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Response of yellow corn varieties to organic acids

Raeda Abd Al-Redha Sabe1 and , Mohammed Radwan Mahmoud 2

[1,2] Agriculture College, Al-Muthanna University, Al-Muthanna, Iraq.

[2]E-mail: modrn@mu.edu.iq

Abstract

A field experiment was conducted during the spring season of 2022 at the Organic Fertilizer Project in Shatrah District, Thi Qar Governorate (40 km north of the city center). The study aimed to evaluate the performance of four maize varieties under varying levels of humic and fulvic acid applications.The study followed a factorial experimental design involving two primary factors: were Maize Cultivars: Four varieties approved by the Ministry of Agriculture (Furat, ZP, Kaws, and Maha). And Humic Acid Levels: Four application rates (Control, 10, 20, and 30 L/ha) of a humic and fulvic acid blend.The statistical analysis revealed significant effects across several growth and nutrient parameters:Humic Acid Impact: The 30 L/ha concentration significantly outperformed other treatments regarding plant height, days to flowering, and the internal concentration of phosphorus (P) and potassium (K), Cultivar Performance: The Maha cultivar was superior in the number of days to flowering, while Furat excelled in leaf area. The Kaws cultivar recorded the highest concentrations of phosphorus and potassium. Interaction Effects: * The combination of Control × Kaws achieved the best results for days to flowering. The 20 L × Furat interaction significantly increased leaf area. While The 20 L × Kaws interaction resulted in the highest potassium concentration. The 40 L × Maha* interaction showed the highest phosphorus concentration.

Keywords. Humic, Fulvic, Growth, Maize cultivars.

1. Introduction

Maize (*Zea mays* L.) is a plant in the Poaceae family, it is a monoecious annual herbaceous plant with eight genera, the most important of which is the genus Zea, Mays [1]. Yellow maize occupies the second place in the world in terms of cultivated area and the first in the world in terms of production

The global area cultivated for yellow corn in (2016) of grain yield reached 7.296 tons ha^{-1}, in some developed countries, such as the United States of America, global productivity may reach double, while the productivity rate in Iraq was 3.425 h^{-1}, despite the great importance of this crop and the growing interest in its cultivation in Iraq, however, its production rate is still low per unit area for many reasons, including the lack of productivity of cultivated varieties and not adding the appropriate amount of fertilizers, especially chemical ones that contain elements (NPK), with the neglect of foliar feeding, which plays an important role in increasing the quantity of the crop and improving its quality

Likewise, not choosing the dates for adding fertilizer at the appropriate or critical stages of plant growth that greatly affect its productivity [2].

The economic importance of yellow corn lies in its seeds containing a high percentage of carbohydrates (81%), protein (10.6%) and oil (4.6%), in addition to containing vitamins (B2, B1 and E), one kilogram of it provides (3460) calories and (93) grams of protein, corn flour was used in the production of bread after mixing it with wheat flour, corn starch is used in making pastries and various foods, the sugary juice is extracted from its stems and oil from the embryo of its seeds, in addition to using its stems and leaves in the manufacture of different types of paper [3].

The nutritional importance of maize crop and its adaptability to multiple environments, it is cross-pollinated and contains both male and female organs as a monoecious plant, the crop gave great attention in the field of scientific research, especially in the processes of breeding and improvement, especially hybridization, helps plant breeders to produce varieties and hybrids that far outperformed the varieties, used to prevail in the world in the past through the discovery or clarity of the phenomenon of hybrid forces (Hybraid vigor) and the production of hybrid corn, it has been described by plant breeders as the agricultural revolution and the greatest event in plant breeding matter, led to the spread of new high-production hybrids around the world, depends mainly on genetic divergence between parents, each environmental region has its own varieties and hybrids that are suitable for it, and which differ among themselves in their genetic ability, as well as the extent to which it responds to various modern and advanced agricultural methods. Humic organic matter, including humic acid, plays an effective role in improving the physical and chemical properties of soil, by the interaction of these compounds with soil minerals and then improve the physical properties of the soil as well as the adsorption capacity of mineral elements, humic organic acids affect the improvement of plant growth and the availability of elements. Humic acid is a complementary source of polyphenols in the early stages of plant growth, acts as a chemical intermediate, leads to an increase in the vital activity of the plant, as the enzyme system becomes more effective, cell division increases, the root system develops, and dry matter production increases. Organic acids increase nutrient availability as well as act as a buffer against changes in soil reactivity, as well as preserving nutrients from loss to the bottom away from the roots, for its ability to hold ions on its surface, many researchers have reached, that the organic and biological fertilization led to an increase in the concentration of element availability in the soil when planting [1].

Therefore, the study aimed to know the best studied varieties in terms of growth and production under the influence of organizations and to determine the best level of humic acids in terms of the effect on increasing production and the studied traits.

2. Materials and Methods

2.1. Experiment Site

A field experiment was carried out in the spring season 2022 in the organic fertilizer project in Thi Qar Governorate, Shatrah district, which is 40 km north of the city.

2.2. The Experience Factors

- The first factor: four cultivars of maize (Zp, Maha, Forat and Kaws) and the following codes were given (V4, V3, V2, V1)

respectively, and they were cultivars approved by the Ministry of Agriculture and their source is the Agricultural Research Department, Department of Yellow Maize.

- The second factor: levels of fulvic humic acids:
- Without adding (T1) comparison.
- 10 liters per hectare (T2) of fulvic and humic acids.
- 20 liters per hectare (T3) of fulvic and humic acids.
- 30 liters per hectare (T4) of fulvic and humic acids.

2.3. Agricultural Operations

Cultivation took place in the middle of March, the spring season, and the experimental land was prepared in terms of plowing, smoothing, and leveling as needed, fertilized the field with compound fertilizer (NPK) and urea fertilizer 100 kg per dunum, in three batches, the first at planting, the second after a month of planting, and the third at the beginning of flowering, in the form of a row.

Table 1. Chemical and physical properties of soil.

Chemical properties		**Physical properties**	
Available Nitrogen	2.08	Sand	16.00
Available Phosphorus	0.33	Silt	39.70
Available potasium	1.13	Clay	44.30
Organic matter	12.80	Soil texture	Silty clay
pH	8.35		
EC	3.47		

2.4. The Traits Studied are Traits of Growth

- The number of days for female flowering: calculated based on the period from planting until the appearance of the female inflorescence (75%) of the plants in the experimental unit.
- Plant height (cm): The average of ten random plants is calculated from the median lines from the soil surface level to the base of the male inflorescence.
- The length of the ear: calculated as an average of the ten plants that are randomly taken from the median lines from the soil surface level to the phalanx node, which bears the main ear.
- The leaf area of the plant (cm^2): calculated as an average of five plants before flowering.
- According to the equation:

$$\text{Leaf area} = \text{leaf length} \times \text{width at its widest in } 0.75$$

- Chlorophyll content: measured with a Chlorophyll content meter ccm-200 plus (Spad)

3. Results and Discussion

3.1. Number of Days to Flowering 50%

Table 2. showed that there were significant differences between the levels of humic and fulvic acid and between cultivars, and the interaction between them in the number of days from planting to 50% flowering. Table 2. showed a significant superiority of the levels of humic and fulvic acids in the number of days from planting to 50% flowering. The comparison treatment excelled and gave the highest number of days from planting to 50% flowering 58.83 days, while the 30-liter treatment gave the least number of days to reach flowering 56.16 days from planting. The reason is due to the nutrients that humic contains that encourage growth, in addition to containing organic compounds and carbon, which increases the available of other elements, which increases the flowering period, which increased the flowering period, stated that the increase in humic acid concentrations in the barley crop caused an increase in the number of days from planting until flowering.

Table 2. showed a significant superiority among the cultivars in the number of days from planting to 50% flowering, where the Maha cultivar was superior, as it gave 58.83 days from planting to 50% flowering, while the cultivar Furat gave the least number of days to reach flowering 55.66 days from planting. The results showed that there was a significant interaction between the levels of humic and fulvic acid and the cultivars, the combination (the comparison treatment ×

Kaws cultivar) gave the highest number of reaching flowering 60 days from planting.

Table 2. Effect of humic, fulvic and cultivars on the number of days from planting to 50% flowering.

V	T				Average
	T1	T2	T3	T4	
V1	57.667	55.667	55.000	54.333	55.667
V2	58.333	56.667	54.333	55.000	56.083
V3	60.000	58.333	57.000	56.333	57.917
V4	59.333	58.333	58.667	59.000	58.833
Average	58.833	57.250	56.250	56.167	
L.S.D0.05	T		V		T*V
	0.4604		0.5827		0.9284

3.2. Plant Height (cm)

Table 3. showed significant differences between the levels of humic and fulvic acid, and the cultivars and the interaction between them did not show significant differences in plant height.

Table 3. showed a significant superiority of the levels of humic and fulvic acid in plant height, where the 3 gm treatment excelled and gave a plant height of 209.4 cm, while the comparison treatment gave the lowest plant height of 171.4 cm, perhaps the reason is due to the effect of humic acid in increasing the vital activities of the plant and raising the rate of absorption of nutrients, which leads to an increase in the rate of plant growth, or the reason may be due to the fact that humic acid has a hormonal effect as it affects the cell protoplasm and the cell wall, which leads to rapid cell division and growth, and thus an increase in plant height, as this result agreed with what was reached by [4], who stated that an increase in the concentration of humic acid in the wheat crop caused an increase in plant height. [5], also concluded that there is a significant effect of adding humic acid with fertilizers and inoculation with Glomus moss. It led to a significant increase in plant height and dry plant weight of yellow corn crop. The findings of [6], showed that the effect of adding Bacillus subtilis and spraying humic and fulvic acid on leaves, soil and their interactions was significant on some characteristics of vegetative growth of maize plants, including plant height, chlorophyll content and dry weight.

Table 3. Effect of humic, fulvic and cultivars on plant height (cm).

V	T				Average
	T1	T2	T3	T4	
V1	189.5	225.0	199.1	208.1	205.4
V2	161.4	185.7	202.1	200.9	187.5
V3	183.1	217.1	196.8	225.6	205.7
V4	151.5	180.5	181.2	203.0	179.0
Average	171.4	202.1	194.8	209.4	
L.S.D0.05	T		V		T*V
	29.13		NS		NS

3.3. Number of Leaves Per Plant

Table 4. showed that there were no significant differences between the levels of humic and fulvic acid and between cultivars, and the interaction between them in the number of leaves per plant.

Table 4. The effect of humic, fulvic and cultivars on the number of leaves per plant.

V	T				Average
	T1	T2	T3	T4	
V1	13.13	13.60	13.20	13.13	13.27
V2	13.80	13.20	14.47	13.60	13.77
V3	13.27	13.33	13.13	13.47	13.30
V4	13.40	13.43	14.00	13.47	13.57

Average	13.40	13.39	13.70	13.42	
L.S.D0.05	T		V		T*V
	NS		NS		NS

3.4. Leaf Area cm²

Table 5. showed that there were no significant differences between the levels of humic and fulvic acid, while there were significant differences between the cultivars and the interaction between them in the leaf area cm².

Table 5. showed a significant superiority among the cultivars on the leaf area cm², where the Furat cultivar excelled as it gave 792.8 cm² in the leaf area cm², while the Kasws variety gave the least in the leaf area 686.9 cm².

Table 5 showed a significant superiority of the interaction between the levels of humic and fulvic acids and the cultivars, and the interaction gave a treatment of 2 g X the Furat cultivar with the highest leaf area of 832.9 cm².

Table 5. Effect of humic, fulvic and cultivars on leaf area.

V	**T**				**Average**
	T1	**T2**	**T3**	**T4**	
V1	750.0	787.4	832.9	800.9	792.8
V2	740.1	756.0	829.8	696.3	755.6
V3	652.3	734.6	620.1	740.4	686.9
V4	734.7	781.4	710.3	822.6	762.3
Average	719.3	764.9	748.3	765.0	
L.S.D0.05	T		V		T*V
	NS		46.67		101.29

3.5. Potassium %

Table 6 showed that there were significant differences between the levels of humic and fulvic acid, and between cultivars, and the interaction between them in potassium percentage.

Table 6 showed a significant superiority of humic and fulvic acid levels in potassium percentage. Where the treatment of the third level excelled 2 gm and the fourth 3 gm and gave the highest percentage of potassium 0.65%, while the comparison treatment and the first level of 1 gm gave the lowest percentage of potassium 0.62% and 0.63% for both treatments, and this is consistent with Islam and Munda[7] that adding humic acid to the soil or spraying on the leaves led to the accumulation of phosphorus and potassium in the leaves of yellow corn.

Table 6 showed a significant superiority among the cultivars in the percentage of potassium %. Whereas, the Kaws variety was superior, as it gave 0.65% potassium. While the zp cultivar and the Maha cultivar gave the lowest potassium content of 0.62%. The results also showed a significant superiority of the interaction between the levels of humic and fulvic acids and the cultivars.

Table 6. Effect of humic, fulvic, and cultivars on potassium percentage.

V	**T**				**Average**
	T1	**T2**	**T3**	**T4**	
V1	0.59	0.62	0.64	0.66	0.62
V2	0.60	0.63	0.66	0.62	0.62
V3	0.62	0.66	0.68	0.67	0.65
V4	0.66	0.62	0.65	0.66	0.64
Average	0.62	0.63	0.65	0.65	
L.S.D0.05	T		V		T*V
	0.03		0.02		0.03

3.6. Phosphorous %

Table 7 showed that there were significant differences between the levels of humic and fulvic acid, and between cultivars, and the interaction between them in the percentage of phosphorus%.

Table 7 showed a significant superiority of the levels of humic and fulvic acid in the proportion of phosphorous%. Where the fourth

level treatment excelled 3 gm and gave the highest percentage of phosphorus 0.68%, while the comparison treatment gave the lowest percentage of phosphorus 0.58% and this agrees with [7], that adding humus acid to the soil or spraying on the leaves led to the accumulation of the element phosphorus and potassium in the soil. Yellow corn leaves.
Table 7 showed a significant superiority among the cultivars in % phosphorus. Whereas, the Kaws variety excelled as it gave 0.65% phosphorus, while the zp variety gave the lowest phosphorus percentage of 0.61%.
The results also showed the emergence of a significant superiority of the interaction between the levels of humic and fulvic acids and the cultivars, and the interaction gave the fourth level treatment 3 gm X the Kaws variety with the highest percentage of phosphorus 0.70%.

Table 7. Effect of humic, fulvic and cultivars on phosphorus %.

V	T				Average
	T1	T2	T3	T4	
V1	0.57	0.60	0.63	0.66	0.61
V2	0.58	0.63	0.65	0.67	0.63
V3	0.60	0.63	0.67	0.70	0.65
V4	0.59	0.62	0.66	0.69	0.64
Average	0.58	0.62	0.65	0.68	
L.S.D0.05	T		V		T*V
	0.01		0.01		0.01

4-

6Nitrogen Percentage (%)

The analysis of variance results (table 8) indicated significant differences in nitrogen percentage due to the levels of humic and fulvic acids, maize cultivars, and their interaction.Cultivar Effect: According to Table 11, there was a significant variation among cultivars. The Kaws (V3) cultivar achieved the highest nitrogen percentage at 1.314%, while the ZP (V1) cultivar recorded the lowest value at 1.257%.Humic and Fulvic Acid Effect: Significant differences were observed between treatment levels. The fourth level (T3 - 3g) was superior, yielding the highest nitrogen percentage of 1.459%, whereas the control treatment (T0) gave the lowest percentage of 1.07%.Interaction Effect: The interaction between acid levels and cultivars significantly influenced the results. The combination of the fourth level (T3) × Kaws cultivar (V3) recorded the highest nitrogen content at 1.483%.

Table 8 Effect of humic, fulvic and cultivars on ***Nitrogen Percentage***

AVRAGE	T				V
	T3	T2	T1	T0	
1.2575	1.43	1.32	1.23	1.03	V1
1.2833	1.4667	1.3467	1.2500	1.0700	V2
1.3142	1.4833	1.4133	1.2633	1.0967	V3
1.2892	1.4500	1.3500	1.2767	1.0800	V4
	1.4592	1.3583	1.2567	1.0700	AVRAGE
T*V	V		T		L.S.D0.05

0.02969	0.01527	0.01679	

5-6

Oil Percentage (%)

The analysis of variance results (Appendix 1) showed significant differences attributed to the levels of humic and fulvic acids. However, no significant differences were observed for the cultivars or their interaction regarding oil percentage.Humic and Fulvic Acid Effect: Table 12 illustrates that the 3g treatment (T3) was significantly superior, achieving an oil percentage of 5.321%. In contrast, the control treatment recorded the lowest oil percentage at 3.338%.

Table 9 Effect of humic, fulvic and cultivars on *Oil Percentage*

AVRAGE	T				V
	T3	T2	T1	T0	
4.293	5.253	4.627	4.200	3.093	V1
4.366	5.340	4.723	4.260	3.140	V2
4.383	5.263	4.720	4.343	3.207	V3
4.497	5.427	4.733	3.913	3.913	V4
	5.321	4.701	4.179	3.338	AVRAGE
T*V	V		T		L.S.D0.05
ns	ns		0.3755		

6-6 Protein Percentage (%)

The analysis of variance results (Appendix 1) revealed significant differences based on the levels of humic and fulvic acids. Similar to the oil percentage, the cultivars and their interactions did not show any significant impact on this trait.Humic and Fulvic Acid Effect: As shown in Table 13, the 3g treatment (T3) significantly excelled, producing a protein percentage of 9.11%. The control treatment (T0) yielded the lowest protein percentage, recorded at 6.19%.

Table 10 Effect of humic, fulvic and cultivars on **Protein** *Percentage*

AVRAGE	T				V
	T3	T2	T1	T0	
7.84	8.94	8.25	7.71	6.44	V1

8.01	9.15	8.40	7.80	6.70	V2
8.15	9.27	8.61	7.88	6.84	V3
7.56	9.06	8.42	7.96	4.78	V4
	9.11	8.42	7.84	6.19	AVRAGE
T*V	V		T		L.S.D0.05
ns	ns		0.732		

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