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Field Emergence Affected by Zea Mays L. Cultivars and Seed Soaking in Acids of Ascorbic, Citric and Humic

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Abstract

A field experiment was carried out during the spring season 2019 and 2020 to obtain a fast, uniform, and high field emergence ratio of maize seeds under a wide range of environmental conditions. Randomize complete block design in the split-plot arrangement was used with three replications. The first factor in the main plots was cultivars (5018, Baghdad3 and Sumer). The second factor in the sub-plots was seeds soaking with ascorbic and citric acids (100 mg L^{-1}) each and humic (1 ml L^{-1}) in addition to control treatment (seeds soaking with distilled water only). Results showed the superiority of soaking with humic acid significantly, as means of characteristics of field emergence in both seasons, respectively, were as follows: Last day of field emergence (12.4 and 12.6 days), time spread of field emergence (4.4 and 4.6 days), emergence at first and final counts (62.4 and 34.4 %) and (95.8 and 88.0 %), daily emergence rate (8.0 and 7.3 % day^{-1}), mean field emergence time (8.7 and 9.3 days), emergence index rate (11.1 and 9.7 % day^{-1}), velocity coefficient of field emergence (11.4 and 10.8) and emergence index (407.6 and 333.3). Cultivars didn't differentiate among themselves, with the effect of seeds soaking in most traits. It can be concluded that seeds soaking with humic acid improved characteristics of emergence and seedlings, so it can be recommended to soaking maize seeds with humic acid at the concentration (1 ml L^{-1}) when planting them in the spring season.

Keywords: Daily rate, Emergence index, First counts, Index rate, Last day, Maize.

1. Introduction

Raising production efficiency, quantity and quality of crops requires using modern techniques in agriculture like plant growth stimulants to cultivate high-quality cultivars. [1], studied three maize hybrids (TWC: 310, 323, and 324) and found that the hybrid TWC 310 gave the highest final germination (87.33%), mean germination (3.12 days) and germination energy (76.07%), while the hybrids TWC 324 gave the highest germination index (114.62%) compared to the other hybrids. Seeds soaking with stimulator materials is a technique that increases seeds viability by giving active seedlings that can compete and grow compared to non-stimulated seeds [2]. The seed activation technique helps to improve the behavior of seedlings in a wide range of environmental conditions [3]. [4], studied four maize genotypes (Talar, Messerra, Al-eizz and Bouhouth 106) and found a significant effect; the cultivar Talar outperformed in the percentage of final emergence 94.8%. In recent years, studies have been directed towards the possibility of improving seed vigor and increasing the resulting plants' ability to grow under biotic and abiotic stresses by seeds soaking in various nutrient solutions [5]. Seeds are allowed to complete part of the metabolic processes during pre-sowing activation [6]. The seed activation process improves the viability and vigor of deteriorated seeds [7].
Results of [8], indicated that significant differences resulted from seeds soaking in antioxidants, including ascorbic acid, at a concentration of 100 ml L^{-1} on germination characteristics such as final germination percentages, germination rate, germination index and germination energy. The results of [9], concluded that maize seeds soaking in citric acid at a concentration of 100 1 ml L^{-1} improved all germination measurements significantly. [10], showed that treatment with humic acid has a positive effect on germination speed when using a concentration of 158 ml per 100 kg of seeds. Several studies indicated that seed activation led to an improvement in the growth of seedlings under salt stress in maize and sorghum, and under drought stress in wheat and improving the viability of embryos for deteriorated seeds, which was positively reflected in the induction of callus in wheat, as well as an improvement in the growth of seedlings resulting from deteriorated seeds in oats [11-17]. Accordingly, this study aimed to know the effect of soaking seeds with ascorbic, citric and humic acids on field emergence and seedlings growth of cultivars of maize in the spring season.

2. Materials and Methods

A field experiment was carried out during two spring seasons at the fields of 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 in the same first site due to the curfew imposed by the corona pandemic (COVID-19)). Randomize complete block design in the split-plot arrangement was used with three replicates. The first factor in the main plots was cultivars (5018, Baghdad3 and Sumer). The second factor in the sub-plots was seeds soaking with ascorbic and citric acids (100 mg L^{-1}) each and humic (1 ml L^{-1}) in addition to control treatment (seeds soaking with distilled water only). The seeds were soaked for 18 hours. Maize seeds were obtained from the Agricultural Research Department, Ministry of Agriculture. The soil was analyzed before planting at a depth of 0-30 cm (Table 1). Soil and crop service operations were conducted according to the recommendation of the Ministry of Agriculture (2015). 436 kg h^{-1} of DAP fertilizer (46:18) (P: N) and 348 kg h^{-1} of urea fertilizer (46% N) were added when preparing the soil (Al-Bahrani, 2015). The planting was carried out on lines with a distance of 75 cm between one line and another and 25 cm between the hole and another to obtain a 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 [18]. Traits were studied as follow:

- Last day of field emergence (day): It's the day on which the last field emergence event occurred. Lower values indicate a faster ending of field emergence (21 days after planting) [19,20].
- Time spread of field emergence (day): It's the time in days between the first and last field emergence events occurring in a seed lot. The higher value, the greater the difference in field emergence speed between the 'fast' and 'slow' field emergence members of a seed lot [21,22].
- Percentage of field emergence at the first and final counts (%): It was calculated from the number of seeds planted in the two middle lines from each experimental unit and for each treatment and according to the number of seedlings emerging on the soil surface. The first count was calculated after 8 days and the final count was 12 days after planting. Then the results were converted into a percentage.

$$\text{Field emergence (\%)} = \frac{\text{number of emerged seedlings}}{\text{total number of planted seeds}} \times 100$$

- Daily emergence rate (% day^{-1}): Number of emerged seedlings after 12 days divided by the number of days.
- Mean field emergence time (day): It's the seedlings that emerged on the day. The lower value, the faster a population of seedlings have emerged (after 12 days of planting) and was calculated from equation No. 1 [23,24].
- Index of field emergence rate (% day-1): It reflects the percentage of field emergence on each day of the field emergence period. A higher value indicates higher and faster field emergence (12 days after planting) and was calculated from equation 2 [2,26].

$$\text{Average of field emergence time (day)} = \frac{\sum(NiTi)}{\sum Ni} \quad (1)$$

$$\text{Index of field emergence rate (\% } day^{-1}) = \sum\left(\frac{Ni}{i}\right) \quad (2)$$

- Coefficient of Velocity of field emergence: It indicates the rapidity of field emergence. It increases when the number of emerged seedlings increases and the time required for emergence decreases. Theoretically, the highest possible value is 100. This would occur if all seeds germinated and seedlings emerged on the first day [27,28]. It was calculated from equation No. 3

$$\text{Velocity coefficient of field emergence (\% } day^{-1}) == \frac{(\sum Ni)}{\sum(NiTi)} \times 100 \quad (3)$$

- Emergence index: No. of emerged seedlings on the first, second and subsequent days until the last calculated day; and 1 are weights given to the number of emerged seedlings on the first, second and subsequent days, respectively. Maximum weight is given to the seedlings that emerged on the first day and less to those that emerged later on. The lowest weight would be for seedlings that emerged on the last calculated day. Therefore, It emphasizes both the percentage of field emergence and its speed. A higher value denotes a higher percentage and rate of field emergence [29,30]. It was calculated from equation No. 4

$$\text{Emergence index} = (N1 \times 12) + (N12 \times 1) \quad (4)$$

Since: N is the percentage of emerged seedlings (%) at day i, and Ti is the day's sequence from planting.
Data were analyzed statistically using the GenStat program. The variance analysis was performed according to the randomize complete block design in the split-plot arrangement with three replications. Means were compared using the least significant difference test at the probability level of 0.05 (LSD 0.05) [31].

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

3. Results and Discussion

3.1 Last day of field emergence (day)

Table 2 showed that there was an insignificant effect for cultivars and the interaction between the two studied factors on the last day of field emergence. There was significant superiority of the soaking treatment of the humic acid by giving the lowest mean of the last day of field emergence (12.4 and 12.6 days) which didn't differ significantly with the treatment of soaking with citric acid for the spring season 2019, and the treatment of soaking with citric acid didn't differ significantly with the treatment of soaking with ascorbic acid in the spring season 2020. In contrast, the control treatment gave the highest time of field emergence, 13.3 and 13.8 days in both seasons, and the results indicate that the Baghdad3 cultivar gave the lowest average for the last day of field emergence (12.8 days) for the spring season 2020, and there was no significant difference with Sumer cultivar, as the results show that the lowest mean of the last day of field emergence (11.0 days) resulted from soaking the seeds of the Baghdad3 cultivar in humic acid, while the highest mean of emergence resulted from the 5018 cultivar, seed soaking in distilled water reached 14.0 days, which didn't differ significantly with soaking with citric and ascorbic acids in the second spring season, respectively. Perhaps the positive effect of humic acid on germination is its effect on the physiological processes of cereal grains of crops such as sorghum [32,33]. Humic acid carries essential nutrients and water to the seeds, thus stimulating germination [34].

Table 2. Last day of field emergence (day) affected by maize cultivars, seeds soaking in acids of ascorbic, citric and humic and interaction.

	Cultivars	Seeds soaking				Mean
		Distilled water	Ascorbic	Citric	Humic	
Spring season 2019	5018	13.0	13.3	12.7	12.0	12.8
	Baghdad3	13.7	13.3	13.0	12.7	13.2
	Sumer	13.3	13.3	13.0	12.7	13.1
	LSD 0.05	Interaction NS				Cultivars NS
	Mean	13.3	13.3	12.9	12.4	
	LSD 0.05	Seeds soaking 0.6				
Spring season 2020	5018	14.0	14.0	14.0	13.7	13.9
	Baghdad3	13.7	13.0	13.3	11.0	12.8
	Sumer	13.7	12.3	13.0	13.0	13.0
	LSD 0.05	Interaction NS				Cultivars NS
	Mean	13.8	13.1	13.4	12.6	
	LSD 0.05	Seeds soaking 0.4				

LSD 0.05: least significant difference at the probability level of 0.05; NS: Non-significant at P>0.05

3.2 Time spread of field emergence (day)

Table 3 showed that there was an insignificant effect of cultivars and interaction on the time spread of field emergence during spring season 2019. There was significant superiority of the soaking treatment of the humic acid by giving the lowest mean time to field emergence (4.4 and 4.6 days). In comparison, the control treatment gave the highest time to field emergence (5.3 and 5.8 days) in both seasons, respectively. Humic acid may cause an increase in the permeability of the cell membrane, which is important for the transport and availability of micronutrients, and that the absorption of nutrients stimulates the germination of seeds and then their ability to germination and emergence and this causes an increase in the ability of plants to grow through increase plant uptake of nitrogen, potassium, calcium, magnesium and phosphorous [35]. The results also indicated that the Baghdad3 cultivar outperformed the other cultivars under study by giving the lowest mean time for field emergence (4.8 days) for the second spring season, which didn't differ significantly with the Sumer cultivar. The results also showed that the lowest mean time for field emergence (3.0 days) resulted from soaking the seeds of Baghdad3 cultivar in humic acid. In comparison, the highest mean emergence of 5018 cultivars resulted from soaking the seeds in distilled water (6.0 days), which didn't differ significantly with seeds soaking with citric and ascorbic acids in the second spring season.

Table 3. Time spread of field emergence (day) affected by maize cultivars, seeds soaking in acids of ascorbic, citric and humic and interaction.

	Cultivars	Seeds soaking				Mean
		Distilled water	Ascorbic	Citric	Humic	
Spring season 2019	5018	5.0	5.3	4.7	4.0	4.8
	Baghdad3	5.7	5.3	5.0	4.7	5.2
	Sumer	5.3	5.3	5.0	4.7	5.1
	LSD 0.05	Interaction NS				Cultivars NS
	Mean	5.3	5.3	4.9	4.4	
	LSD 0.05	Seeds soaking 0.6				
Spring season 2020	5018	6.0	6.0	6.0	5.7	5.9
	Baghdad3	5.7	5.0	5.3	3.0	4.8
	Sumer	5.7	4.3	5.0	5.0	5.0
	LSD 0.05	Interaction 0.7				Cultivars 0.2
	Mean	5.8	5.1	5.4	4.6	
	LSD 0.05	Seeds soaking 0.5				

LSD 0.05: least significant difference at the probability level of 0.05; NS: Non-significant at P>0.05

3.3 Field emergence at the first count (%)

Table 4 showed that there was an insignificant effect of cultivars and interaction on field emergence at the first count during spring season 2019. The treatment of seeds soaking with humic acid was surpassed significantly and gave the highest mean of field emergence at the first count (62.4 and 34.4%), which didn't differ significantly with the treatment of seeds soaking with citric acid in the first spring season 2019 in comparison with the control treatment that gave the lowest percentage of field emergence at the first count (51.6 and 19.3%), respectively. The results also indicated that the Baghdad3 cultivar outperformed the other cultivars by giving the highest mean of field emergence at the first count (39.8 %) in the spring season 2020, while the 5018 cultivars gave the lowest mean of field emergence (16.1%). The results also showed that the highest mean of field emergence at the first count (54.7%) resulted from soaking the seeds of the Baghdad3 cultivar in humic acid in the spring season 2020, while the lowest mean yielded for field emergence at the first count (10.0%) by soaking the seeds of 5018 cultivars in distilled water. This may be because humic acid has a beneficial and positive effect on ionic transport inside the plant cell, which improves its permeability and then affects the absorption process and then promotes increased respiration and the speed of enzymatic reactions of the Krebs cycle, which leads to an increase in ATP energy production, and this is consistent with [29].

Table 4. Field emergence at first count (%) affected by maize cultivars, seeds soaking in acids of ascorbic, citric and humic and interaction.

	Cultivars	Seeds soaking				Mean
		Distilled water	Ascorbic	Citric	Humic	
Spring season 2019	5018	50.7	54.7	62.0	62.0	57.3
	Baghdad3	47.3	49.3	53.3	58.7	52.2
	Sumer	56.7	68.0	62.7	66.7	63.0
	LSD 0.05	Interaction NS				Cultivars NS
	Mean	51.6	57.3	59.3	62.4	
	LSD 0.05	Seeds soaking 4.8				
Spring season 2020	5018	10.0	16.6	18.0	20.0	16.1
	Baghdad3	29.3	39.3	36.0	54.7	39.8
	Sumer	18.7	27.3	25.3	28.7	25.0
	LSD 0.05	Interaction 14.3				Cultivars 14.5
	Mean	19.3	27.8	26.4	34.4	
	LSD 0.05	Seeds soaking 4.2				

LSD 0.05: least significant difference at the probability level of 0.05; NS: Non-significant at P>0.05

3.4 Field emergence at final count (%)

Table 5 showed that there was an insignificant effect of cultivars and interaction on field emergence at the final count during spring season 2019. There was significant superiority of seeds soaking in humic acid and gave the highest mean of field emergence at the final count (95.8 and 88.0%), while the control treatment gave the least ratio (86.7 and 74.2%) in both seasons, respectively. The results indicated that Sumer cultivar outperformed the other cultivars by giving the highest ratio (89.5%), which didn't differ significantly with Baghdad3 cultivar (88.7%), while the 5018 cultivars gave the lowest ratio of field emergence at the final count (71.5%) during spring season 2020. The results also showed that the highest mean of field emergence at the final count reached 100%, resulting from seeds soaking of Baghdad3 cultivar in humic acid. In comparison, the lowest ratio of the field emergence in the final count was 63.3%, resulting from seeds soaking of the 5018 cultivar in distilled water only in the spring season 2020, which didn't differ significantly with the other treatments. The superiority of the emergence ratio in the final count may be due to its original superiority in the emergence ratio in the first count (Table 4), which reflects the inherent ability of the seeds in these treatments to give a high percentage of active seedlings, or humic acid may be activated the H + ATPase present in the plasma membrane, which explains the increase in uptake rates and nutrient elevation for the removal of solutes and increases in water capacity and increases in the capacity of cation exchange, and thus the increase in the field emergence ratio [12].

Table 5. Field emergence at final count (%) affected by maize cultivars, seeds soaking in acids of ascorbic, citric and humic and interaction.

	Cultivars	Seeds soaking				Mean
		Distilled water	Ascorbic	Citric	Humic	
Spring season 2019	5018	85.3	89.3	95.3	98.7	92.2
	Baghdad3	82.7	90.0	88.7	95.3	89.2
	Sumer	92.0	91.3	94.0	93.3	92.7
	LSD 0.05	Interaction NS				Cultivars NS
	Mean	86.7	90.2	92.7	95.8	
	LSD 0.05	Seeds soaking 4.3				
Spring season 2020	5018	63.3	70.7	76.0	76.0	71.5
	Baghdad3	76.7	94.0	84.0	100.0	88.7
	Sumer	82.7	97.3	90.0	88.0	89.5
	LSD 0.05	Interaction 8.7				Cultivars 4.3
	Mean	74.2	87.3	83.3	88.0	
	LSD 0.05	Seeds soaking 5.0				

LSD 0.05: least significant difference at the probability level of 0.05; NS: Non-significant at P>0.05

3.5 Daily field emergence rate (day)

Table 6 showed that there was an insignificant effect of cultivars and interaction on daily field emergence rate during spring season 2019. The seeds soaking in humic acid were surpassed significantly and gave the highest daily field emergence rate (8.0 and 7.3 days), which didn't differ significantly with the seeds soaking in citric acid in the spring season 2019 and with the seeds soaking citric and ascorbic acids in the spring season 2020, while the control treatment gave the lowest daily field emergence rate (7.2 and 6.2 days) in both seasons, respectively. The results also indicated that the Baghdad3 cultivar outperformed the other cultivars under study by giving the highest mean daily field emergence rate (7.5 days) for the spring season 2020, which didn't differ significantly with the Sumer cultivar. The results also showed that the highest mean of the daily field emergence rate (8.3 days) resulted from seeds soaking of the Baghdad3 cultivar in humic acid, which didn't differ significantly with the seeds soaking in ascorbic acid for the second spring season 2020, while the lowest average of the daily field emergence rate (5.3 days) resulted from seeds soaking of the 5018 cultivars in distilled water only in the spring season of 2020. This may be because preparing the seeds with humic acid has a beneficial effect on seed emergence, as it can promote the growth of the seed. It was through early root development. It also showed a significant increase in the amount of nitrogen in the soil and the nitrogen stored in the plant with its beneficial effect on different soil properties [18].

Table 6. Daily field emergence rate (day) affected by maize cultivars, seeds soaking in acids of ascorbic, citric and humic and interaction.

	Cultivars	Seeds soaking				Mean
		Distilled water	Ascorbic	Citric	Humic	
Spring season 2019	5018	7.1	7.4	7.9	8.2	7.7
	Baghdad3	6.9	7.5	7.4	7.9	7.4
	Sumer	7.7	7.6	7.8	7.8	7.7
	LSD 0.05	Interaction NS				Cultivars NS
	Mean	7.2	7.5	7.7	8.0	
	LSD 0.05	Seeds soaking 0.4				
Spring season 2020	5018	5.3	5.9	6.3	6.3	6.0
	Baghdad3	6.4	8.1	7.0	8.3	7.5
	Sumer	6.9	7.8	7.5	7.3	7.4
	LSD 0.05	Interaction 0.7				Cultivars 0.3
	Mean	6.2	7.3	6.9	7.3	
	LSD 0.05	Seeds soaking 0.4				

LSD 0.05: least significant difference at the probability level of 0.05; NS: Non-significant at P>0.05

3.6 Mean field emergence time (day)

Table 7 showed that there was an insignificant effect of cultivars and interaction on mean field emergence time during spring season 2019. There was an insignificant effect of seeds soaking and interaction on mean field emergence time during spring season 2020. There was significant superiority of the seeds soaking treatment with humic acid by giving the lowest mean field emergence time (8.7 days) in the spring season 2019 with the insignificant difference with the other treatments, except the control treatment which gave (9.0 days), and this may be due to the superiority of the same trait at the percentage of field emergence at the first and final counts (Table 4 and 5). The Baghdad3 cultivar outperformed the other cultivars by giving the lowest mean field emergence time (8.9 days) in the spring season 2020, with insignificant difference with the Sumer cultivar.

3.7 Index of field emergence rate (% day^{-1})

Table 8 showed that there was an insignificant effect of cultivars, seeds soaking and interaction on the index of field emergence rate during spring season 2019. The treatment of soaking in humic acid was superior significantly by giving the highest mean of the field emergence rate index (11.1 and 9.7% day^{-1}), which didn't differ significantly with the treatment of soaking with citric acid in the spring season 2019, and the treatment of soaking with ascorbic acid in the spring season 2020. Soaking with citric acid differed significantly with ascorbic acid treatment in spring season 2019. The control treatment (soaking in distilled water only) gave the field emergence rate index (9.8 and 8.0% day^{-1}) in both seasons, respectively. The results also indicated that the Baghdad3 cultivar outperformed the other cultivars under study by giving the highest mean of the field emergence rate index (10.1 % day^{-1}) in the spring season 2020. It didn't differ significantly with the Sumer cultivar. The results also showed that the highest mean of the field emergence rate index (11.7 % day^{-1}) resulted from soaking the seeds of Baghdad3 cultivar in humic acid, and the lowest average was obtained from soaking the seeds 5018 cultivars in the

distilled water treatment (6.6 % day^{-1}). This may be because humic acid, due to its low molecular weight, is rapidly absorbed from the seeds, which increases the uptake of important nutrients such as nitrogen and phosphorous, thus increasing the field emergence rate index [21].

Table 7. Mean field emergence time (day) affected by maize cultivars, seeds soaking in acids of ascorbic, citric and humic and interaction.

	Cultivars	Seeds soaking				Mean
		Distilled water	Ascorbic	Citric	Humic	
Spring season 2019	5018	9.1	8.7	8.8	8.7	8.8
	Baghdad3	9.1	9.1	8.9	8.9	9.0
	Sumer	8.9	8.6	8.7	8.6	8.7
	LSD 0.05		Interaction NS			Cultivars NS
	Mean	9.0	8.8	8.8	8.7	
	LSD 0.05		Seeds soaking 0.2			
Spring season of 2020	5018	9.8	9.7	9.8	9.7	9.7
	Baghdad3	9.0	9.0	8.9	8.6	8.9
	Sumer	9.6	9.3	9.4	9.5	9.4
	LSD 0.05		Interaction NS			Cultivars 0.5
	Mean	9.4	9.3	9.4	9.2	
	LSD 0.05		Seeds soaking NS			

LSD 0.05: least significant difference at the probability level of 0.05; NS: Non-significant at P>0.05

Table 8. Index of field emergence rate (% day^{-1}) affected by maize cultivars, seeds soaking in acids of ascorbic, citric and humic and interaction.

	Cultivars	Seeds soaking				Mean
		Distilled water	Ascorbic	Citric	Humic	
Spring season 2019	5018	9.6	10.4	11.0	11.5	10.6
	Baghdad3	9.3	10.1	10.1	10.9	10.1
	Sumer	10.6	10.8	11.0	11.0	10.9
	LSD 0.05		Interaction NS			Cultivars NS
	Mean	9.8	10.4	10.7	11.1	
	LSD 0.05		Seeds soaking 0.5			
Spring season 2020	5018	6.6	7.4	7.9	8.0	7.5
	Baghdad3	8.6	10.6	9.5	11.7	10.1
	Sumer	8.8	10.7	9.7	9.4	9.6
	LSD 0.05		Interaction 0.9			Cultivars 0.7
	Mean	8.0	9.6	9.1	9.7	
	LSD 0.05		Seeds soaking 0.5			

LSD 0.05: least significant difference at the probability level of 0.05; NS: Non-significant at P>0.05

3.8 Velocity coefficient of field emergence

Table 9 showed that there was an insignificant effect of cultivars and interaction on velocity coefficient of field emergence during spring season 2019. There was an insignificant effect of seeds soaking and interaction on velocity coefficient of field emergence during spring season 2020. There was significant superiority for all soaking treatments in comparison with the control treatment in the spring season 2019, and at the same time, there were insignificant differences between the three acids used. The Baghdad3 cultivar outperformed the other cultivars by giving the highest velocity coefficient of field emergence (11.3), while 5018 cultivars gave the lowest mean (10.3) in spring season 2020. This is because soaking the seeds with humic acid causes some metabolic and biochemical changes inside the seed during the soaking process, and due to enzyme activity and hydrolysis reaction, part of this process leads to rapid germination and improves seedling emergence [15,17].

Table 9. Velocity coefficient of field emergence affected by maize cultivars, seeds soaking in acids of ascorbic, citric and humic and interaction.

	Cultivars	Seeds soaking				Mean
		Distilled water	Ascorbic	Citric	Humic	
Spring season 2019	5018	11.0	11.5	11.3	11.5	11.3
	Baghdad3	11.0	11.0	11.2	11.2	11.1
	Sumer	11.3	11.7	11.6	11.6	11.5
	LSD 0.05	Interaction NS				Cultivars NS
	Mean	11.1	11.4	11.4	11.4	
	LSD 0.05	Seeds soaking 0.2				
Spring season 2020	5018	10.2	10.2	10.4	10.4	10.3
	Baghdad3	11.1	11.1	11.2	11.6	11.3
	Sumer	10.5	10.8	10.7	10.5	10.6
	LSD 0.05	Interaction NS				Cultivars 0.5
	Mean	10.6	10.7	10.7	10.8	
	LSD 0.05	Seeds soaking NS				

LSD 0.05: least significant difference at the probability level of 0.05; NS: Non-significant at P>0.05

3.9 Field emergence index

Table 10 showed that there was an insignificant effect of cultivars and interaction on the index of field emergence during spring season 2019. There was significant superiority of the soaking treatment with humic acid for maize seeds by giving the highest field emergence index (407.6 and 333.3), which didn't differ significantly with the soaking treatment with citric acid in the spring season 2020, while the control treatment gave the lowest field emergence index (346.7 and 265.1) in both seasons, respectively, and this may be due to the superiority of the emergence ratio in the first count (Table 4) and the final count (Table 5), which reflects the inherent ability of the seeds in these treatments to give a high percentage of active seedlings, and perhaps the reason is that the humic acid activates the H+ ATPase present in the plasma membrane, which explains the increase in absorption rates, the elevation of nutrients to get rid of solutes, the increase in the capacity of water and the increase in the capacity of the exchange of positive ions, and then the increase in the rate of field emergence [22].

Table 10. Field emergence index affected by maize cultivars, seeds soaking in acids of ascorbic, citric and humic and interaction.

	Cultivars	Seeds soaking				Mean
		Distilled water	Ascorbic	Citric	Humic	
Spring season 2019	5018	335.3	383.3	397.3	422.0	384.5
	Baghdad3	324.7	353.3	360.7	390.0	357.2
	Sumer	380.0	406.7	408.7	410.7	401.5
	LSD 0.05	Interaction NS				Cultivars NS
	Mean	346.7	381.1	388.9	407.6	
	LSD 0.05	Seeds soaking 17.3				
Spring season 2020	5018	204.7	236.0	244.7	254.7	235.0
	Baghdad3	306.7	376.0	343.3	440.0	366.5
	Sumer	284.0	364.7	322.7	305.3	319.2
	LSD 0.05	Interaction 48.3				Cultivars 48.1
	Mean	265.1	303.6	325.6	333.3	
	LSD 0.05	Seeds soaking 17.0				

LSD 0.05: least significant difference at the probability level of 0.05; NS: Non-significant at P>0.05

Conclusions

It can be concluded that soaking of maize seeds in the humic acid improved the characteristics of field emergence and seedlings behavior. Therefore, we recommended soaking the maize seeds in humic acid at a concentration of 1 ml L^{-1} for 18 hours when planting in the spring season, which is less ideal for germination and emergence than autumn season conditions.

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