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RESPONSE OF SEVERAL GENOTYPES OF MAIZE (*Zea mays* L.) TO ORGANIC FERTILIZER (HUMIC ACID)

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Abstract

Two field experiments were conducted during the spring and fall seasons of 2017. The study included nine genotypes of maize under the effect of three levels of (humic acid) fertilizer (500, 750 and 1000) gm. donum^{-1}. The layout of the experiment was RCBD design according split plot pattern with three replicates. The genotypes differed significantly in all characters of vegetative growth, yield and its components. The G5 genotype gave the shortest time to reach 50% of anthesis. The G8 genotype gave the highest mean of the number of grains in the row and the G2 genotype gave the highest values of leaf area index and singular plant yield reached (3.159 and 190.9) respectively, while the genotype G7 recorded the highest mean number of rows per ear reached 19.481 row.ear^{-1}, in addition to the genotype G7 and G8 did not differ significantly from the genotype G2 in singular plant yield because of their superiority in most of the characters of the (number of rows in ear and number of grains in the row). The addition of humic levels was significant in all studied characters, except the number of rows per ear, which did not reach the significant. The first level (500 gm. Donum^{-1}) gave the highest values of the leaf area index, the number of grains per row, the weight of 300 grains and the singular plant yield which reached 176.7 gm. while the second level gave the highest number of rows per ear which reached 17,819. Thelowest number of days to reach 50% anthesis (51.44) days obtained from third level of humic.
***Keywords*:** *Zea mays*, genotypes, humic acid, plant yield.

Introduction

The maize crop (*Zea mays* L.) is one of the most important grain crops in the world which is grown in large areas. This crop occupies the third place after wheat and rice in terms of economic importance and productivity. it is a multipurpose crop. Its seeds and plants are used in human food, animal feeds and industrial products, including vegetable oils (FAO, 2010). In Iraq the maize crop is grown in spring and fall season, with an estimated area of 222.8 thousand donums, with a production rate reached 185.3 thousand tons (the Directorate of Agricultural Statistics, 2018). However, its average productivity in Iraq is still below the level of ambition compared to global production. Therefore, researchers, producers and plant breeders have to promote the cultivation of this crop in order to achieve qualitative and quantitative improvement in its productivity. This puts plant breeders in front of a major challenge in how to improve the quantitative characters of maize crop being controlled by several genetic pairs that are weak in gene expression (Allard, 1960).

The maize crop is a field crop of the cross fertilization plants, so the breeding and improvement processes are easy, especially the hybridization, which aims at producing new genotype that benefit the breeder in the selection programs for the production of high yielding breeds and hybrids (Elsahookei, 1990). The appropriate service processes for these genotypes ensure good performance and high productivity, among which are the use of modern technologies such as organic nutrition, which play a large role in the growth and productivity of this crop. The organic agriculture is the modern approach to growing field crops and using organic fertilizer to improve crop production rather than chemical fertilizers that cause damage to the environment and human health (Taha, 2007), Such as Humic acid, which is a basic substance that is derived from the decomposition of organic matter and contains in its composition carbon, hydrogen, oxygen and nitrogen, which plays a key role in increasing soil fertility and plant nutrition (Khattak and Muhammad, 2006). It has many physiological benefits for plants and soil. It also has a physiological, chemical and biological significance. It is characterized by its odorless black color and is harmless to humans, plants and the environment. It also plays a role in reducing the pooling of water in the root region, causing the spread of diseases and bacteria. According to the importance of the above, the aim of this study is to determine the best genotype among the local and extracted genotypes and to determine the best level of humic fertilizer.

Materials and Methods

Two field experiments were carried out during the spring and fall seasons of 2017. The first experiment was carried out in the experimental field of field crops department, Abu Ghraib (alternative site) and the second experiment carried out in one of the farmers' fields in al-Husay village in Fallujah district, Al-anbar province.

The first experiment: The experiment soil was plowed two times orthogonally, then pulverization and leveling were conducted. Experiment soil was divided into furrows with length of 5 m and a width of 90 cm, with a line for each breeds. These lines were manually cultivated on 1/3/2017 in holes on the furrows. The experiment included a number of pure breeds derived locally. The breeds were introduced in the Half Diallel cross program according to the second method proposed by Griffing (1956). urea fertilizer (N46%) was added by 400 $kg.ha^{-1}$ and phosphate fertilizer (DAP) with two doses, and the field was irrigated according to need, as well as well as the insect of the corn stalk borer (*Criteca sesamia*) has been controlled with diazinonas needed. All the Diallel Crosses required for the single crosses was done according to the second Griffing method (1956). At the same time, the self-pollination of the paternal breeds was carried out to multiply their seeds. At the end of the season, the hybrid ears was harvested then dried up and the grain extracted to planting in the next season.

The second experiment: was conducted according split-plot pattern and the design of the RCBD with three replicates. The main plots included the levels of humic fertilizer (500, 750, 1000 gm) which symbolized by (H1, H2 and H3). While the sub plots occupied the genotypes which is symbolized by (G). The process of service of the soil was conducted by plowing, pulverization and leveling, and was divided into plots with length of 5 m and a width of 2.25 m with three lines of experimental unit and the distance between the lines was 75 cm and between holes 25 cm, the single crosses seeds obtained from the previous season were planted manually on (6 /8/2017) in addition to the control genotypes (Maha and Sara). Soil and crop service operations were conducted as in the previous season. The humic fertilizer was added as two doses, the first one after one month of planting and the second before anthesis stage.

Studied characters

Five plants randomly selected from each experimental unit to study the following characters:

The number of days from planting to 50% anthesis, the number of grains per row ($grain.row^{-1}$), the number of rows per ear ($row.ear^{-1}$), the weight of 300 grains (gm) and the singular plant yield.

The statistical data were analyzed according to analysis of variance method and RCBD design using the statistical program Genstat and the use of the least significant difference (LSD) at the 5% significant level to compare the arithmetic averages of the studied characters (Steel and Torrie, 1980).

Results and Discussion

Number of days of planting up to 50% anthesis (day)

The duration of access to anthesis and its interaction with pollen dispersion in maize crop is great importance in increasing the pollination rate then the fertilization rate thus its effect in increasing the number of ear grains. Table (1) indicates that there is a significant difference between the genotypes in the period to 50% anthesis of the plants. The genotype of G5 took the minimum duration to flowering reached 50.89 days while the G9 genotype required the longest period to reach 50% of the (anthesis) female flowering.. This may be due to the fact that female flower is determined by the characters of the genotype and the appropriate photovoltaic duration, which results in a reversal of the time required to reach 50% of the female flowering. This results in agreement with results of Nataraj *et al.* (2014), Alrawi (2016), Pandey *et al.* (2017), Ardeaan *et al.* (2017), and Musarbat, (2017) with significant differences between the genotypes to reach 50% female flowering. The table also showed a significant difference between the levels of the humic fertilizer, the third level was superior by achieving a minimum number of days to reach 50% of the female flowering in plants which reached 51.44 days compared to the treatment of second level plants, which gave the highest average of period to reach 50% female flowering which was 53.00 days. This finding in agreement with results of Azeem *et al.* (2014) whose found significant differences between the levels of the humic. There were no significant differences between the two factors interaction.

Table 1: Effect of the genotype and levels of humic acid and the interaction between them in the number of days from planting to 50% anthesis.

Genotypes	**Humic acid levels ($gm.donum^{-1}$)**			**G mean**
	H1	**H2**	**H3**	
G1	52.33	53.33	51.67	52.44
G2	54.00	51.67	49.00	51.56
G3	52.67	53.33	51.33	52.44
G4	52.33	52.33	49.33	51.33
G5	51.33	50.33	51.00	50.89
G6	52.33	53.67	52.00	52.67
G7	52.67	53.67	50.67	52.33
G8	52.33	53.00	51.67	52.33
G9	56.67	55.67	56.00	56.11
H mean	52.96	53.00	51.44	
LSD (0.05)		H	G	G x H
		1.279	1.205	NS

Leaf area index (LAI)

The results of Table (2) show significant differences between the mean of this character between genotypes and humic acid levels and the interaction between them. The results of the table indicate that the genotype of G2 exceeded the highest value of this character reached 3.159 and did not differ significantly from the genotypes G1, G3, G8. the G9 genotype gave the lowest value of leaf area index reached 1.775, this results in agreement with results of Alnasiri *et al.* (2016) and Jassim and Katib (2017).

Table 2 : Effect of the genotype and levels of humic acid and the interaction between them in leaf area index.

Genotypes	Humic acid levels (gm.donum^{-1})			G mean
	H1	H2	H3	
G1	3.363	2.818	3.121	3.101
G2	3.011	3.326	3.141	3.159
G3	3.448	2.796	3.051	3.098
G4	2.971	2.811	2.778	2.853
G5	2.960	2.948	2.822	2.910
G6	2.767	2.583	2.701	2.684
G7	3.098	2.932	2.948	2.993
G8	3.288	3.110	3.005	3.135
G9	1.778	1.760	1.787	1.775
H mean	2.965	2.787	2.817	
LSD (0.05)	H	G	G x H	
	0.0820	0.0975	0.1697	

The results of the same table showed a significant effect of the humic acid fertilizer in this character. The treatment of first level (500 gm. donum^{-1}) (H1) gave the highest value of the leaf area index which was 2.965, which was significantly higher than the second level plants (750 gm. donum^{-1}) (H2), which gave the lowest value of this character which reached 2.787. This results in agreement with results of Daur *et al.* (2013) and Mahnna *et al.* (2015).

The interaction between the genotypes and levels of humic acid resulted in a significant effect in this characters. The interaction treatment (G3 and first level (500 gm.donum^{-1}) were given a higher value reached 3.448 compared to interaction treatment (G9 and 750 gm.donum^{-1}) (G9H2), which gave the lowest value of leaf area index which was 1.760.

Number of grains per row

This character is one of the secondary components of the yield in maize and affects it directly and is affected by the environmental conditions surrounding the plant.

Table (3) shows that the G8 genotype has the highest mean of this character reached 37.34 grain.row^{-1}, significantly higher than the other genotypes, G9 genotype gave the lowest value reached (27.37 grain.row^{-1}). The superiority of the G8 genotype in this character may be due to its high genetic ability to harness its potential to take advantage of nutrients and other growth factors to increase the percentage of fertility in the flowers then increase the number of grains in the row. This result is consistent with results of Nataraj *et al.* (2014), Pandey *et al.* (2017), Ardeaan, (2017), Abd *et al.* (2017) and Musarbat, (2017). Who found significant differences in the effect of genotypes. The same table indicates that the number of grains in the row decreased significantly with increase of humic acid level as the plants were treated with the first level of the humic (500) gm.donum^{-1} gave the highest value reached 33.64 grain. Plant^{-1} compared to plants which treated with a high level of humic acid 1000 gm.donum^{-1} which gave the lowest rate of this character was 31.74 grain. row^{-1}, perhaps due to the increase in leaf area and its index in the plants of level I (H1), which was reflected positively in the increase of this character, as contributed leaf area to increase the products of the photosynthesis and transfer of these products to the sites of new development in the plant, including flowers and the positive effect in increasing the proportion of fertility thus increase the number of grains in the row. These results in agreement with results of Khudair (2007), guratani and AlTai, (2011), Muhanna *et al.* (2015) and Al-Fahdawi (2017).

Table 3 : Effect of the genotype and levels of humic acid and the interaction between them in Number of grains per row (grain.row^{-1}).

Genotypes	Humic acid levels (gm.donum^{-1})			G mean
	H1	H2	H3	
G1	34.93	30.60	32.48	32.67
G2	36.19	31.28	33.25	33.57
G3	35.47	34.97	27.00	32.48
G4	33.87	34.08	32.53	33.49
G5	33.53	28.43	29.37	30.44
G6	33.83	35.47	35.33	34.88
G7	31.05	36.33	33.21	33.53
G8	36.28	39.33	36.40	37.34
G9	27.58	28.44	26.08	27.37
H mean	33.64	33.22	31.74	
LSD (0.05)	H	G	G x H	
	0.411	1.318	2.171	

The results of the same table show a significant interaction between the levels of the humic acid and the genotypes in this character. The results show a significant increase in the number of grains per row in all genotypes with variation in response to levels of humic acid, but the increase was more pronounced in the genotype G8 which was superior compared to the other genotypes under the effect of all levels of the humic acid, the highest value of this character obtained from second level (750 gm.donum^{-1}) reached 39.33 grain.row^{-1} by increase percent of 13.25% compared to genotype G9 with highest level of humic acid which gave the lowest value reached 26.08 grain.row^{-1}.

Number of rows per ear

The number of rows per ear of the maize crop is one of the important components of the crop and is determined at the beginning of ear formation, which is a genetic character and is also influenced by the environmental factors affecting the vegetative growth characters (Elsahookei, 1990). The results of Table (4) show significant differences between the genotypes in the number of rows per ear. The genotype of G7 was superior by giving highest value reached19.481 row.ear^{-1}, and not significantly different from the G6, G8, and G3, which gave 19.07, 18.6 and 18.17 respectively surpassed the rest of the genotypes. G2 genotype gave the lowest rate of this character reached 15.713 row.ear^{-1}. This may be due to the genetic nature of the genotypes because it relates mainly to the nature of the genetic structure and the environmental conditions. These results in agreement with results of Nataraj *et al*. (2014), Pandey *et al*. (2017), Ardeaan, (2017), Abd *et al*. (2017) and Mosarbat, (2017). It is clear from the results of analysis of variance that the levels of the humic acid did not significantly affect in the number of rows per ear but the interaction between the genotypes and the humic acid levels was significant.

Table 4 : Effect of the genotype and levels of humic acid and the interaction between them in Number of rows per ear (row.ear^{-1}).

Genotypes	Humic acid levels (gm.donum^{-1})			G mean
	H1	H2	H3	
G1	16.200	16.733	15.577	16.170
G2	15.817	16.053	15.270	15.713
G3	18.00	20.200	16.333	18.178
G4	18.667	15.683	16.600	16.983
G5	16.800	18.067	17.353	17.407
G6	18.833	19.933	18.467	19.078
G7	19.333	19.233	19.877	19.481
G8	18.333	18.467	19.000	18.600
G9	16.667	16.000	16.133	16.267
H mean	17.628	17.819	17.179	
LSD (0.05)		H	G	G x H
		N.S.	0.6605	1.1598

The same table indicates that the plants of the genotype G3 and the humic acid level (750 gm. donum^{-1}) gave the highest rate of number of rows per ear (20.200 row.ear^{-1}) while the genotype G2 and the humic acid at the high level (1000) gm. donum^{-1}gave the lowest number of rows per ear was 15.270 row.ear^{-1}.

Weight of 300 grains

The weight of the grain is one of the main components of maize, where it directly affects the singular plant. The weight of the grain is determined by the period of grain filing and the amount of processed food (Tollenaar *et al*., 2000).

The results of Table (5) indicate that there are significant differences between the genotypes in the weight of 300 grains. The genotype of G4 exceeds the highest by giving 91.22 gm by increase of 20.37% from the G9 genotype which gave the lowest rate of this character reached 75.78 gm. in addition, the genotypes of G1 and G5 were superiors by giving(90.11 and 89.44 gm respectively, This increase was attributed to the ability of the genotype to transfer and transport photosynthesis products from the manufacturing sites to the new places of development which contributed to the processing of growing grains with their requirements of The food that led to its fullness and increase its weight, as the grains is the largest consumer of food produced in leaves and food in other plant tissues. This is consistent with results of Nataraj *et al*. (2014), Pandey *et al*. (2017), Ardeaan, (2017), Abd *et al*. (2017) and Mosarbat, (2017).

There was also a significant difference between the levels treatments of humic acid. Table (5) shows that the treatment of humic acid in the first level (500gm.donum^{-1}) gave the highest level of weight of 300 grains which was 87.11 gm, recording a significant difference from the other levels where the third level H3 gave the lowest value reached 82.22 gm. and the last two levels did not differ significantly from each other. The effect of this positive level is due to increase the leaf area and its index positively reflected the efficiency of photosynthesis and increase the storage of food in the plant, which later moves to the growing grains (sink) and increase the fullness and increase in size.

Table 5 : Effect of the genotype and levels of humic acid and the interaction between them in weight of 300 grains (gm).

Genotypes	Humic acid levels (gm.donum^{-1})			G mean
	H1	H2	H3	
G1	98.00	88.00	84.33	90.11
G2	88.00	82.67	91.00	87.22
G3	86.33	80.33	78.67	81.78
G4	90.33	91.33	92.00	91.22
G5	95.33	84.67	88.33	89.44
G6	76.67	75.00	67.33	76.00
G7	86.33	88.33	79.67	84.78
G8	80.00	80.33	75.00	78.44
G9	83.00	69.67	74.67	75.78
H mean	87.11	82.26	82.22	
LSD (0.05)		H	G	G x H
		2.832	3.882	6.650

The results were consistent with result of Khafaji (2015), Muhnna *et al.* (2015), Albahrani, (2015), Albarakat, (2016) and Mehdi (2016). The results of Table (5) show a significant interaction between the genotypes and the levels of the humic acid as it is clear that the genotype of G1 under the effect of the first level of humic acid (500gm.donum^{-1}) was better than the rest of the other genotypes with the highest rate of weight of 300 grains reached 98.00 gm. And its performance was high significant compared to sixth genotype under the level of the third fertilization (G6H3), which gave the lowest rate of this character reached 67.33 gm.

Singular plant yield

The singular plant yield is one of the most important field parameters. it represents the final yield of the plant's biological processes, which are mainly related to genetic factors and are interrelated with the available growth factors (Elsahookie, 2007). The results of Table (6) indicate that there are significant differences between genotypes in this character. The genotype of G2 was significantly superior in singular plant yield by giving the highest yield reached 190.9 gm. plant^{-1}with increase reached 78% higher than the G9 plants genotype which gave the lowest value of plant yield reached 112.9 gm. plant^{-1}. This is due to the superiority of this genotype in the number of ears per plant. Also it didn't differ significantly from the G7 and G8 genotypes, which showed remarkable superiority in most components of the crop (number of grains per row and number of rows per ear). These results in agreement with results of Nataraj *et al*. (2014), Almamari and Alfahadi, (2015), Al-Raawi, (2016), Pandey *et al*. (2017) and Abd *et al*. (2017).

It is clear from the results of the same table that the humic acid at first level H1 gave the highest value of singular plant yield reached 176.7 gm. plant^{-1}with an increase of 15.5 gm compared to the treatment of humic acid at third level (H3), which gave the lowest yield reached 161.2 gm. plant^{-1}, The effect of this positive increasewas because of the number of cereals per row and the weight of 300 grains, respectively, which was reflected in the increase of singular plant yield. These results are consistent with results of Algurtani and AlTai, (2011), AlKhafaji, (2015) and Mahdi, (2016).

Table 6 : Effect of the genotype and levels of humic acid and the interaction between them in singular plant yield (gm. plant^{-1}).

Genotypes	Humic acid levels (gm.donum^{-1})			G mean
	H1	H2	H3	
G1	148.9	150.1	179.7	171.6
G2	212.2	166.1	194.5	190.9
G3	183.9	189.4	115.6	163.0
G4	190.1	163.0	165.2	172.8
G5	179.1	145.2	150.0	158.1
G6	163.0	177.1	166.0	168.7
G7	172.8	205.7	176.0	184.8
G8	177.2	195.1	198.7	190.3
G9	127.1	106.6	104.9	112.9
H mean	176.7	166.5	161.2	
LSD (0.05)		H	G	G x H
		6.76	14.38	23.95

The interaction between the genotypes and the humic acid levels resulted in a significant effect on the singular plant yield. The treated plants with the first level of humic acid and the second genotype (G2H1) gave the highest value of singular plant yield reached 212.2 gm.plant^{-1} compared to other treatments where the interaction treatment (G9H3) which gave the lowest value of this character reached 104.9 gm.plant^{-1}.

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