Available online at http://bajas.edu.iq
http://dx.doi.org/10.37077/25200860.2019.190
College of Agriculture, University of Basrah

Basrah Journal of Agricultural Sciences

ISSN 1814 – 5868 Basrah J. Agric. Sci., 32(2): 23-32, 2019 E-ISSN: 2520-0860

Effect of Humic Acid and Silicon on some Growth Characteristics of Maize (*Zea mays* L.)

Haider H. Hassan, Kadhim H. Huthily & Kareem H. Mohsen

Department of Field Crops, College of Agriculture, University of Basrah, Iraq
***Corresponding author e-mail:** haidarx90@gmail.com

Received 15 Stamper 2019; Accepted 24 October 2019; Available online 14 November 2019

Abstract: A field experiment was conducted during the autumn season of 2018 at agricultural research station in Al- Qurna district (80 km north of Basra center). The aim was to study the effect of spraying different concentrations of humic acid (HA) and silicon on the some growth characteristics of maize (*Zea mays* L.). The experiment was conducted using Three Concentration of humic acid were used 0, 2 and 4 gm L^{-1}, which took the following symbols H_0, H_1, and H_2 respectively and four concentrations of silicon 0, 1, 2 and 3 mML^{-1} which took the symbols S_0, S_1, S_2 and S_3 respectively. A factorial experiment was used in randomized completely block design with four replicates. Maize seeds cv. Fajir1 were planted at 20/7/2018 in a silty loam soil. The results showed that the concentrations of HA differed significantly in all most of the studied characteristics, plant height, leaf area and ear length with an increase by 11.69, 24.89 and 3.49% respectively as compared to the control treatment (H_0). The spraying with silicon showed a significant effect. Moreover, the concentration of S_3 gave the highest values for plant height, stem diameter, leaf area and ear length. The interaction between HA and silicon showed a significant effect on some of the studied characteristics, the combination of $S_3 \times H_2$ produced the highest values of plant high (174.42 cm) and leaf area (7390.65 cm^2).

Keywords: Maize, Humic acid, Silicon, Growth characteristics.

Introduction

Maize (*Zea mays* L.) is one of the most important Cereal crops on the world for its numerous utilizations: in human or animal food as green fodder or silage. The use of grains in the food industry has led to high demand for them, giving impetus to search for ways to increase production. An expansion in yields can be get by animating common physiological procedures influencing plant attributes, One of these important and effective processes is the using of fertilizers or plant growth promoters as foliar spraying, especially when there are factors prevent or limit availability or absorption of nutrients through the roots, such presence of $CaCO_3$, high alkalinity, water stress or drought; These problems reduce the process of construction and lead to retard development of seedling and maturity (Eyheraguibel *et al.*, 2008; Ertani *et al.*, 2011; Rong, 2012). Humic acid (HA) is produced from various sources such as soil, humus, plant residues and oxidation of coal and positively affects the growth of plants and increases the growth of stems, roots and absorption of many nutrients and is not dangerous to plant and external environment (Haghighi *et al*., 2011). HA is a catalyst for plant growth through changes in root structure and growth dynamics, increasing the size and density of roots, so lead to increase the absorption surface (Canellas & Olivares, 2014).

The treatment of maize seeds with HA increases the production of dry matter, growth and rate of seedling (Rodrigues *et al*., 2017). Ragheb (2016) reported that there was a significant effect of spraying of HA in growth properties of maize plants; the concentration 2.5 ml l^{-1} gave the most elevated an incentive for plant height, stem diameter and ear length. Bilal *et al*. (2016) study the effect of four concentrations of HA on maize productivity, Their results showed a significant differences in leaf area, ear length, and biological yield.

Improving food production in areas prone to salinity and drought is essential to meeting growing food needs in the future. Studies have shown that silicon decreases stresses from drought and salinity in plants. It increases plant growth and grain yield and quality by reducing sodium uptake while increasing potassium absorption and transport within plant. In addition silicon increases plant resistance to lodging, enhancing photosynthesis, increases plant tolerance to strong sunlight or shading, decreases oxidative damage in stressful plants and decreases sodium and cadmium in bud and roots of stressful plants (Liang *et al*., 2015; Rizwan *et al*., 2015; Cooke & Leishman, 2016). It was found that foliar application of silicon at average of 4 mM. L^{-1} to maize plants cultivated in plastic pods gave a significant excess in the growth and physiological characteristics (Rohanipoor *et al*., 2013). In another study, it was observed that, the foliar application of 5 ml L^{-1} of potassium silicate on maize significantly affected; plant height, leaf area, stem diameter, and number of leaves in plant (Shedeed, 2018). Regarding to the lacks of studies of using spray fertilization of HA and silicon on maize in south of Iraq. Moreover, the soil in south of Iraq suffering from high salt, high CaCO3 and alkalinity. This study was conducted to revealed the influence of foliar application of humic acid and silicon and their interaction in some vegetative parameters of maize.

Materials & Methods

A field experiment was conducted during autumn season of 2018 at Agricultural Research Station located in the district of Qurna (80 km north of Basra center). A factorial experiment was applied according to the randomized complete block design with four replicates. The first factor included spraying with three concentrations of HA: (0, 2 and 4 gm L^{-1}) which were symbolized as H_0, H_1, and H_2 respectively. Humic acid was used in the form of humiplant fertilizer (80% HA). The second factor was four concentrations of silicon 0, 1, 2 and 3 mM L^{-1}, which were symbolized as S_0, S_1, S_2 and S_3 respectively, The silicon used in form of Armurox fertilizer (8% SiO_2). Spraying of humic acid and silicon were sprayed at three timing (25, 50 and 75 days after planting) Tween 20 was used to decrease the surface tension of the spray solution. Random samples were taken from field soil before planting, dried and passed through a sieve of 2 mm and tested for physical and chemical properties (Table 1). Soil was prepared by laying two orthogonal tillage, softening, and settling them, and then divided into four blocks, each block has 12 experimental units. The experimental unit area was 11.2 m^2 and each unit include four rows of 4 m length, the distance between each rows was 70 cm. Within the row, seeds were swing in distance of 25 cm. Nitrogen fertilizer applied at the average of 320 kg N h^{-1}, phosphate fertilizers at the average of 60 kg P h^{-1} and the Potassium fertilizer at the average of 90 kg k h^{-1}. *Z. mays* seeds (cv. Fajir 1) were sowing at 20/7/2018; three seeds were placed in each hill. Then, the Plants defoliation two weeks after germination and one plant was left in each hill. Surface Irrigation was applied. Service processes were conducted out by continuously removing the weeds from the field. The concentrations of studied fertilizers were sprayed in the early morning using a hand spray and the control treatment was spray with distilled water only. The following characteristics have been studied: number of days to 50% tasselling, number of days to 50% silking, plant height (cm), stem diameter (mm), leaf area (cm^2) and ear length (cm). Data was analyzed by using SPSS program ver.23 and the least significant difference (L.S.D) was used to compare the treatments means at $P < 0.05$.

Table (1): Some Chemical and Physical Properties of Soil.

properties	unit	value	Properties	Unit	Value
pH	\	7.66	Dissolved Ions (meq.L^{-1})	Ca^{++}	13.0
E.C.e	ds m^{-1}	7.20		Mg^{++}	16.5
Organic matter	g kg-1	11.8		Na^{+}	45.6
Sand	g kg-1	60		K^{+}	1.99
Silt		688		Cl^{-}	65.5
Clay		252		$SO_4^{=}$	12.0
Soil texture	Silty loam			HCO_3^{-}	1.80
Available (mg kg^{-1})	NO_3^{-}	22.0			
	NH_4^{+}	14.0			
	P	11.5			

Results & Discussion

Number of days to 50% tasselling

The outcomes of table (2) showed that spraying of humic acid had a significant effect on this character. The increasing of humic acid concentration, lead to reduced days number to reach 50% tasselling. Spraying the plants by H_2 level lead the plants to reached to 50% tasselling by the lowest days number 61.31 days, with a decrease reached to 4.58% compared to the control treatment which recorded the longest period to reach 50% tasselling 64.25 days**.** This is could be due to the chemical structure of humic acid and its mineral content, nitrogen and some another nutrients which lead to increase; photosynthesis rate, accumulation of dry matter and crop growth that is reflect in early flowering. These results are concurrence with El-Mekser *et al.* (2014) and Khan *et al*. (2015).

The results of table (2) indicated that spraying of silicon significantly affected the period from planting to 50% tasselling. Plants that were sprayed with S_3 level required lowest period from planting to 50% 61.83 days with a decrease of 2.87% compared to S_0, which required 63.66 days. The reason due to the role of the silicon in increasing efficiency of photosynthesis and increase activity of antioxidant enzymes, modify balance of plant hormones, and increase content of proteins and sugars in leaves. While, data in table (2) revealed that, the interaction between concentrations of HA and silicon did not affect significantly on this character.

Table (2): Effect of concentrations of humic acid and silicon in number of days to 50% tasselling.

Si / HA	S_0	S_1	S_2	S_3	Average of Humic acid
H_0	65.00	64.25	63.75	64.00	64.25
H_1	63.75	62.00	62.25	61.50	62.37
H_2	62.25	61.75	61.25	60.00	61.31
Average of Silicon	63.66	62.66	62.41	61.83	
L.S.D ≤ 0.05) (P	Humic acid		Silicon		Interaction
	0.61		0.71		N.S.

Number of days to 50% silking

The results of table (3) demonstrated a reduction in days from planting to 50% silking with increase concentration of HA. Plants treated with H_2 concentration required 64.31 days to reach this stage compared to the control treatment (H_0) which required 67.12 days, and that means a decrease by 4.19%. Treat plants with HA lead to increase the amount of nutrients in plant, thus affecting the biological processes within the plant, including increased photosynthesis, accumulation of dry matter and increase the chlorophyll content, thus affecting the period required to reach this stage.

These results are concurrence with results of El-Mekser *et al.* (2014) and Khan *et al*. (2015). The results of table (3) exhibited that spraying the plants by S_3 and S_2 silicon levels led to reduce days number from planting to 50% silking, reached to 64.58 and 65.15 days respectively with a decrease of 3.37 and 2.51% compared to S_0, which gave the longest period of days number to50% silking (66.83). The results of table (3) revealed that the interaction between humic acid and silicon did not have a significant effect in this trait.

Table (3): Effect of concentrations of humic acid and silicon in number of days to 50% silking.

Si / HA	S_0	S_1	S_2	S_3	Average of Humic acid
H_0	68.00	67.50	66.25	66.75	67.12
H_1	67.00	66.00	65.25	64.25	65.62
H_2	65.50	65.00	64.00	62.75	64.31
Average of Silicon	66.83	66.16	65.15	64.58	
L.S.D ≤ 0.05) (P	Humic acid		Silicon		Interaction
	0.61		0.70		N.S.

Plant height (cm)

The results of table (4) indicated that plant height was significantly affected by treated plants with HA, the H_2 level which gave the highest plant high 166.58 cm, with an increase of 11.69% as compared to control treatment (H_0), which gave the lowest value (149.15 cm). The reason is that HA increases the permeability of cellular membranes, accelerates cellular division, and develops the root system (Khaled & Fawy, 2011). These results are agreement with the results of Ragheb (2016). The results of table (4) demonstrated that spraying of plants by silicon had a significant effect on plant height. The S_3 treatment gave the highest value of plant height reached to 164.05 cm with an increase of 8.59% compared to the control treatment, which gave the lowest value of this character (151.07 cm). This increase in plant height is attributed to the role of Silicon in increasing the absorption of water and nutrients such as P and K, increasing rate of chlorophyll biosynthesis and efficiency of photosynthesis, as well as reducing oxidative harm in stressful plants (Xie *et al.*, 2014; Cooke & Leishman, 2016).

Table (4): Effect of concentrations of humic acid and silicon and their interaction in plant height (cm).

Si / HA	S_0	S_1	S_2	S_3	Average of Humic acid
H_0	144.67	147.22	152.10	152.60	149.15
H_1	151.32	160.57	164.85	165.15	160.47
H_2	157.22	165.37	169.30	174.42	166.58
Average of Silicon	151.07	157.72	162.08	164.05	
L.S.D ≤ 0.05) (P	Humic acid		Silicon		Interaction
	1.60		1.85		3.21

These results are consistent with his findings by some studies (Rohanipoor *et al.*, 2013; Salim, 2014; Shedeed, 2018).

Interaction between spraying of HA and silicon had a significant effect in plant height. The highest plant height was 174.42 cm have been obtain by the combination of $S_3 \times H_2$ with an increase 20.56% compared to the combination ($S_0 \times H_0$) which gave 144.67 cm (Table 4).

Stem diameter (mm)

The results in table (5) displayed an increase in stem diameter with increase HA concentration. The H_2 level gave the highest plant diameter 27.11 mm with an increase by 5.65% and 4.15% compared to H_0 and H_1 respectively. The spraying of plants with HA provided important nutrients for plant growth by increasing the absorption of monocular ions such as Nitrogen and potassium by accelerating the active absorption of plant roots, which increases the efficiency of photosynthesis, cell division and development, Increase the number of vascular bundles and their size and thus increase stem diameter (Shahryari *et al.,* 2011). Our results are in agreement with findings of Eldardiry *et al.* (2012). The results of table (5) showed that foliar application of 3 mM silicon. l^{-1} (S_3) significantly affected and exceeded the stem diameter. Silicon S_3 was significantly exceeded the stem diameter, giving the highest mean of this character of 26.88 mm, with an increase of 3.90% compared to S_0, which gave the lowest value (25.87mm). This increase in stem diameter can be attribute to role of silicon accumulating in cell walls, which is intertwine with cellulose and pectin, thus enhancing tissue mechanics. The spraying of silicon results in its deposition in cell membrane where silica becomes gel, resulting in hardening of the wall and increasing its thickness (Gao *et al*., 2006; Sahebi *et al*., 2015). These results are similar with that in Shedeed (2018). There is no interaction between humic concentration and silicon.

Table (5) Effect of concentrations of humic acid and silicon in Stem diameter (mm)

Si / HA	S_0	S_1	S_2	S_3	Average of Humic acid
H_0	25.24	25.19	25.77	26.45	25.66
H_1	25.66	25.73	26.16	26.58	26.03
H_2	26.73	26.70	27.39	27.61	27.11
Average of Silicon	25.87	25.88	26.44	26.88	
L.S.D (P ≤ 0.05)	Humic acid		Silicon		Interaction
	0.24		0.27		N.S.

Leaf area (cm^2)

The results in table (6) indicated that leaf area increased progressively irrespective of the treatment over control for both factors. Regarding to HA, the highest value was recorded by H_2 level (7022.83 cm^2), with an increase 24.89 % compared to H_0 which gave 5623.25 cm^2. this may be due to the positive role of this added acid and then increase the amount of macro and micro-nutrients availability for absorption, which led to the development of vegetative growth and increase photosynthesis and then increase the leaf area of the plant (Pettit, 2004; Vaccaro *et al*., 2015). Corresponding to silicon, the same table showed that S_3 gave the highest value for leaf area reached to 6779.05 cm^2; differ significantly from the other levels, with an increase by 16.41% compared to control (S_0) which recorded 5823.62 cm^2. This may be due to the positive effect of silicon when sprayed on plant vegetation by increasing the efficiency of enzymatic activity. The accumulated silicon in cuticle cells also affects the angle of leaf's inclination to make it more efficient, that receive more sunlight and more it increases reception of light. Moreover, silicon increases chlorophyll a, chlorophyll b and total chlorophyll, thereby enhancing photosynthesis, inhibiting transpiration and increasing water use efficiency (Barbosa *et al*., 2015; Liang *et al*., 2015). These outcomes are agreement with Rohanipoor *et al*. (2013) and Shedeed (2018). With respect to results in table (6), it is clearly indicated a significant effect due to interaction between the two factors. The highest value was obtained by using 4 gm. l^{-1} from humic acid with 3 mM silicon (H_2S_3), which recorded 7390.65 cm^2 and an increase of 40.19% compared to combination ($H_0 \times S_0$), which recorded the lowest value (5271.98 cm^2).

Table (6) Effect of concentrations of humic acid and silicon in leaf area (cm^2).

HA \ Si	S_0	S_1	S_2	S_3	Average of Humic acid
H_0	5271.98	5635.05	5827.77	5758.22	5623.25
H_1	5718.82	6626.63	6972.21	7188.28	6626.48
H_2	6480.07	7091.72	7128.90	7390.65	7022.83
Average of Silicon	5823.62	6451.13	6642.96	6779.05	
L.S.D ≤ 0.05) (P	Humic acid		Silicon		Interaction
	75.38		87.05		150.77

Ear length (cm)

The results of table (7) presented that spraying of humic acid has a significant effect on ear length. H_2 and H_1 levels gave the highest value reached to 17.48 and 17.45 cm with an increase by 3.49% and 3.32% respectively as compared with the treatment without spray, which gave the lowest value (16.89 cm). This is due to the important role of humic acid in increasing plant height and leaf area (Tables 4 & 6), which reflected positively on photosynthesis proses and then on increasing ear length. These results are in agreement with Ragheb (2016). The results of table (7) also showed that silicon spray has a significant effect. The S_3 and S_2 levels gave the highest values of ear length (17.64 and 17.61 cm) with an increase of 6.01% and 5.83% as compared with treatment without spray, which gave the lowest value of 16.64 cm. This may be due to the role of silicon in

Table (7) Effect of concentrations of humic acid and silicon in Ear length (cm).

Si / HA	S_0	S_1	S_2	S_3	Average of Humic acid
H_0	15.72	17.03	17.41	14.40	16.89
H_1	16.96	17.38	17.46	18.00	17.45
H_2	17.23	17.18	17.96	17.53	17.48
Average of Silicon	16.64	17.20	17.61	17.64	
L.S.D ≤ 0.05) (P	Humic acid		Silicon		Interaction
	0.12		0.14		0.24

increasing of water use efficiency, maintaining the balance of nutrients within plant and it is increasing the production of dry matter (Janislampi, 2012). For the effect of interaction, the (H_1 × S_3) and (S_2 × H_2) combination recorded the highest values of ear length (18.00 and 17.96 cm) with an increase by 25% and 24.72% compared to combination (S_3 × H_0) which gave the lowest value of 14.40 cm.

Conclusion

Based on the obtained results, it could be concluded that under the condition of this work when foliar application Humic Acid and silicon play an important role in plant growth. Spraying by Humic Acid and silicon gave the best results of , plant height, stem diameter, and ear length. Humic acid sprayed at rate 4 gm L^{-1} with silicon at level of 3Mml^{-1} were extremely effective in increasing plant height, leaf area and ear length .

Acknowledgements

The authors thank the staff of the Field Crops Department, College of Agriculture, University of Basrah for their supporting and advices in some parts of the study.

Conflict of interest: The authors declare that they have no conflict of interest.

References

Barbosa, M.A.M.; Silva, M.H.L.; Viana, G.D.M.; Ferreira, T.R.; Souza, C.L.F.D.; Lobato, E.M.S.G. & Lobato, A. K.D.S. (2015). Beneficial repercussion of silicon (Si) application on photosynthetic pigments in maize plants. Aust. J. Crop. Sci., 9(11): 1113-1118.

Bilal, M.; Umer, M.; Khan, I.; Munir, H.; Ahmad, A.; Usman, M. & Iqbal, R. (2016). Interactive Effect of Phosphorous and Humic Acid on Growth, Yield and Related Attributes of Maize. J. Agr. Res., 54(3): 433-445.

Canellas, L.P. & Olivares, F.L. (2014). Physiological responses to humic substances as plant growth promoter. Chem. Bio. T. Agr., 1(3): 1-11.

Cooke, J. & Leishman, M.R. (2016). Consistent alleviation of abiotic stress with silicon addition: A meta-analysis. Funct. Ecol., 30(8): 1340-1357.

Eldardiry, E.I.; Sabreen, K.P. & El Hady, M.A. (2012). Improving soil properties, maize yield components grown in sandy soil under irrigation treatments and humic acid application. Aust. J. Basic. Appl. Sci., 6(7): 587-593.

El-Mekser, H.; Mohamed, Z.E.O.M. & Ali, M. (2014). Influence of humic acid and some micronutrients on yellow corn yield and quality, World Appl. Sci. J., 32(1): 1-11.

Ertani, A.; Francioso, O.; Tugnoli, V.; Righi, V. & Nardi, S. (2011). Effect of commercial lignosulfonate-humate on *Zea mays* L. metabolism. J. Agric. Food Chem., 59: 11940-11948.

Eyheraguibel, B.; Silvestre, J. & Morard, P. (2008). Effects of humic substances derived from organic waste enhancement on the growth and mineral nutrition of maize. Bioresource Technol., 99: 4206-4212.

Gao, X.; Zou, C.; Wang, L. & Zhang, F. (2006). Silicon decreases transpiration rate and conductance from stomata of maize plants. J. Plant Nutr., 29(9): 1637-1647.

Haghighi, S.; Saki-Nejad, T. & Lack, S.H. (2011). Evaluation of changes the qualitative and quantitative yield of horse been (*Vicia faba* L.) plants in the levels of humic acid fertilizer. Life Sci. J., 8(3): 583-588.

Janislampi, K.W. (2012). Effect of silicon on plant growth and drought stress tolerance. M. Sc. Thesis. Univ. Utah State: 101pp.

Khaled, H. & Fawy, H.A. (2011). Effect of different levels of humic acids on the nutrient content, plant growth, and soil properties under conditions of salinity. Soil Water Res., 6(1): 21-29.

Khan, M.I.; Qadoons, M.; Suleman, M.; Khan, H.; Aqeel, M. & Rafiq, M. (2015). Response of maize crop to different levels of humic acid. Life Sci. Int. J., 9(Issue 1-4): 3116-3120.

Liang, Y.; Nikolic, M.; Belanger, R.; Gong, H. & Song, A. (2015). Silicon in agriculture: From theory to practice. Springer, Amsterdam: 325pp.

Pettit, R.E. (2004). Organic matter, humus, humate, humic acid, fulvic acid and humin: Their importance in soil fertility and plant health. CTI Research: 17pp.

Ragheb, E.E. (2016). Sweet corn as affected by foliar application with amino–and humic acids under different fertilizer sources. Egypt. J. Hort., 43(2): 441-456.

Rizwan, M.; Ali, S.; Ibrahim, M.; Farid, M.; Adrees, M.; Bharwana, S.A. & Abbas, F. (2015). Mechanisms of silicon-mediated alleviation of drought and salt stress in plants: a review. Environ. Sci. Pollut. R., 22(20): 15416-15431.

Rodrigues, L.A.; Alves, C.Z.; Rego, C.H.Q.; Silva, T.R.B.D. & Silva, J.B.D.. (2017). Humic Acid on germination and vigor of corn seeds. Rev. Caatinga Mossoró, 30(1): 149-154.

Rohanipoor, A.; Norouzi, M.; Moezzi, A. & Hassibi, P. (2013). Effect of silicon on some physiological properties of maize (*Zea mays* L.) under salt stress. J. Biol. Environ. Sci., 7(20): 71-79.

Rong, Y. (2012). Estimation of maize evapotranspiration and yield under different deficit irrigation on a sandy farmland in Northwest China. Afr. J. Agric. Res., 7(33): 4698-4707.

Sahebi, M.; Hanafi, M.M.; Akmar, A.S.N.; Rafii, M.Y.; Azizi, P.; Tengoua, F.F. & Shabanimofrad, M. (2015). Importance of silicon and mechanisms of biosilica formation in plants. Biomed. Res. Int., 2015: 396010: 16pp.

Salim, B.B. (2014). Effect of boron and silicon on alleviating salt stress in maize. Middle East J. Agric. Res., 3(4): 1196-1204.

Shahryari, R.; Khayatnezhad, M. & Bahari, N. (2011). Effect of two humic fertilizers on germination and seedling growth of maize genotypes. Adv. Environ. Biol., 5(1): 114-118.

Shedeed, S. I. (2018). Assessing effect of potassium silicate consecutive application on forage maize plants (*Zea mays* L.). JIPBS, 5 (2): 119-127.

Vaccaro, S.; Ertani, A.; Nebbioso, A.; Muscolo, A.; Quaggiotti, S.; Piccolo, A. & Nardi, S. (2015). Humic substances stimulate maize nitrogen assimilation and amino acid metabolism at physiological and molecular level. Chem. Bio. T. Agr., 2(5): 1-12.

Xie, Z.; Song, F.; Xu, H.; Shao, H. & Song, R. (2014). Effects of silicon on photosynthetic characteristics of maize (*Zea mays* L.) on alluvial soil. Sci. World J., 2014: 718716: 6pp.