EFFECT OF SEEDS SOAKING AND VEGETATIVE PARTS NUTRITION WITH ACIDS OF ASCORBIC, CITRIC AND HUMIC ON MAIZE GROWTH

J. J. Kadhim[1] **J. H. Hamza[2]**
Lecturer **Prof.**
[1]Vocational Education, Babel Education, Ministry of Education
[2]Dept. of Field Crops, Coll. of Agric. Engin. Sci., Univ. of Baghdad
* Corresponding author: E-mail: j.hamza@coagri.uobaghdad.edu.iq

ABSTRACT
A field experiment was carried out during two spring seasons in 2019 and 2020. This study was aimed to increase dry matter weight and crop growth rate of maize. First factor in main plots was nutrition vegetative parts with ascorbic and citric (100 mg l^{-1}) for both of them and humic (1 ml l^{-1}), in addition to the control treatment (spraying of vegetative parts with distilled water only). Second factor in sub-plots was seeds soaking with same acids above, as well as the control treatment (soaking the seeds with distilled water only). Randomize complete block design in split plot arrangement was used with three replications. The results showed a significant superiority of seeds soaking in humic acid for traits of number of days from planting to 75% anthesis and silking (66.4 and 66.3 day) and (72.3 and 72.3 day), plant height (194.0 and 230.8 cm), leaves area plant^{-1} (6969.5 and 6570.2 cm^2), leaf area index (3.71 and 3.50), dry matter weight (11.6 and 12.2 ton ha^{-1}), crop growth rate (3.0 and 3.2 g cm^{-2} day^{-1}) and chlorophyll leaf content (60.2 and 69.5 SPAD) for both seasons, respectively. Effect of vegetative parts nutrition and interaction effect of both studied factors was non-significant for most traits. It can be concluded that seeds soaking in humic acid improved growth traits. It can be recommended to soak seeds of maize before planting in humic acid at concentration of 1 ml l^{-1}.

Key words: chlorophyll, crop growth, dry matter weight, foliar spraying, priming
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تأثير نقع البذور وتغذية الجزء الخضري بأحماض الأسكوربيك والستريك والهيوميك في نمو الذرة الصفراء

جزران جرد كاظم [1] جلال حميد حمزة [2*]
مدرس أستاذ
[1]التعليم المهني – تربية بابل– وزارة التربية [2]قسم المحاصيل الحقلية – كلية علوم الهندسة الزراعية – جامعة بغداد

المستخلص
أجريت تجربة حقلية في العروتين الربيعيتين في 2019 و 2020 بهدف زيادة وزن المادة الجافة ومعدل نمو محصول الذرة الصفراء. استخدم تصميم القطاعات الكاملة المعشاة بترتيب الألواح المنشقة وبثلاثة مكررات. العامل الأول في الالواح الرئيسة هو تغذية الأجزاء الخضرية بأحماض الأسكوربيك والستريك (100 ملغم لتر$^{-1}$) لكل منهما والهيوميك (1 مل لتر$^{-1}$)، فضلاً عن معاملة المقارنة (رش الأجزاء الخضرية بالماء المقطر فقط). العامل الثاني في الألواح الثانوية هو نقع البذور بنفس الأحماض أعلاه، فضلاً عن معاملة المقارنة (نقع البذور بالماء المقطر فقط). أظهرت النتائج تفوقاً معنوياً لمعاملة نقع البذور بحامض الهيوميك في صفات عدد الأيام من الزراعة إلى 75٪ إزهار ذكري و أنثوي (66.4 و 66.3 يوم) و (72.3 و 72.3 يوم) وارتفاع النبات (194.0 و 230.8 سم) والمساحة الورقية للنبات (6969.5 و 6570.2 سم^2) ودليل المساحة الورقية (3.71 و 3.50) ووزن المادة الجافة (11.6 و 12.2 ط هـ$^{-1}$) ومعدل نمو المحصول (3.0 و 3.2 غم سم$^{-2}$ يوم$^{-1}$) ومحتوى الورقة من الكلوروفيل (60.2 و 69.5 سباد) في العروتين بالتتابع. ولم يكن تأثير تغذية الاجزاء الخضرية أو التداخل بين عاملي الدراسة معنوياً في أغلب الصفات المدروسة. ويمكن الاستنتاج أن نقع البذور بحامض الهيوميك حسن خصائص النمو. ويمكن التوصية بنقع بذور الذرة الصفراء قبل الزراعة بحامض الهيوميك بتركيز 1 مل لتر$^{-1}$.

كلمات مفتاحية: الكلوروفيل، نمو المحصول، وزن المادة الجافة، الرش الورقي، تنشيط

*جزء من أطروحة الدكتوراه للباحث الأول.

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INTRODUCTION

The process of seeds priming by soaking them with stimulating materials is an important agricultural process to raise the vitality and vigour of seeds and stimulate them to produce active plants that have ability to compete and grow in a wide range of environmental conditions compared to non-primed seeds. Seed priming is used to improve seedling growth under a wide range of environmental conditions (7, 22). Seed priming is used to allow seeds complete a part of metabolic processes during the pre-activation that preceded seeds planting (11). There is a possibility to improve growth under biotic and abiotic stresses by seeds soaking in various nutrient (12). Seeds priming process to improve seeds viability and vigour of deteriorated seeds, also has improved viability of embryo, which was reflected positively in callus induction (13). Abboud and Dawood (1) studied soaking of sorghum seeds with ascorbic acid at concentrations 5, 10, 20 and 40 mg l^{-1} and found that 20 mg l^{-1} gave the highest average number of leaves (17.10 leaf plant^{-1}) compared to the other concentrations, and the highest average of chlorophyll content in leaves (49.2 SPAD), followed by concentrations 40 and 5 mg l^{-1} (47.63 leaf plant^{-1} and 46.33 SPAD), respectively. Results of Seadh and El-Metwally (21) confirmed that soaking wheat seeds before planting in different antioxidant treatments (soaking and without soaking in tap water, salicylic, citric and ascorbic at concentration of 300 mg l^{-1} for each acid) had a significant effect on growth characteristics during both seasons, as it obtained the highest averages in all growth traits as a result of seeds soaking in salicylic acid, followed by ascorbic and citric acids, as plant height reached 92.20 and 93.80 cm, respectively, during both seasons. Muhanna et al. (16) showed that soaking of maize seeds in humic acid at concentration of 1000 mg kg^{-1} before 24 hours of planting had given the highest average of plant height, number of leaves and leaf area index (139.58 cm, 11.11 leaf plant^{-1} and 2.38), respectively. Studies proved that foliar nutrition is an effective method to absorb nutrients by plant and contribute to increase growth and yield by allowing absorption and rapid utilization of nutrients that used and removing visible symptoms from leaves that due to deficiency of one or more elements, as well as reducing the need for large quantities of nutrients, especially essential elements compared to other methods. Ascorbic acid is one of the necessary basic components of normal growth of high-end plants, due to its functions in plant tissues, including a reducing of heat stress and toxicity, stimulating of respiration, cell division, increasing of enzymes activity, and preserving of cell components from photo-oxidation like chlorophyll (18). Citric acid plays an active and influential role in formation and production of compounds that contribute to build plant cell and formation of its compounds such as fats, proteins, and various carbohydrates that makes by plant during growth period, as well as chlorophyll, growth pigments, phytochromes and cytochromes (24). Humic acid is an effective source of carbon necessary for activity of micro-organisms, and spraying it on plants or adding it to soil increases growth of root system, as well as its hormonal effect on cell protoplasm and cell wall, which leads to rapid cell division and growth (4). This study was conducted to determine which of studied factors has an effect to increase maize growth, especially dry matter weight and crop growth rate during spring season as a wide range of environmental conditions.

MATERIAIS AND METHODS

A field experiment was carried out during two spring seasons at the College of Agricultural Engineering Sciences, University of Baghdad in 2019 and at Babylon governorate in 2020 (it was not possible to repeat the implementation of the experiment at the same first site due to the curfew imposed by the Corona pandemic (COVID-19)). Randomize complete block design within split plot arrangement was used with three replications. First factor in main plots was nutrition vegetative parts with ascorbic and citric (100 mg l^{-1}) for both of them and humic (1 ml l^{-1}), in addition to the control treatment (spraying of vegetative parts with distilled water only). Second factor in sub-plots was seeds soaking with same acids above, as well as the control treatment (soaking the seeds with distilled water only). Two nutrition stages for acids were fixed when

6 and 10 real leaves appeared. The seeds were soaked for 18 hours. Maize seeds (cv. Baghdad3) were obtained from the Agricultural Research Department, Ministry of Agriculture. Soil was analyzed before planting by taking samples with a depth of 0-30 cm to study some physical and chemical characteristics (Table 1). Soil and crop service operations were conducted according to the recommendations of the Ministry of Agriculture (15). DAP fertilizer (46:18) (P: N) was added when preparing the soil by 436 kg h^{-1}. 348 kg h^{-1} urea fertilizer (46% N) was added when planting. The planting was carried out on lines with a distance of 75 cm between one line and another, and 25 cm between hole and another to obtain the necessary plant density of 53333 plant h^{-1}. The experimental unit consisted of four lines, 3 m long, with a total area of 9 m^2, and the distance between replications was 1.5 m. The seeds were planted on March 21st. The plants were irrigated as needed (15).

Table 1. Some physical and chemical characteristics of the experimental soil in the two spring seasons of 2019 and 2020

Characteristics	Unit	Spring season 2019	Spring season 2020
Sand	g kg^{-1} soil	592	233
Silt	g kg^{-1} soil	320	342
Clay	g kg^{-1} soil	88	425
Soil texture		silty loam	silty clay loam
pH		7.12	7.46
Available nitrogen	mg kg^{-1} soil	25.11	27.7
Available phosphorus	mg kg^{-1} soil	8.35	11.4
Available potassium	mg kg^{-1} soil	80.71	100.8
Organic material	g kg^{-1} soil	6.3	10.7
EC	dS m^{-1}	3.30	3.20
HCO^{-3}	meq l^{-1}	2.10	2.12
Cl^{-1}	meq l^{-1}	28.22	26.18
SO^{-4}	meq l^{-1}	2.56	2.44
Ca	meq l^{-1}	18.10	20.11
Mg	meq l^{-1}	10.41	12.25
Na	meq l^{-1}	3.89	4.10

The following traits were studied:

1. Number of days from planting to 75% anthesis and silking (day)
2. Internodes number $plant^{-1}$: It was determined from first internode at the soil surface to the last internode when anthesis was completed.
3. Stem diameter (cm): It was measured using vernia at the point after the second node on plant stem from soil surface.
4. Plant height (cm): It was measured from first node above soil surface to inferior node of male flower after anthesis was completed (9).
5. Leaves number $plant^{-1}$: It was calculated from the first green leaf at soil surface (usually dry) to the flag leaf after plant had reached full maturity (9).
6. Leaves area $plant^{-1}$ (cm^2): It was calculated by measuring leaf's length that under cob's leaf, and if there is more than one, then the upper cob is taken for that measurement, then multiply by fixed factor. Fixed factor that used is differs, it is 0.65 if leaves number is between 11-13 leaves, but if its 14-16 leaves which is common then the fixed factor that used is 0.75 instead of 0.65 according to the equation of El-Sahooki (8).

$$\text{Leaf } area\ (cm^2) = \textit{square of leaf's length of leaf that under the cob's leaf} \times \mathbf{0.75}$$

7. Leaf area index: It was calculated according to equation of El-Sahookie (8).

$$\text{Leaf area index} = \frac{\text{plant leaf area}}{\text{land area that occupied by plant}}$$

8. Dry matter weight (ton ha^{-1}): It was calculated from the means of three guarded plants that were cut and dried using an oven until weight fix, and then weight was converted according to ton ha^{-1}.
9. Crop growth rate (g cm^{-2} day^{-1}): It was calculated from dividing of dry matter on days number from planting irrigation up to 75% silking (2).

10. Leaf chlorophyll content (SPAD): Readings were made for five flag sheets after flowering stage was completed (100%), that was done by taking three readings from blade of each leaf with a Japanese-made device (Minolta SPAD 502) (19). Data were analyzed statistically using the GenStat program. The variance analysis was performed according to the randomize complete block design within split plot arrangement with three replications.. Means were compared using the least significant difference test at a probability level of 0.05 (23).

RESUITS AND DISCUSSION

Number of days from planting to 75% anthesis (day)

Results in table 2 showed significant superiority of seeds soaking treatment with humic acid and had the lowest average of number of days from planting to 75% of anthesis (66.4 and 66.3 days), while control treatment had the highest average of number of days from planting to 75% of anthesis (67.8 and 67.7 days) during both seasons, respectively. The reason could be due to the effect of soaking with humic acid and its encouraging nutrients that helped emergence and growth, as well as its containment of organic compounds that increase the readiness of other nutrients, which led to obtain active plants, which leads plant to flowering faster. Results are consistent with Al-Fahdawi (6) who mentioned that increasing the concentrations of humic acid in barley crop caused a decrease number of days from planting to flowering. Effect of vegetative parts nutrition or interaction between studied factors was not significant during both seasons.

Table 2. Number of days from planting to 75% anthesis (day) affected by seeds soaking and vegetative parts nutrition with acids of ascorbic, citric and humic in maize during spring seasons of 2019 and 2020

	Vegetative parts nutrition	Seeds soaking				Average
		Distilled water	Ascorbic	Citric	Humic	
Spring of 2019	Distilled water	67.7	67.3	67.0	66.3	67.1
	Ascorbic	68.0	67.7	66.7	66.3	67.2
	Citric	67.7	67.7	66.3	66.3	67.0
	Humic	67.7	67.7	66.3	66.7	67.1
	LSD 5%		NS			NS
	Average	67.8	67.6	66.6	66.4	
	LSD 5%		0.4			
Spring of 2020	Distilled water	67.7	67.0	66.7	66.3	66.9
	Ascorbic	68.0	67.0	66.7	66.3	67.0
	Citric	67.3	67.3	67.0	66.7	67.1
	Humic	67.7	67.7	67.7	66.0	67.3
	LSD 5%		NS			NS
	Average	67.7	67.3	67.0	66.3	
	LSD 5%		0.5			

LSD 5%: least significant difference at a probability level of 5%; NS: Non-significant at P<0.05.

Number of days from planting to 75% silking (day)

Data in table 3 showed significant superiority of seeds soaking treatment in humic acid and had the lowest average for number of days from planting to 75% silking (72.3 and 72.3%), while control treatment had the highest average (73.6 and 73.9 days) during both seasons, respectively. Reason of that could be due to seeds soaking with humic acid leads to increase outputs of photosynthesis process as plant continues to grow vegetative and push it to flowering, and this is consistent with findings of Sayeb (20) about prolonging number of days from planting to female flowering. Effect of vegetative parts nutrition or interaction between studied factors was not significant during both seasons.

Table 3. Number of days from planting to 75% silking (day) affected by seeds soaking and vegetative parts nutrition with acids of ascorbic, citric and humic in maize during spring seasons of 2019 and 2020

Season	Vegetative parts nutrition	Seeds soaking: Distilled water	Ascorbic	Citric	Humic	Average
Spring of 2019	Distilled water	73.7	73.3	72.7	72.3	73.0
	Ascorbic	73.3	73.7	73.0	72.0	73.0
	Citric	73.3	73.7	72.3	72.7	73.0
	Humic	74.0	73.7	72.3	72.0	73.0
	LSD 5%		NS			NS
	Average	73.6	73.6	72.6	72.3	
	LSD 5%		0.4			
Spring of 2020	Distilled water	74.0	73.7	73.0	72.3	73.3
	Ascorbic	73.7	73.0	72.7	72.3	72.9
	Citric	74.0	72.0	72.3	72.7	72.8
	Humic	74.0	72.7	72.7	72.0	72.8
	LSD 5%		NS			NS
	Average	73.9	72.8	72.7	72.3	
	LSD 5%		0.4			

LSD 5%: least significant difference at a probability level of 5%; NS: Non-significant at $P<0.05$.

Internodes number plant^{-1}

Data in table 4 showed that seeds soaking with humic acid was significantly superior and gave the highest average internodes number plant^{-1} (12.8 and 16.0), with a significant difference from the other treatments, while control treatment gave the lowest average (11.9 and 14.8) during both seasons, respectively. Increasing in the number of internodes plant^{-1} could be due to effect of humic acid in increasing growth by increasing elongation and cells division, as well as increasing negative osmotic potential inside cells, and then increasing their absorption of water and nutrients, which was reflected in increasing in internodes number plant^{-1}. Effect of vegetative parts nutrition or interaction between studied factors was not significant during both seasons.

Stem diameter (cm)

Table 5 showed significant superiority of seeds soaking with humic acid and gave the highest average stem diameter (3.3 and 3.9 cm), while control treatment gave the lowest average (3.0 and 3.3 cm) during both seasons, respectively. A reason for the superiority of seeds soaking in humic acid could be due to its hormonal effect on protoplasm of cell and cell wall, as it leads to speed of cell division and their growth, then increasing stem diameter. These results is in agreement with Hashem (14). Effect of vegetative parts nutrition or interaction between studied factors was not significant during both seasons.

Table 4. Internodes number plant^{-1} affected by seeds soaking and vegetative parts nutrition with acids of ascorbic, citric and humic in maize during spring seasons of 2019 and 2020

Season	Vegetative parts nutrition	Seeds soaking: Distilled water	Ascorbic	Citric	Humic	Average
Spring of 2019	Distilled water	12.1	12.3	12.4	12.6	12.4
	Ascorbic	12.2	11.9	12.7	12.8	12.4
	Citric	11.9	11.9	12.7	13.0	12.4
	Humic	11.5	12.1	12.6	12.9	12.3
	LSD 5%		NS			NS
	Average	11.9	12.1	12.6	12.8	
	LSD 5%		0.1			
Spring of 2020	Distilled water	14.7	15.3	15.5	16.0	15.4
	Ascorbic	14.7	15.7	15.5	15.9	15.4
	Citric	15.0	15.5	15.8	15.8	15.5
	Humic	14.8	15.5	15.7	16.2	15.5
	LSD 5%		NS			NS
	Average	14.8	15.5	15.6	16.0	
	LSD 5%		0.2			

LSD 5%: least significant difference at a probability level of 5%; NS: Non-significant at $P<0.05$.

Table 5. Stem diameter (cm) affected by seeds soaking and vegetative parts nutrition with acids of ascorbic, citric and humic in maize during spring seasons of 2019 and 2020

	Vegetative parts nutrition	Seeds soaking				Average
		Distilled water	Ascorbic	Citric	Humic	
Spring of 2019	Distilled water	2.9	3.0	3.2	3.3	3.1
	Ascorbic	3.0	3.1	3.2	3.3	3.1
	Citric	3.0	3.0	3.1	3.4	3.2
	Humic	2.9	3.1	3.3	3.3	3.1
	LSD 5%		NS			NS
	Average	3.0	3.1	3.2	3.3	
	LSD 5%		0.1			
Spring of 2020	Distilled water	3.2	3.4	3.7	4.0	3.6
	Ascorbic	3.2	3.4	3.6	3.8	3.5
	Citric	3.4	3.5	3.9	3.7	3.6
	Humic	3.3	3.5	3.5	4.0	3.6
	LSD 5%		NS			NS
	Average	3.3	3.5	3.7	3.9	
	LSD 5%		0.2			

LSD 5%: least significant difference at a probability level of 5%; NS: Non-significant at P<0.05.

Plant height (cm)

Data in table 6 showed significant superiority of seeds soaking treatment with humic acid and produce the highest average of plant height (194.0 and 230.8 cm), while control treatment (seeds soaking in distilled water only) gave the lowest average (175.5 and 210.4 cm) during both seasons, respectively. This is could be due to effect of soaking with humic acid, which increased vital processes of plant and raised absorption of nutrients, then led to an increase plant growth, as well as humic acid has hormonal effect on cell protoplasm and cell wall, then led to an increase in speed of cell division and growth. These results are in agreement with findings of Hashem (14) who stated that an increase in the concentration of humic acid in wheat crop caused an increase in the plant height. Effect of vegetative parts nutrition or interaction between studied factors was not significant during both seasons.

Table 6. Plant height (cm) affected by seeds soaking and vegetative parts nutrition with acids of ascorbic, citric and humic in maize during spring seasons of 2019 and 2020

	Vegetative parts nutrition	Seeds soaking				Average
		Distilled water	Ascorbic	Citric	Humic	
Spring of 2019	Distilled water	176.1	174.7	192.8	194.9	184.6
	Ascorbic	175.3	179.9	192.7	198.3	186.6
	Citric	175.3	182.5	187.1	190.7	183.9
	Humic	175.4	176.5	187.4	191.9	182.8
	LSD 5%		NS			NS
	Average	175.5	178.4	190.0	194.0	
	LSD 5%		3.3			
Spring of 2020	Distilled water	212.7	218.6	224.5	231.6	221.9
	Ascorbic	207.8	217.6	222.9	230.9	219.8
	Citric	211.6	217.2	221.3	229.7	219.9
	Humic	209.3	218.8	220.1	230.9	219.8
	LSD 5%		NS			NS
	Average	210.4	218.1	222.2	230.8	
	LSD 5%		3.7			

LSD 5%: least significant difference at a probability level of 5%; NS: Non-significant at P<0.05.

Leaves number plant^{-1}

Results in table 7 showed significant superiority of seeds soaking treatment with humic acid and gave the highest average of leaves number plant^{-1} (15.6 and 15.2), while control treatment gave the lowest average (14.1 and 14.1) during both seasons, respectively. An increase in leaves number plant^{-1} as a result of seeds soaking in humic acid could be attributed to increase in rates of photosynthesis due to positive effect that humic acid has biological processes of plant. Effect of vegetative parts nutrition or interaction between studied factors was not significant during both seasons.

Table 7. Leaves number plant^{-1} affected by seeds soaking and vegetative parts nutrition with acids of ascorbic, citric and humic in maize during spring seasons of 2019 and 2020

	Vegetative parts nutrition	Seeds soaking				Average
		Distilled water	Ascorbic	Citric	Humic	
Spring of 2019	Distilled water	13.5	14.3	15.2	15.5	14.6
	Ascorbic	14.8	14.8	15.4	15.6	15.2
	Citric	14.3	14.5	15.3	15.5	14.9
	Humic	13.6	13.9	15.1	15.8	14.6
	LSD 5%		NS			NS
	Average	14.1	14.4	15.3	15.6	
	LSD 5%		0.3			
Spring of 2020	Distilled water	14.0	14.9	15.0	14.9	14.7
	Ascorbic	14.1	15.4	14.5	14.9	14.7
	Citric	14.2	14.7	15.4	15.4	14.9
	Humic	14.1	15.1	14.9	15.7	14.9
	LSD 5%		NS			NS
	Average	14.1	15.0	14.9	15.2	
	LSD 5%		0.3			

LSD 5%: least significant difference at a probability level of 5%; NS: Non-significant at P<0.05.

Leaves area plant^{-1} (cm^2)

Data in table 8 showed that treatment of seeds soaking in humic acid was significantly superior by producing the highest average of leaves area plant^{-1} (6969.5 and 6570.2 cm^2), while control treatment (seeds soaking in distilled water) produced the lowest average (5646.9 and 5188.5 cm^2) during both seasons. Vegetative parts nutrition with humic acid also had a significant effect on leaves area plant^{-1}, as it recorded the highest average (6431.8 cm^2), with a significant difference from other treatments during spring season 2019 only. Seeds soaking with humic acid may have led to grow and activity of root system, an increase in plant growth and amount of elements that absorbed from soil, and an increase in efficiency and speed of photosynthesis average, which was reflected on an increase on leaves area plant^{-1}. That was in line with Yildirim (26). Effect of interaction between studied factors was not significant during both seasons.

Table 8. Leaves area plant^{-1} (cm^2) affected by seeds soaking and vegetative parts nutrition with acids of ascorbic, citric and humic in maize during spring seasons of 2019 and 2020

	Vegetative parts nutrition	Seeds soaking				Average
		Distilled water	Ascorbic	Citric	Humic	
Spring of 2019	Distilled water	5359.5	5539.7	6266.5	6742.1	5976.9
	Ascorbic	5835.7	5959.3	6808.3	7047.9	6412.8
	Citric	5652.9	5932.5	6664.9	7009.2	6314.9
	Humic	5739.6	6090.2	6818.5	7078.9	6431.8
	LSD 5%		NS			181.2
	Average	5646.9	5880.4	6639.5	6969.5	
	LSD 5%		170.0			
Spring of 2020	Distilled water	5085.2	5852.1	5971.5	6332.8	5810.4
	Ascorbic	5288.3	5660.4	6111.8	6646.4	5926.7
	Citric	5137.3	5891.0	5654.5	6679.6	5840.6
	Humic	5243.2	5968.0	6121.3	6621.9	5988.6
	LSD 5%		NS			NS
	Average	5188.5	5842.9	5964.8	6570.2	
	LSD 5%		182.2			

LSD 5%: least significant difference at a probability level of 5%; NS: Non-significant at P<0.05.

Leaf area index

Results in table 9 showed that maize seeds soaking in humic acid significantly outperformed and gave the highest average of leaf area index (3.717 and 3.504), while control treatment (seeds soaking in distilled water only) gave the lowest average (3.012, 2.767) during both seasons, respectively. The parameters of all vegetative parts nutrition differed significantly from control treatment, without being significantly different among them, and treatment of humic acid gave the highest average of leaf area index (3,430) during spring season 2019 only. That can be explained by fact that when using humic acid, whether by soaking or foliar feeding, it increased leaves number, which was reflected an increase of leaf area, and then increase of leaf area index, and this is consistent with (Tables 7 and 8). Effect of vegetative parts nutrition or interaction between studied factors was not significant during both seasons.

Dry matter weight (ton ha^{-1}): Data in table 10 showed that treatment of seeds soaking with humic acid was significantly superior and gave the highest average of dry matter weight (11.6 and 12.2 ton ha^{-1}) with a significant difference from the other treatments, while control treatment gave the lowest average (8.7 and 10.6 ton ha^{-1}), during both seasons, respectively. A reason for increase in dry matter weight of plant when seeds are soaked in humic acid could be due to increase in chlorophyll content of leaf, which is positively reflected on prolongation of leaf survival time to stay effective and able to intercept a largest amount of light, which leads to an increase in average carbon representation and accumulation of dry matter in all parts of plant and then increase dry weight of plant (3). This result is consistent with Elsahookie (10) who found that increases in plant dry matter could be due to positive and high correlation between dry weight of plant and leaf area. Effect of vegetative parts nutrition or interaction between studied factors was not significant during both seasons.

Table 9. Leaf area index affected by seeds soaking and vegetative parts nutrition with acids of ascorbic, citric and humic in maize during spring seasons of 2019 and 2020

	Vegetative parts nutrition	Seeds soaking				Average
		Distilled water	Ascorbic	Citric	Humic	
Spring of 2019	Distilled water	2.858	2.955	3.342	3.596	3.188
	Ascorbic	3.015	3.164	3.555	3.738	3.368
	Citric	3.112	3.178	3.631	3.759	3.420
	Humic	3.061	3.248	3.637	3.775	3.430
	LSD 5%		NS			0.150
	Average	3.012	3.136	3.541	3.717	
	LSD 5%		0.090			
Spring of 2020	Distilled water	2.712	3.121	3.185	3.378	3.099
	Ascorbic	2.740	3.142	3.016	3.563	3.115
	Citric	2.820	3.019	3.260	3.545	3.161
	Humic	2.796	3.183	3.265	3.532	3.194
	LSD 5%		NS			NS
	Average	2.767	3.116	3.181	3.504	
	LSD 5%		0.121			

LSD 5%: least significant difference at a probability level of 5%; NS: Non-significant at P<0.05.

Table 10. Dry matter weight (ton ha^{-1}) affected by seeds soaking and vegetative parts nutrition with acids of ascorbic, citric and humic in maize during spring seasons of 2019 and 2020

	Vegetative parts nutrition	Seeds soaking				Average
		Distilled water	Ascorbic	Citric	Humic	
Spring of 2019	Distilled water	8.6	9.7	10.0	10.6	9.7
	Ascorbic	9.3	10.1	10.7	11.9	10.5
	Citric	8.9	9.8	10.9	11.1	10.2
	Humic	7.9	10.2	12.0	12.9	10.8
	LSD 5%		NS			NS
	Average	8.7	10.0	10.9	11.6	
	LSD 5%		0.2			
Spring of 2020	Distilled water	10.8	11.1	11.0	11.9	11.2
	Ascorbic	9.3	11.9	11.3	12.2	11.2
	Citric	11.0	11.4	11.5	12.3	11.5
	Humic	11.4	11.5	11.9	12.3	11.8
	LSD 5%		NS			NS
	Average	10.6	11.5	11.4	12.2	
	LSD 5%		0.1			

LSD 5%: least significant difference at a probability level of 5%; NS: Non-significant at P<0.05.

Crop growth rate (g cm^{-2} day^{-1})

Results in table 11 showed significant superiority of seeds soaking in humic acid and gave the highest average of crop growth rate (3.0 and 3.2 g cm^{-2} day^{-1}) with a significant difference from other seeds soaking treatments, while control treatment gave the lowest average (2.2 and 2.8 g cm^{-2} day^{-1}) during both seasons, respectively. Interaction between seeds soaking and vegetative parts nutrition had a significant effect on crop growth rate, as interaction treatment (seeds soaking in humic acid × vegetative parts nutrition with humic acid) was superior and gave the highest average (3.4 and 3.3 g cm^{-2} day^{-1}) during both seasons, respectively. That's may be due to fact that humic acid increases permeability of root cell membranes, and then enhances absorption of nutrients by roots, which is reflected on plant growth faster and more efficiently, and to obtain a balanced and ideal growth rate. Effect of vegetative parts nutrition was not significant during both seasons.

Table 11. Crop growth rate (g cm^{-2} day^{-1}) affected by seeds soaking and vegetative parts nutrition with acids of ascorbic, citric and humic in maize during spring seasons of 2019 and 2020

	Vegetative parts nutrition	Seeds soaking				Average
		Distilled water	Ascorbic	Citric	Humic	
Spring of 2019	Distilled water	2.2	2.5	2.6	2.7	2.5
	Ascorbic	2.4	2.6	2.7	3.1	2.7
	Citric	2.3	2.5	2.8	2.9	2.6
	Humic	2.0	2.6	3.1	3.4	2.8
	LSD 5%		0.09			NS
	Average	2.2	2.5	2.8	3.0	
	LSD 5%		0.07			
Spring of 2020	Distilled water	2.4	3.1	3.0	3.3	3.0
	Ascorbic	2.8	3.0	2.9	3.2	3.0
	Citric	3.0	3.1	3.2	3.3	3.1
	Humic	2.9	3.0	3.0	3.3	3.1
	LSD 5%		0.07			NS
	Average	2.8	3.0	3.0	3.2	
	LSD 5%		0.03			

LSD 5%: least significant difference at a probability level of 5%; NS: Non-significant at P<0.05.

Leaf chlorophyll content (SPAD)

Data in table 12 showed significant superiority of seeds soaking treatment in humic acid and gave the highest average of leaf chlorophyll content (60.2 and 69.5 SPAD), while control treatment gave the lowest average (50.1 and 52.5 SPAD) during both seasons, respectively. The highest average of vegetative parts nutrition with humic acid (56.8 and 64.6 SPAD), while control treatment gave the lowest average (54.3 and 60.2 SPAD) during both seasons, respectively. A reason could be attributed to superior of seeds soaking or vegetative parts nutrition with humic acid as a result of its ability to withdraw nutrients from soil to leaves and other plant's parts, which encourages formation of chlorophyll and prevents its loss, and thus leaves retain their greenness, and increase in chlorophyll content works for a longer period as chlorophyll plays a major role in process of photosynthesis and production of carbonaceous and nutrients (25). A reason could be that humic acid affects some plant metabolic processes such as respiration and photosynthesis, as well as its ability to increase the antioxidant content in plant cells. These results agreed with Al-barakat (5), Mustafa and Cheyed (17), their study on maize yield, as they found that increasing the chlorophyll content of leaves increased with increasing humic acid concentrations. The effect of the interaction between the studied factors was not significant on this trait during both seasons. The reason could also be that humic acid affects some plant metabolic processes such as photosynthesis, as well as its ability to increase the antioxidant content in plant cells. This result is consistent with Al-barakat (5), Mustafa and Cheyed (17), who found that increasing the chlorophyll content of leaves increased with increasing humic acid concentrations. Effect of vegetative parts nutrition or interaction between studied factors was not significant during both seasons.

Table 12. Chlorophyll ratio (SPAD) affected by seeds soaking and vegetative parts nutrition with acids of ascorbic, citric and humic in maize during spring seasons of 2019 and 2020

	Vegetative parts nutrition	Seeds soaking				Average
		Distilled water	Ascorbic	Citric	Humic	
Spring of 2019	Distilled water	49.6	50.3	57.8	59.5	54.3
	Ascorbic	49.6	50.5	59.4	60.5	55.0
	Citric	50.3	52.7	59.2	60.4	55.6
	Humic	51.1	54.3	61.5	60.2	56.8
	LSD 5%		NS			1.2
	Average	50.1	51.9	59.5	60.2	
	LSD 5%		2.0			
Spring of 2020	Distilled water	49.4	63.6	63.9	63.7	60.2
	Ascorbic	52.0	56.5	64.2	70.3	60.7
	Citric	55.0	66.0	63.0	69.2	63.3
	Humic	53.4	64.1	66.1	74.7	64.6
	LSD 5%		NS			1.8
	Average	52.5	62.5	64.3	69.5	
	LSD 5%		2.5			

LSD 5%: least significant difference at a probability level of 5%; NS: Non-significant at P<0.05.

CONCLUSIONS

It can be concluded that seeds soaking in humic acid improved growth characteristics of maize, but nutrition of vegetative parts with acids under study did not have the same effect, and this lead to reconsider the concentrations that used and increase them in future studies to find out fact and extent of their impact or not on growth traits. It can be recommended to soak maize seeds before planting in humic acid at concentration of 1 ml l^{-1} for increasing growth characteristics, especially dry matter weight and crop growth rate.

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