potassium, which affects many vital activities, reflected in increased leaf area **[29]** As for the interaction, the interaction between the application date of April 15th (3 ml L^{-1}) and the application date of April 15th resulted in a non-significant increase, with an average of 74.34 dm^2, compared to the interaction between the two dates. The 15/3 planting date, used for comparison, recorded the lowest average at 53.52 dm^2. The effect of the 15/4 planting date and the foliar humic acid application technique contributed to greater light interception, thus increasing photosynthesis and vegetative growth through increased stem height and number of leaves, which was reflected positively in an increase in leaf area .

Table 4. Effect of planting dates and spraying with Humic acid on leaf area (dm^2) of maiz plant .

Average Dates	**Humic Acid concentrations ml L^{-1}**			**Planting Dates**
	3	**2**	**0**	
57.92	**60.63**	**59.62**	**53.52**	**/ 3 /15**
63.22	**68.23**	**62.60**	**58.84**	**/ 4 / 1**
65.69	**74.34**	**68.26**	**54.48**	**/ 4 / 15**
	67.73	**63.49**	**55.61**	**Humic Average**
Interaction N.S.	**Humic 7.16**	**7.16 Dates**		**L S D 0.05**

Leaf Area Index:

The results in Table 5 showed no significant differences between planting dates and different humic acid concentrations, nor any interaction between them, in the leaf area index. However, the 1/4 planting date recorded a non-

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significant increase in this trait, with an average of 28.81, compared to the other two planting dates, 15/4 and 15/3, which recorded the lowest averages of 28.33 and 24.79, respectively. The 3 ml L^{-1} level also recorded a non-significant increase, with an average of 30.23, compared to the 2 ml L^{-1} level and the control treatment, which recorded the lowest average. 27.82 and 23.87 respectively.

This may be attributed to the fact that this trait is not affected by other factors, including planting dates or different concentrations of humic acid .

Table 5. The effect of planting dates and spraying with humic acid on the leaf area index of maize plants.

Average Dates	Humic Acid concentrations ml L^{-1}			Planting Dates
	3	2	0	
24.79	**26.72**	**24.98**	**22.67**	**/ 3 /15**
28.81	**32.48**	**28.08**	**25.87**	**/ 4 / 1**
28.33	**31.49**	**30.42**	**23.08**	**/ 4 / 15**
	30.23	**27.82**	**23.87**	**Humic Average**
Interaction N.S.	**Humic N.S.**	**N.S. Dates**		**L S D 0.05 Least**

Dry weight of the vegetative body (g $plant^{-1}$):

The results in Table 6 showed significant differences between the different concentrations of humic acid. No significant differences were observed in planting dates or the interaction between planting dates and humic acid application in the dry weight of the vegetative body (g plant-1). The concentrations 3 and 2 ml L^{-1} were superior, with averages of 134.50 and 118.30 g plant-1, respectively, compared to the control treatment, which recorded the lowest average of 97.58 g plant-1, representing an increase of 37.83% and 21.23%, respectively. The increase recorded for these concentrations may be due to their recording the highest average stem height,

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number of leaves, and leaf area (Tables 1, 2, and 4). Although there were no significant differences between the planting dates, the April 15th date showed a non-significant increase in the same trait, with an average of 129.83 g plant-1, compared to the other two dates, march 15th and April 1st, which recorded the lowest averages of 110.55 and 110.00 g plant-1, respectively. As for the interaction, the April 15th date combined with the application of 3 ml L-1 resulted in a non-significant increase, with an average of 156.50 g plant-1, compared to the April 1st date, which showed the lowest average of 88.00 g plant-1. The interaction between planting dates and humic acid had a less significant effect than the effect of humic acid alone.

Table 6. The effect of planting dates and spraying with humic acid on the dry weight of vegetative total (plant-1 g) of maize plant.

Average Dates	Humic acid concentrations ml L^{-1}			Planting Dates
	3	2	0	
24.79	**26.72**	**24.98**	**22.67**	**/ 3 /15**
28.81	**32.48**	**28.08**	**25.87**	**/ 4 / 1**
28.33	**31.49**	**30.42**	**23.08**	**/ 4 / 15**
	30.23	**27.82**	**23.87**	**Humic Average**
Interaction N.S.	**Humic N.S.**	**N.S. Dates**		**L S D 0.05**

Conclusion

The sowing dates of April 1st and April 15th, combined with the application of humic acid at concentrations of 2 and 3 ml L^{-1}, significantly outperformed other treatments in most vegetative growth characteristics. These parameters played a critical role in enhancing both productivity and overall yield compared to the control treatment for the yellow maize synthetic variety 5018. Consequently, we recommend further studies involving these specific dates and concentrations to further elucidate their impact on the growth and production dynamics of yellow maize.

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