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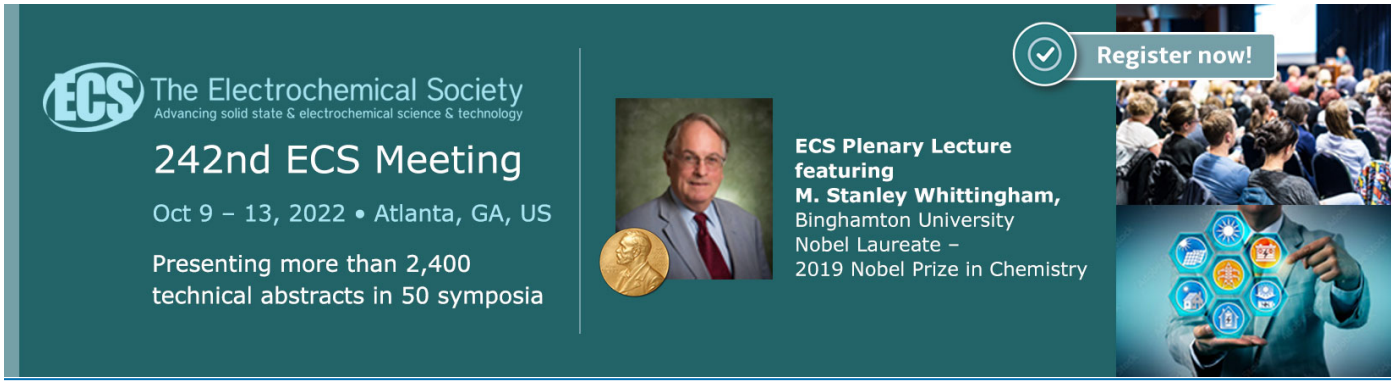

The Effect of Amino Acids and The Date of Planting on Yield and Some Yield Components of Three Maize Varieties

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Abstract. The experiment was carried out according to the randomized complete block design (R.C.B.D) and the arrangement of split-split plot with three replications, at the Field Crops Research Station of the Agricultural Research Department - Abu Ghraib during the spring season for the years 2019 and 2020. With the aim of studying the effect of amino acids, planting dates and their effect on some of the yield characteristics and its components for three varieties of maize in the spring season. Planting dates (March 15, March 25 and April 5) occupied the main plots, while amino acids and the control treatment (proline, arginine, and distilled water) occupied the sub-plot, whereas the varieties (Rabi, Baghdad 3 and Fajr 1) occupied the sub-sub-plot, and the most important results were summarized as follows:The two cultivars, Rabi and Fajr-1, achieved a significant increase in most of the yield characteristics and its components for the seasons. The addition of the amino acid proline also led to a significant increase in most of the studied traits (the number of grains in ear, weight of 500 grains, total grain and biological yield, and harvest index), planting dates also have a significant effect on most of the studied traits. The first date (15/3) recorded increase in the number of grains per ear, the weight of 500 grams, and the grain and biological yield. The plants of the Rabi variety when cultivated on March 15th and sprayed with the amino acid proline achieved the highest average for the grain yield, which reached 7.48 ton. ha^{-1} for spring 2019.

1. Introduction

Maize (*Zea mays* L.) is an important cereal crop in Iraq, which has been cultivated in large areas due to its nutritional importance and its high ability to produce when suitable environmental conditions are available. The area planted with this crop in Iraq is estimated at about 515.2 thousand dunums, and its yield is 473.1 thousand ton for the spring and autumn seasons [1]. These quantities produced from maize grains are insufficient to meet the needs of humans and animals in view of the increasing growth of the population and in order to fill the shortfall in production, and to provide the necessary raw materials, a solution must be found to the problems that hinder the cultivation of maize in the spring season, and then expand its cultivation and increase its production. Among the most prominent problems that reduce the production of maize in the spring season is the rise in temperatures during the period of flowering and the formation of pollen grains, which affects fertilization and thus production decreases compared to the autumn season of high productivity, especially in the central and southern

regions of Iraq. Despite the progress in the world and their knowledge of the most important environmental changes that occur in the near term, the problems of heat and drought, which are responsible for the deterioration of crops and agricultural lands, persist to this day. Therefore, it is necessary to pay attention to crop management by determining the optimal date for planting and using nutrients that reduce the impact of environmental fluctuations during critical stages in the plant, such as amino acids, in addition to choosing genotypes or good varieties appropriate to the conditions of the region in order to achieve the important goals to reach a tangible increase in the amount of yield. Therefore, determining the date of planting is one of the important things that works to increase production per unit area because the temperatures during the growing season may limit the growth of certain varieties of maize in their production areas and thus reduce the nutritional content of the corn crop and its adaptation to climate change due to the influence of genotype and environmental interaction [2]. In order to reduce its effects, it requires additives that improve the growth of the varieties grown during the spring season, such as amino acids that play an important role in transporting nitrogen from different parts of the plant as well as being a source of carbon and energy that protect the plant from stress and diseases and work to modify the osmotic content because it is one of the main sources of building Protein, including enzymes important for vital processes [3]. In order to increase production per unit area, the efficiency of varieties suitable for fall cultivation in the spring season must be improved by using different genotypes and knowing the performance of each genotype and its response to the added amino acids when planted at different dates. Therefore, this study came with the aim of studying the suitability of the fall varieties when planting them in the spring, the best planting date, best amino acid, and determining the most important interactions that achieve the best growth and grain yield.

2. Materials and Methods

A field experiment was carried out at the Abu Ghraib Research Station of the Agricultural Research Department for the year 2019 and 2020 according to R.C.B.D design and with three replications, following the spilt-split plots. The study included three factors. The first was the planting dates (15 March, 25 March and 5 April) allocated to the main plot. Second factor was and amino acids (proline, arginine) at a concentration of 200 mg. L^{-1} as well as the control treatment spraying with distilled water which allocated to the (Sub-plot), while the varieties (Rabi, Baghdad 3 and Fajr 1) allocated to the sub-sub plots. The nutrient solutions sprayed with two sprays, the first in the 7-leaf stage of vegetative growth and the second at the beginning of the male flowering in the early morning. Soil service operations were carried out, including plowing, smoothing, leveling, and then dividing the field into three replicates, and each replicate contained 27 experimental units with dimensions (4 x 3) m, and the distance between one furrow and another was 75 cm and between hills and another 25 cm. The seeds were planted by hand by placing three seeds in the hill and then thinned to one plant. The experiment land was also fertilized with nitrogen and phosphate fertilizers, according to the recommendation of the Ministry of Agriculture [4]. The stem borer insect was controlled with the granulated diazinon insecticide 15% active ingredient at a rate of 6 kg ha^{-1} in two batches, the first after 20 days of emergence and the second 15 days after the first batch.

Ten plants were taken from the midlines and the characteristics below were measured: The number of grains in ear, the weight of 500 grains (gm) was weighed with a sensitive scale and adjusted to a moisture content of 15% [5]. The grain yield of one plant was also measured and the grain yield (ton. ha-1) was extracted from multiplying the average plant yield x the specified plant density. The biological yield (ton ha^{-1}) was calculated by drying these plants with ear from the midlines and converting them on the basis of ton ha^{-} as follows:

Biological yield = total dry plant weight x number of plants per unit area.

Harvest index was also calculated by dividing the total grain yield by the biological yield multiplied by 100 [6].

3. Results and discussion

3.1. *Number of grains in ear.* The two varieties Rabi and Fajr 1 achieved the highest average number of grains in ear with 339.9 and 414.1 grains ear^{-1} for both seasons respectively (Table 1), while the two cultivars, Fajr and Rabi, recorded the lowest mean for this trait, reaching 314 and 381 grains ear^{-1} for the 2019 and 2020 planting seasons, respectively. The reason for the difference in the varieties in this trait is due to their genetically different, and the ability of each variety to prepare the sites of initiation with the nutritional requirements to complete the fertilization process, which was positively reflected in the number of grains per ear. This is in agreement with the results of [7].

Table 1. The effect of cultivar, amino acids, and planting dates on number of grains per ear for the spring season for the years 2019 and 2020.

		First season 2019				Second season 2020			
Planting date	Amino acid	Verities			Date x Amino	Verities			Date x Amino
		Rabi	Baghdad 3	Fajr 1		Rabi	Baghdad 3	Fajr 1	
3/15	Dist. Water	258.7	278.7	240.7	259.3	292.7	309.7	357.7	320.0
	Prolin	475.3	459.3	375.7	436.8	501.3	490.0	504.0	498.4
	Arginin	377.7	341.3	410.7	376.6	414.7	427.3	500.3	447.4
3/25	Dist. Water	242.3	280.7	247.0	256.7	281.7	309.3	292.0	294.3
	Prolin	367.7	390.3	387.7	381.9	460.3	461.0	511.0	477.4
	Arginin	340.3	392.0	341.7	358.0	398.0	390.3	424.3	404.2
4/5	Dist. Water	249.3	226.3	233.3	236.3	263.7	286.7	314.0	288.1
	Prolin	424.3	355.3	317.3	265.7	439.7	445.0	472.0	452.2
	Arginin	323.0	314.7	275.7	304.4	377.0	387.7	351.7	372.1
L.S.D 5%			37.7		25.96		n.s		n.s
					Dates				Dates
Dates* variety	3/15	370.6	359.8	342.3	357.6	402.9	409.0	454.0	422.0
	3/25	316.8	354.3	325.4	332.2	380.0	386.9	409.1	392.0
	4/5	332.2	298.8	275.4	302.1	360.1	373.1	379.2	370.8
L.S.D 5%			21.7		17.78		n.s		22.01
					Amino Acid				Amino Acid
Amino × Variety	Dist. Water	250.1	261.9	240.3	250.8	279.3	301.9	321.2	300.8
	Prolin	422.4	401.7	360.2	394.8	467.1	465.3	495.7	476.0
	Arginin	347.0	349.3	342.7	346.3	396.6	401.8	425.4	407.9
L.S.D 5%			21.78		16.07		n.s		21.26
Variety		339.9	337.6	314		381.0	389.7	414.1	
L.S.D 5%			12.5				20.7		

The results show that the highest average number of grains per ear for the seasons 2019 and 2020 was 394.8 and 476.0 grains ear^{-1} respectively when spraying plants with proline at a concentration of 200 mg L^{-1} compared to the control treatment (spraying with distilled water), which recorded the lowest mean for this characteristic (250.8 and 300.8) for both seasons respectively. This is due to the

protective role of proline for the plant when exposed to different stresses (temperatures), which is one of the most important environmental factors affecting the productivity of the crop because the high temperature leads to a reduction in the efficiency of the photosynthesis process and thus the growth rate of the crop and the length of each stage of its growth decreases and this is reflected in economic yield [8]. Also, there was a significant increase in the average number of grains in the main ear when planting on the date (15 March), as the plants of this date achieved the most number of grains in ear (357.6 and 422.0 grains ear^{-1}) for both seasons respectively, while this number decreased to (302.1 and 370.8 grains ear^{-1}) when planting plants at the late date (April 5). The reason may be due to the difference in the light period and temperature of the agricultural dates that led to the opportunity to give the plant when planted at the date of 3/15 for the stages of growth in order to obtain sufficient time for growth and their access to nutrients during this stage, which was reflected in the increase in the fertility rate and thus increased the number of grains in ear. The interaction between the cultivars and amino acids had a significant effect on the average of this trait for the first season only, as the plants of the cultivar Rabi, sprayed with proline, recorded the highest number of grains per ear (422.4 grains ear^{-1}), while the plants of the cultivar Fajr 1 and spraying with distilled water gave the lowest average for the studied trait (240.3 grains ear^{-1}). It was also noticed through the results that early sowing on March 15 in which the plants of the Rabi variety achieved the highest average for the trait, which reached 370.6 grains ear^{-1}, while the average for this trait decreased (275.4 grains ear^{-1}) when planting plants of the variety Fajr 1 on April 5 for the first season only. It is also noticed that the interaction between amino acids and planting dates had a significant effect on the average of this trait for the first season, as proline added when planting on March 15 recorded the highest number of grains per ear (436.8 grains ear $^{-1}$), while this number decreased significantly (236.3 grains ear^{-1}) when planting late and spraying with distilled water. As for the three-way interaction, it had a significant effect on this trait in the first season only, as the plants of the variety Rabi planted at a date (March 15) and sprayed with proline gave the highest average for the trait (475.3 grains ear $^{-1}$), compared to plants of the variety Baghdad 3 when planted at the late date (April 5) and sprayed with distilled water gave the lowest average for this characteristic of 226.3 grains ear^{-1}.

3.2. *Weight of 500 grains (gm).* The results of Table (2) showed that the varieties were significantly different in this characteristic in the second season only. The plants of the Fajr 1 cultivar outperformed the highest average of 132.00 g, which was not significantly different from the plants of the variety Baghdad 3, but it differed significantly from the plants of the variety Rabi, which scored the lowest average of 130.30 g. Perhaps the superiority of the Fajr 1 variety is due to its high efficiency in distributing photosynthesis products in favor of the economic yield (Table 3), which was positively reflected in the increase in grain weight. The results of the same table for both seasons showed a significant increase in the weight of 500 grains when spraying plants with proline at a concentration of 200 mg L^{-1} (136.06 and 137.33 g) respectively compared to the control treatment that recorded the lowest average for this trait of 123.89 and 125.33 g for the two seasons respectively. The increase in the weight of 500 grains resulting from spraying the amino acid proline may be due to its effective role in changing the osmotic effort of the plant tissue, which was positively reflected in the increase in the process of photosynthesis and the accumulation of manufactured substances in the leaves and their transfer to the final sink in the seeds, which led to an increase in their weight. In addition to the role of proline in providing adequate nutrition with the important elements during the period of filling the grain, as it is a source of nitrogen in its composition, which is ready for absorption, and this result is consistent with what [9].

The planting dates also had a significant effect on the weight of 500 grains, as the first date gave the highest average for this trait (133.90 and 132.96 g) for both seasons respectively, compared to the Late date plants that recorded the lowest average of 126.56 and 128.63 g. The reason may be that early cultivation prolongs the time needed for the grain filling period and gives a longer period of time for the leaves to store the components manufactured from the photosynthesis process and their transfer to the grains, and these agree with the results of Regab and Jassim [10]. The two-way interaction

between varieties and amino acids also had a significant effect on the average grain weight, as plants of variety Baghdad 3 gave the highest grain weight when spraying with proline (137.00 and 139.11 g) and the lowest average for 500 grains of the same variety Baghdad 3 when spraying with distilled water (122.72 and 124.11 g) for both seasons respectively. The interaction between varieties and planting dates also showed a significant effect on the weight of 500 grains for the first season only, as the spring Rabi variety scored higher and lower average for this characteristic when planted in the early and late dates (136.44 and 124.61 g) respectively.

Table 2. The effect of cultivar, amino acids, and planting dates on weight of 500 grain or the spring season for the years 2019 and 2020.

		First season 2019				Second season 2020			
Planting date	Amino acid	Verities			Date x Amino	Verities			Date x Amino
		Rabi	Baghdad 3	Fajr 1		Rabi	Baghdad 3	Fajr 1	
3/15	Dist. Water	128.67	124.67	125.33	126.22	129.67	127.67	126.00	127.78
	Prolin	145.67	141.00	141.00	142.56	137.33	139.33	140.00	138.89
	Arginin	135.00	130.67	133.08	132.92	131.67	130.00	135.00	132.22
3/25	Dist. Water	124.50	123.17	124.67	124.11	128.33	124.00	124.33	125.56
	Prolin	131.67	135.67	135.00	134.11	131.67	139.67	140.67	137.33
	Arginin	127.67	134.33	131.33	131.11	131.33	136.33	133.33	133.67
4/5	Dist. Water	122.00	120.33	121.67	121.33	124.00	120.67	123.33	122.67
	Prolin	127.00	134.33	133.17	131.50	132.67	138.33	136.33	135.78
	Arginin	124.83	128.33	127.33	126.83	126.00	127.33	129.00	127.44
L.S.D 5%			n.s		2.59		n.s		n.s
					Dates				Dates
Dates* Variety	3/15	136.44	132.11	133.14	133.90	132.89	132.33	133.67	132.96
	3/25	127.94	131.06	130.33	129.78	130.44	133.33	132.78	132.19
	4/5	124.61	127.67	127.39	126.56	127.56	128.78	129.56	128.63
L.S.D 5%			2.55		2.38		n.s		2.02
					Amino Acid				Amino Acid
Amino × Variety	Dist. Water	125.06	122.72	123.89	123.89	127.33	124.11	124.56	125.33
	Prolin	134.78	137.00	136.39	136.06	133.89	139.11	139.00	137.33
	Arginin	129.17	131.11	130.58	130.29	129.67	131.22	132.44	131.11
L.S.D 5%			1.99		1.24		3.38		2.58
Variety		129.67	130.28	130.29		130.30	131.48	132.00	
L.S.D 5%			n.s				1.02		

It is also noticed in Table (2) that there is a significant interaction between the amino acids and the planting dates first season only, as the plants planted on 3/15 and that were sprayed with proline

recorded the highest average of 142.56 g, while the plants planted in 5/4 sprayed with distilled water recorded the lowest average of 121.67 g.

3.3. *Total Grain yield (ton ha^{-1})*. The results of Table (3) show that the cultivars had a significant effect on grain yield for both seasons. The two cultivars, Rabi and Fajr 1, were significantly better, with the highest grain yields of 4.84 and 5.88 ton. ha^{-1}, while the two varieties, Fajr-1 and Rabi, gave the lowest average for this characteristic of 4.40 and 5.32 ton ha^{-1} for both varieties and the two growing seasons respectively. The reason for this difference may be due to the difference in the genetic makeup of each variety in their ability to transfer the elements represented from the source to the final sink, as well as the superiority of the two varieties Rabi 'and Fajr in the characteristic of the total number of grains in ear in the first season (Table1), which was positively reflected in the increase in the quantity of the grain yield in unit area. This result was consistent with the results of other researchers who observed a significant difference between the different varieties of maize plants in their yield of total grains [11]. The results also showed that maize plants sprayed with proline at a concentration of 200 mg. L^{-1} outperformed significantly by giving the highest average seed yields of 5.74 and 6.97 ton ha^{-1} and it was significantly different from all other treatments in both seasons. While spraying with distilled water gave the lowest average for grain yield (3.31 and 4.02 ton ha^{-1}) for both seasons respectively. The superiority of proline in the two characteristics of the number of grains in ear and the weight of 500 grains (Table 1 and 2) led to an increase in the total grain yield. This result agreed with Al-Hammoudi [12] who indicated that spraying proline on the vegetative part of the plant affected the yield components, which led to an increase in total grain yield.

Planting dates also had a significant effect on the average of grain yield. When planting on March 15, the grain yield per unit area increased by an average of 5.16 and 6.01 ton ha^{-1}, and it is different from the rest of the other dates for both study seasons respectively, while the grain yield decreased when planting plants at the late date, with a lower average for grain yield of 4.09 and 5.14 ton ha^{-1} for both seasons respectively. The reason may be attributed to the suitability of environmental conditions during the flowering stage at the early date, and consequently the increase in the number of grains in ear (Table 1) in addition to the plants obtaining the time required to fill the grain, which led to an increase in its weight (Table 2), which reflected positively on the total yield per unit area. This result is in agreement with Regab and Jassim [10] who observed significant variation in total grain yield between different dates.

The effect of the two-way interaction between the varieties and the amino acids significantly affected the grain yield, as the Rabi variety when sprayed with proline achieved the highest average for the grain yield, reaching 6.19 ton ha^{-1}, while the variety Fajr-1 scored the lowest average of grain yield (3.17 ton ha^{-1}) when distilled water was sprayed for the first season only.

There was also a significant increase when the variety Rabi was planted at the early date of March 15, with the highest grain yield reaching 5.55 ton ha^{-1}, while the total grain yield (3.76 ton ha^{-1}) for the Fajr 1 variety decreased when it was planted on the late April 5 date. for the first season only. The plants of the first date sprayed with proline recorded the highest average total yield of 6.64 ton ha^{-1}, compared to the third date and spraying with distilled water, which gave the lowest grain yield (3.06 ton ha^{-1}) in the first season. The three-way interaction between the study factors showed significant differences in the grain yield for the first season only, as the Rabi variety when planted on the first date under the influence of proline gave the highest average for this characteristic (7.48 ton ha^{-1}), while the Baghdad-3 variety, when planted at the late date, and sprayed with distilled water, recorded the lowest average for the total grain yield of 2.80 ton ha^{-1}.

Table 3. The effect of cultivar, amino acids, and planting dates on total grain yield of the spring season for the years 2019 and 2020.

Planting date	Amino acid	First season 2019				Second season 2020			
		Verities			Date x Amino	Verities			Date x Amino
		Rabi	Baghdad 3	Fajr 1		Rabi	Baghdad 3	Fajr 1	
3/15	Dist. Water	3.65	3.61	3.21	3.49	4.04	4.21	4.80	4.35
	Prolin	7.48	6.81	5.64	6.64	7.34	7.28	7.51	7.37
	Arginin	5.53	4.65	5.83	5.34	5.81	5.91	7.20	6.31
3/25	Dist. Water	3.31	3.58	3.28	3.39	3.84	4.09	3.86	3.93
	Prolin	5.26	5.55	5.57	5.46	6.46	6.87	7.67	7.00
	Arginin	4.74	5.51	4.78	5.01	5.58	5.70	6.05	5.77
4/5	Dist. Water	3.34	2.80	3.03	3.06	3.51	3.71	4.14	3.78
	Prolin	5.84	5.00	4.51	5.11	6.23	6.58	6.85	6.55
	Arginin	4.40	4.20	3.74	4.11	5.07	5.29	4.86	5.07
L.S.D 5%			0.54		0.35		n.s		n.s
					Dates				Dates
Dates* Variety	3/15	5.55	5.02	4.89	5.16	5.73	5.80	6.50	6.01
	3/25	4.44	4.88	4.54	4.62	5.29	5.55	5.86	5.57
	4/5	4.51	4.00	3.76	4.09	4.94	5.19	5.28	5.14
L.S.D 5%			0.30		0.22		n.s		0.35
					Amino acids				Amino acid
Amino × Variety	Dist. Water	3.43	3.33	3.17	3.31	3.80	4.00	4.27	4.02
	Prolin	6.19	5.78	5.24	5.74	6.67	6.91	7.34	6.97
	Arginin	4.89	4.79	4.78	4.82	5.49	5.63	6.04	5.72
L.S.D 5%			0.32		0.22		n.s		0.30
Variety		4.84	4.63	4.40		5.32	5.51	5.88	
L.S.D 5%			0.17				0.30		

3.4. *Biological yield (ton ha^{-1}).* The results indicated that the plants of the two varieties Rabi 'and Fajr 1 recorded the highest average for biological yield (19.13 and 18.56 ton ha^{-1}) for both cultivars for the two seasons respectively, while the two cultivars, Baghdad 3 and Rabi, gave the lowest average for the biological yield (18.54 and 17.01 ton ha^{-1}) for the two varieties and the two seasons respectively (Table 4). The reason may be due to the difference in the genotype of the varieties that gave the opportunity to increase the dry weight and grain yield, which is reflected in the biological yield. This result is in agreement with the findings of Al-Tamimi [13] and Ali et al. [14] who indicated a significant difference between cultivars in their average biological yield. The addition of the amino acid proline to plants at a concentration of 200 mg. Liter^{-1} led to a significant increase in biological yield for both seasons, with the highest average of 20.63 and 19.00 ton ha^{-1}, while the control treatment gave the lowest average of (16.59 and 15.77 ton ha^{-1}) for both seasons respectively. The reason for the superiority of proline in biological yield is a reflection of its superiority in the grain yield and its components, which gave a significant increase in the biological yield. Planting dates also had a significant effect on biological yield for both seasons. Planting on March 15 recorded the highest average of biological yield, reaching 20.12 and 19.58 ton ha^{-1}, while this percentage decreased when planting on March 25 (17.60 and 16.77 ton ha^{-1}) for both seasons, respectively. This is because of the superiority of the early date in most of the yield characteristics and its components, which was reflected in the increase of biological yield.

The results also showed that the plants of the two varieties, Rabi and Fajr 1, were sprayed with the amino acid proline at a concentration of 200 mg. L^{-1} they achieved the highest biological yield for both seasons, reaching 21.18 and 19.84 tons. ha^{-1} for the two varieties, respectively. While the biological yield of the two varieties, Baghdad 3 and Rabi, decreased when they were sprayed with distilled water, and thus recorded the lowest average for biological yield (15.56 and 14.25 ton ha^{-1}) for the two varieties and the two seasons, respectively. When planting early (March 15), the plants of the two varieties, Baghdad and Fajr-1, achieved the highest average for biological yield (20.47 and 20.20 ton ha^{-1}), while the two varieties Baghdad and Rabi recorded the lowest biological yield when planted on March 25 (16.31 and 14.64 ton ha^{-1}) for both varieties and seasons respectively.

Table 4. The effect of cultivar, amino acids, and planting dates on biological yield of the spring season for the years 2019 and 2020.

		First season 2019				Second season 2020			
Planting date	Amino acid	Verities			Date x Amino	Verities			Date x Amino
		Rabi	Baghdad 3	Fajr 1		Rabi	Baghdad 3	Fajr 1	
3/15	Dist. Water	17.93	16.99	18.00	17.64	15.26	17.34	18.40	17.00
	Prolin	21.96	22.67	23.14	22.59	21.24	20.88	21.77	21.29
	Arginin	18.54	21.77	20.10	20.13	22.60	18.26	20.43	20.43
3/25	Dist. Water	15.96	13.50	14.28	14.58	11.96	15.01	15.88	14.28
	Prolin	20.62	18.59	18.29	19.16	17.13	15.48	19.89	17.50
	Arginin	21.95	16.84	18.44	19.07	14.82	19.85	20.92	18.53
4/5	Dist. Water	19.71	16.19	16.73	17.54	15.53	16.10	16.42	16.02
	Prolin	20.97	20.02	19.43	20.14	18.13	18.62	17.86	18.20
	Arginin	14.56	20.34	18.71	17.87	16.45	16.86	15.45	16.25
L.S.D 5%			1.28		0.82		1.336		0.97
					Dates				Dates
Dates* variety	3/15	19.48	20.47	20.41	20.12	19.70	18.83	20.20	19.58
	3/25	19.51	16.31	17.00	17.60	14.64	16.78	18.89	16.77
	4/5	18.41	18.85	18.29	18.52	16.70	17.19	16.57	16.82
L.S.D 5%			0.73		1.11		0.85		0.78
					Amino acids				Amino acids
Amino × Variety	Dist. Water	17.87	15.56	16.33	16.59	14.25	16.15	16.90	15.77
	Prolin	21.18	20.42	20.28	20.63	18.83	18.33	19.84	19.00
	Arginin	18.35	19.65	19.08	19.03	17.95	18.32	18.93	18.40
L.S.D 5%			0.73		0.47		0.757		0.54
Variety		19.13	18.54	18.75		17.01	17.60	18.56	
L.S.D 5%			0.42				0.39		

It is noticed from the results that there is a significant effect of the two-way interaction between amino acids and planting dates, as Proline was achieved the highest average of biological yield when sprayed on the vegetative part of the maize plant at a concentration of 200 mg. L^{-1} on March 15 with average biological yield of 22.59 and 21.29 tons. ha^{-1}. While spraying with distilled water on cultivated plants on March 25 gave the lowest average for biological yield (14.58 and 14.28 ton ha^{-1}) for both seasons 2019 and 2020 respectively. The three-way interaction had a significant effect on biological yield, as the plants of the two cultivars Fajr 1 and Rabi outperformed when planting on March 15 and under the influence of proline and arginine, with the highest mean of biological yield

23.14 and 22.60 tons. H-1 for the study factors overlapping and for both seasons respectively, and the plants of the variety spring gave the lowest average for the character (13.50 and 11.96 tons. ha^{-1}) when planting on March 25 and spraying with distilled water for both seasons respectively.

3.5. *Harvest index %.* The results indicated that the plants of the variety Rabi achieved the highest average of harvest index (25.30%), which was not significantly different from the variety Baghdad 3, while the plants of the variety Fajr 1 recorded the lowest average for this trait (23.47%), which was significantly different from the rest of the other varieties of the first season (Table 5). The reason for the superiority of the Rabi variety may be due to the efficiency of the vegetative parts and its ability to convert the products of the photosynthesis process into an economic return, and thus is reflected in the increase of the harvest index. This result is in agreement with Ahmed et al. [3] and Khan et al. [15] who indicated that the varieties of maize differ in average harvest index. It is also noticed that the harvest index increased its value when adding amino acids, as the plants treated with proline gave the highest average for the harvest index of 27.79 and 37.01%, while the control treatment (spraying with distilled water) recorded the lowest average for harvest index of (20.19 and 25.74%) for both seasons respectively. The reason may be due to the effective role of proline in increasing the vegetative parts and the proportion of chlorophyll in the leaves, which was reflected in the increase of photosynthesis products that were transported to the final sink and thus increased the economic return and a decrease in the value of their biological yield, which led to an increase in the harvest index. The planting dates had a significant effect on the value of the harvest index for the first season only, as the plants grown on March 25 gave the highest average for the studied trait, which reached 26.46%, and this percentage decreased when planting late on April 5, recording the lowest average for harvest index (22.09%) for the first season only.

The difference in the period between the vegetative and reproductive growth stages directly affects the amount of dry matter and the economic yield when suitable environmental conditions are available for this crop. The greater the period from planting to the flowering stage, the greater the accumulation of nutrients, which later transfer to the flowering and then to the seeds (final sink), thus increasing the economic yield at the expense of dry weight, which leads to an increase in the harvest index. The two-way interaction of the varieties and amino acids, it had a significant effect on the average of harvest index for the first season only. The cultivar Rabi sprayed with Proline achieved the highest average for harvest index, which reached 29.23%, and it differed significantly from all other treatments, including the control treatment that was recorded with the cultivar Fajr 1, the lowest average for the harvest Index was 19.41%. The effect of the interaction between varieties and planting dates was significant in harvest index for both seasons. The plants of the two varieties, Baghdad 3 and Rabi, when planted on March 25, recorded the highest average for harvest index (29.92 and 35.83%) for the two cultivars and for both seasons respectively. While the harvest index decreased when the two varieties were planted Fajr 1 on April 5 and Rabi on March 15 (20.56 and 28.96%) for the two varieties and the two seasons, respectively.

The results indicated that the three-way interaction between the study factors had a significant effect on harvest index for both seasons. The plants of the two varieties, Rabi and Baghdad 3, when sprayed with proline and planted on (March 15 and March 25) recorded the highest average for harvesting index, reaching 34.06 and 44.71% for the mentioned study factors and for both seasons respectively. While the cultivar Rabi when planted at the late date and the control treatment (spraying with distilled water) gave the lowest average for the harvest index, reaching 16.95 and 22.69% for the two seasons, respectively.

Table 5. The effect of cultivar, amino acids, and planting dates on harvest index of the spring season for the years 2019 and 2020.

		First season 2019				Second season 2020			
Planting date	Amino acid	Verities			Date x Amino	Verities			Date x Amino
		Rabi	Baghdad 3	Fajr 1		Rabi	Baghdad 3	Fajr 1	
3/15	Dist. Water	20.36	21.25	17.83	19.81	26.48	24.24	26.14	25.62
	Prolin	34.06	30.04	24.37	29.49	34.58	34.86	34.52	34.65
	Arginin	29.83	21.36	29.00	26.73	25.82	32.42	35.21	31.15
3/25	Dist. Water	20.74	26.52	22.97	23.41	32.19	27.23	24.42	27.95
	Prolin	25.51	29.85	30.45	28.60	37.72	44.71	38.60	40.34
	Arginin	21.59	32.72	25.92	26.74	37.57	28.62	28.97	31.72
4/5	Dist. Water	16.95	17.29	18.11	17.45	22.69	23.05	25.25	23.66
	Prolin	27.85	24.98	23.21	25.35	34.48	35.36	38.31	36.05
	Arginin	30.22	20.65	19.99	23.62	30.99	31.37	31.59	31.32
L.S.D 5%			3.08		n.s		5.34		n.s
					Dates				
Dates* variety	3/15	28.49	24.52	23.96	25.66	28.96	30.50	31.96	30.47
	3/25	22.76	29.92	26.71	26.46	35.83	33.52	30.66	33.34
	4/5	24.50	21.22	20.56	22.09	29.39	29.92	31.72	30.34
L.S.D 5%			1.78		1.86		3.56		n.s
					Amino acids				
Amino × Variety	Dist. Water	19.75	21.40	19.41	20.19	27.12	24.84	25.27	25.74
	Prolin	29.23	28.31	25.84	27.79	35.59	38.31	37.14	37.01
	Arginin	26.65	24.38	25.05	25.36	31.46	30.80	31.92	31.39
L.S.D 5%			1.78		1.48		n.s		1.73
Variety		25.30	24.97	23.47		31.39	31.32	31.45	
L.S.D 5%			1.02				n.s		

4. Conclusion

The addition of amino acids led to the improvement of most of the yield characteristics and its components (such as the number of grains in ear, the weight of 500 grains, total grain yield, biological yield and the harvest index). The early spring planting with the addition of the amino acid proline improved most of the yield characteristics and components of maize varieties used in the study.

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