EFFECT OF BIOFERTILIZERS AND SPRAYING WITH MAGNESIUM AND CALCIUM ON THE YIELD AND ITS COMPONENTS OF SWEET CORN

WASAN. S. M. K.
Reasearcher
Gen. Comp. for Grains Proce. Min. of Trading
Gmail:wassansalihmahdi@gmail.com

Ayad.W. A. Al-juboori
Assist. Prof.
Dept. Hort. and Land. Design
Coll. of Agric. Engin. Sci., University of Baghdad, Iraq
E-mail: Ayad waleed@coagri.uobaghdad.edu.iq

ABSTRUCT

This study was aimed to investigate response of two sweet corn hybrids to bacterial biofertilizers and spraying with Mg^{+2} and Ca^{+2} and their impact on the yield during fall season 2021 and spring season 2022, CASH seeds (H1) and ROI SOLEIL seeds (H2) were planted in pots, when they reached 2-3 leaves treated with four treatments which included without biofertilizer (B0), with *Azospirillum brasilense* (B1) with *Pseudomonas fluorescens* (B2) and the interaction with *Azospirillum brasilense* and *Pseudomonas fluorescens* (B3) then transferd to the field, and sprayed the seedling which included without spraying (N0), spraying with Mg^{++} and Ca^{++} with concentration of 25 mg L^{-1} (N1) and 50 mg L^{-1} each elements (N2), The experiment was carried out according to RCBD with in split plot arrangement. The results showed that the H1 hybrid had significant response in number of days to tasseling and silking of 50% of plants, the diameter of ear, number of rows.ear^{-1}, The H2 hybrid had a significant response in the ear length for two seasons, B3 and N2 had significant impact to all the studied traits for two seasons. H1B3N2 had significant impact in number of days to tasseling and silking of 50% of plants, the ear diameter and number of rows.ear^{-1}, H2B3N2 had significant impact to the length of the ear for the two seasons respectively

Keywords: Azospirillum brasilense, Pseudomonas fluorescens, tasseling. silking
Part of Ph.D. dissertation of the 1st author.

تأثير الاسمدة الحيوية البكتيرية والرش بالمغنيسيوم والكالسيوم في الحاصل ومكوناته للذرة السكرية *Zea mays* L.*var saccharata*

وسن صالح مهدي خلف
باحث

اياد وليد عبد الله الجبوري
استاذ مساعد

الشركة العامة لتصنيع الحبوب/ وزارة التجارة
قسم البستنة وهندسة الحدائق/ كلية علوم الهندسة الزراعية \ جامعة بغداد

المستخلص

نفذت تجربة حقلية بهدف معرفة استجابة اثنان من هجن الذرة السكرية للاسمدة الحيوية البكتيرية والرش بالمغنيسيوم والكالسيوم وأثرهما في مكونات الحاصل للموسم الخريفي 2021 والموسم الربيعي 2022، زرعت بذور هجينين من الذرة السكرية CASH (H1) وROI SOLEIL (H2) في اوعية بلاستيكية وعند وصولها لمرحلة تكوين 2-3 اوراق حقيقية تم تلقيح وسط البادرات بالسماد البكتيري والذي تضمن: من دون لقاح (B0) والتلقيح ببكتريا *Azospirillum brasilense* (B1) والتلقيح ببكتريا *Pseudomonas fluorescens* (B2) و التلقيح ببكتريا *Azospirillum brasilense* و*Pseudomonas fluorescens* (B3) بعدها تم نقلها للحقل، تم الرش بعد 20 و 30 يوم من الشتل بثلاثة تراكيز وتضمنت من دون رش (N0) والرش بالمغنيسيوم والكالسيوم بتركيز 25 ملغم لتر$^{-1}$ (N1) و 50 ملغم لتر$^{-1}$ لكل منهما (N2)، نفذت التجربة وفق تصميم القطاعات الكاملة المعشاة بترتيب الالواح المنشقة وبثلاثة مكررات. اظهرت النتائج تفوقا معنويا للهجين H1 في اقل عدد ايام من الزراعة لغاية تزهير 50% ذكري وانثوي وقطر العرنوص وعدد الصفوف بالعرنوص، بينما تفوق الهجين H2 في طول العرنوص لكلا الموسمين، وتفوقت المعاملة B3 و N2 معنويا باغلب الصفات المدروسة. وتفوقت معاملة التداخل الثلاثي H1B3N2 معنويا في اقل عدد ايام من الزراعة لغاية تزهير 50% ذكري وانثوي وقطر العرنوص وعدد الصفوف بالعرنوص بينما تفوقت المعاملة H2B3N2 معنويا بطول العرنوص لكلا الموسمين.

الكلمات المفتاحية: Azospirillum brasilense، Pseudomonas fluorescens، تزهير ذكري، تزهير انثوي

*** البحث مستل من اطروحة دكتوراه للباحث الاول**

Received:15 /8/2022, Accepted:27/11/2022

INTRODUCATION

Sweet corn (*Zea mays* L).var Saccharata is a corn variety with high sugar content in milky and early dough stage and its dry kernels are shriveled transparent, it eats fresh, boiled or grilled and harvested at the horticultural maturity of the grains (the milky stage). Each 100 g of sweet corn grains contains 72.7 g of moisture, 96 calories, 3.5 g of protein, 1 g of fat, 22.1 g of carbohydrates, 0.7 g of fiber and 0.7 g of ash (16). Sweet corn did not receive much attention farmers in Iraq, despite that the climatic conditions are suitable for its cultivation and production. Hybrids of sweet corn are many and varied, and production varies according to their ability to photosynthesis and individual productivity and many quantitative and qualitative characteristics, and the loose of information on the cultivation of sweet corn in Iraq. Fertilizer types play an important role in improving plant growth and increasing its productivity, especially bio-fertilizers, that deal with many issues such as drought (3, 20), seed invigorators (4), soil conditioners (28, 30), diseases resistance (27), and plant growth and yield (23, 24, 25, 26, 31). It also play an important role in fixing nitrogen , improving the nutritional status of plants (12, 29) and reducing the pathogens that may infect the plant (5), Microorganisms differed in the functions they perform towards the plant, as *Azospirillum brasilense* have the potential to fix nitrogen only, but it turned out later that its impact on plant growth is through the production of phytohormones and was then classified as Plant Growth Promoting Rhizobactria, While *Pseudomonas fluorescens* is described a great ability to coloniz around the roots of cultivated plants and produce metabolites that stimulate plant growth and raise the readiness of the phosphorous present in the rhizosphere and contribute to reduce the impact of growth inhibitors and the development of biological control factors (10).Foliar spraying plays an important role in improving plant growth and increasing its productivity by supplying it with its needs of different nutrients, which contribute to many diverse physiological activities in the plant tissue. Magnesium is involved in many physiological and biochemical activities; it is an essential element for plant growth and development, The most commonly known function of Magnesium in plants is probably its role as the central atom of the chlorophyll molecule in the light-absorbing complex of chloroplasts and its contribution to photosynthetic fixation of carbon dioxide and enzyme activation for protein biosynthesis, and phloem translocation of photosynthetics to ensure vegetative and generative growth. Magnesium pectate acts on the cellulose chains in the cell wall which is Calcium interacts with pectic acid to form insoluble Calcium pectate , and Calcium presence is important in fast-growing tissues such as stem and root meristems, which confirms the importance of the two elements in plant growth and the production quality (9, 14). Consequently; the study aimed to Assess how biofertilizers, magnesium, and calcium impact sweet corn growth and yield.

MATERIALS AND METHODS

This study was aimed to investigate response of two sweet corn hybrids to bacterial biofertilizers and spraying with Mg^{+2} and Ca^{+2} and their impact on the yield during Fall season 2021 and spring season 2022, It was carried out at (A) Research Station, College of Agricultural Engineering Sciences, Jadiriyah. Peatmoss was sterilized by packing a weight of 250 g in thermal bags for 30 minute in an autoclave at a temperature of 121 °C and a pressure of 15 pounds, then left to cool and the sterilization process was repeated twice. then, plastic pots with a capacity of 32 plants were prepared and filled with sterilized peatmoss, and planted with sweet corn hybrid seeds . When they reached the stage of forming 2-3 leaves, the seedling soil was inoculated with bio-bacterial fertilizer within the required transactions and was transferred to the field, after prepration of the field plants were planted using 65 cm between the rows and 20 cm with in the rows. The field was of the 50% fertilizer recommendation follow(16):

• Nitrogen fertilizer rate of 178 kg . hectare $^{-1}$ with urea

Tri super phosphate fertilizer added rate of 100 kg hectare $^{-1}$ (P2O5).

• Potassium sulfate fertilizer added rate of 198 kg hectare $^{-1}$ (K2O).

Treatments

1. The first factor includes the inoculation with bacterial biofertilizer, which was added to the soil of the seedlings using liquid inoculum, where the inoculation density of the bacteria used was (1×108 ml^{-1} cfu), which was prepared by the Ministry of Agriculture, Agricultural Research Department, as it was The treatments were as follows:

Comparative treatment (without bio-bacterial fertilizers).

• Treatment of bio-bacterial fertilizers using *Azospirillum brasilense*

• Treatment of bio-bacterial fertilizers using *Pseudomonas fluorescens*

• Interaction treatment of two bio-bacterial fertilizers (*Azospirillum brasilense* and *Pseudomonas fluorescens*).

2.The second factor (the most important) includes foliar spray treatments using three concentrations of Magnesium and Calcium (in the forms of Magnesium Sulfate and Calcium Sulfate). The spraying was carried out twice after 20 and 30 days of seeding in the permanent field (1, 8), the treatments were as follows:-

• without spraying

• Foliar spraying with Magnesium and Calcium at a concentration of 25 mg. L^{-1} each one

• Foliar spraying with Magnesium and Calcium at a concentration of 50 mg. L^{-1} each one

3 The third factor included the cultivation of two hybrids of sweet corn which were: -

• An American origin CASH hybrid.

• A Dutch-origin ROI SOLEIL hybrid

Randomized complete block design (RCBD) with in split plot arrangement with three replicates were used the main plot included the hybrids, while the sub plots included treatments of bacterial inoculation and spraying with Magnesium and Calcium. with a 5% probability level (6).

RESULTS AND DISCUSSION

Number of days from planting to 50% tasseling:

The results in Table 1 show that H1 had significant effect to number of days from planting to 50% tasseling had 34.250 and 38.667 days compared to H2 which had 44.056 and 46.806 days for the two seasons respectively, the treatment of bacterial biofertilizers B3 significant effect with 37.889 days compared to the control treatment B0 which had 40.389 days in the Fall season, The B3 recorded 42.278 days which did not differed significantly from B2 compared to the B1 which took 43.000 which did not differed significantly from the control B0 in the spring season, the treatment of foliar spraying with Magnesium and Calcium N1 recorded 38.792 days compared to control treatment (39.750) during Fall season, N2 had significant effect 42.458 days which did not differed significantly from N1 compared to the control treatment N0 which had 43.083 days in the Spring season. The second interaction H1B3 had significant effect with 33.111 and 37.778 days, but did not differed significantly from H1B2 when compared to the H2B0 and H2B2 had 45.556 and 46.778 days for two seasons ,H1N1 had significant effect with 33.760 days which did not differed significantly from H1N2 and H1N0 treatment in the Fall season, and H1N2 recorded 38.250 days which did not differed significantly from the H1N1 and H1N0 in the Spring season, compared to the H2N0 which had 44.500 and 47.167 days for the two seasons respectively. B3N1 record 36,833 and 42,000 days compared to B0N0 had 41,000 and 43,333 cm for the two seasons respectively. The triple interference H1B3N1 had significant effects by giving 32,333 days, which did not differed significantly from H1B3N2 compared to the H2B0N0, which had 46,000 days for the Fall season. Both H1B3N2 and H1B3N1 had significant effects (37,667) days which did not differed significantly from H1B3N0, H1B2N1, H1B2N2 and H1B0N2 compared to H2B0N2 with 47.000 days in the Spring season.

Number of days from planting to 50% silking:

The results in Table 2 show that the H1 hybrid significantly effect the minimum number of days from planting to 50% silking had 41.778 and 48.333 days compared to H2 hybrid which had 55.083 and 56.861 days for the two seasons respectively, The biofertilizers B3 had significant effect (48.111 and 51.778 days) compared to the B0 control treatment which had 48.833 and 53.444 days for the two seasons respectively, The treatment of foliar

spraying with Magnesium and Calcium N2 had significant effect with 48.208 and 52.083 days compared to N0 which had 48,667 and 53,042 days for the two seasons respectively. The second interaction H1B3 had significant effect (41.556 and 48.111 days) which did not differed significantly from H1B2, H1B1 and H1B0 compared to H2B0 which gave 55.667 and 58.333 days for the two seasons respectively, H1N2 recorded 41.417 and 47.833 days which did not differ significantly from H1N1 and H1N0 compared to the H2N0 which had 55.250 and 57.667 days for the two seasons respectively.B3N2 recorded 47,833 and 51,500 days which did not differed significantly from the B2N2 and B3N1 compared to B0N0 which gave 49,667 and 53,833 days for the two seasons respectively. The triple interference H1B3N2 had significant effect had 41,000 and 47,667 days which did not differed significantly from H1B3N0, H1B2N1, H1B2N2, H1B1N1 and H1B2N0 compared to H2B0N0 which had 56,667 and 58,667 days for the two seasons respectively,

Ear length (cm)

The results in Table 3 show that the hybrid H2 was effect significantly on ear length which gave 21.944 and 20.125 cm compared to the hybrid H1 which had 19.444 and 17.028 cm for the two seasons, respectively. Biofertilizers B3 had significant effect which gave 21.389 cm, but did not differed significantly from treatment B2, Compared to the control treatment B0, which gave 19.444 cm in the Fall season, Treatment B2 was recorded 19.500 cm, which did not differed significantly with B3, When compared to B0, which had 16.972 cm in the spring season, and the foliar spraying treatment with Magnesium and Calcium N2 recorded 21.125 and 19.042 cm, When control treatment N0, was produced an average of 20.104 and 18.062 cm for the two seasons respectively. The secondary interaction H2B1 was recorded 22.333 cm, but did not differed significantly had H2B2 and H2B3 from H1B0, which gave 17.833 cm in the Fall season. H2B2 was recorded 21.111 cm, which did not differed significantly with H2B3 compared to H1B0 gave 15.611 cm in the spring season. H2N2 was recorded 22.417 and 20.458 cm, which did not differed significantly from the H2N1 treatment, compared to the H1N0, which gave an average of 19.000 and 16.417 cm for two seasons, respectively. B3N2 was arecorded 21.500 and 20.083 cm, which did not differed significantly with B2N3 and B2N1 compared to the treatment B0N0, which had 17.917 and 16.167 cm for the two seasons, respectively. The triple interaction H2B2N2 was recorded 22.667 and 21.333 cm, which did not differed significantly with H2B3N1, H2B2N1 and H2B3N2. When compared to plants of H1B0N0, which had 17.000 and 15.167 cm for the two seasons, respectively.

Ear diameter (cm)

The results in Table 4 show that H1 hybrid impact significant with ear diameter by giving 4.511 and 4.869 cm compared to H2 hybrid which gave 4.070 and 4.208 cm for the two seasons respectively. The plants of biofertilizers B3 had significant impact and gave 4.473 and 4.689 cm compared to B0 which gave 4.144 and 4.344 cm for the two

Table 1Effect of bacterial biofertilizers and spraying with Magnesium and Calcium and the interaction between them on Number of days from planting to 50% tasseling (day) of sweet corn hybrids for the Fall season 2021 and the Spring season 2022

The Fall Season 2021							The Spring Season 2022						
Hybrids	Foliar Spraying	Bacterial Bio Fertilizer B0	B1	B2	B3	Interaction × N H	Hybrids	Foliar Spraying	Bacterial Bio Fertilizer B0	B1	B2	B3	Interaction N× H
H1	N0	36.000	35.000	35.000	34.000	35.000	H1	N0	40.000	39.333	38.667	38.000	39.000
	N1	35.000	34.000	33.667	32.333	33.750		N1	39.333	39.333	38.667	37.667	38.750
	N3	34.667	34.000	34.333	33.000	34.000		N3	38.000	39.000	38.333	37.667	38.250
H2	N0	46.000	45.333	43.000	43.667	44.500	H2	N0	46.667	47.000	47.333	47.667	47.167
	N1	45.333	44.333	44.333	41.333	43.833		N1	46.667	47.000	46.333	46.333	46.583
	N2	45.333	44.000	43.000	43.000	43.833		N2	47.000	46.333	47.000	46.333	46.667
						N Means							Means N
Interaction B×N	N0	41.000	40.167	39.000	38.833	39.750	Interaction B×N	N0	43.333	43.167	43.000	42.833	43.083
	N1	40.167	39.167	39.000	36.833	38.792		N1	43.000	43.167	42.500	42.000	42.667
	N2	40.000	39.000	38.667	38.000	38.917		N2	42.500	42.667	42.667	42.000	42.458
						H Means							Means H
Interaction B × H	H1	35.222	34.333	34.333	33.111	34.250	Interaction B × H	H1	39.111	39.222	38.556	37.778	38.667
	H2	45.556	44.556	43.444	42.667	44.056		H2	46.778	46.778	46.889	46.778	46.806
Means B		40.389	39.444	38.889	37.889		Means B		42.944	43.000	42.722	42.278	
LSD 5%	H	B	N	B×H	N×H	N×B	N×B×H	LSD 5%	H	B	N	B×H	N×H	N×B	N×B×H
	2.0839	0.5557	0.4813	1.5859	1.6407	0.9626	1.7385		1.2649	0.4542	0.3933	0.9581	0.9543	0.7867	1.2474

H1 refers to CASH hybrid and H2 refers to ROI SOLEIL hybrid. B0 refers to no bacterial fertilization, B1 refers to fertilization with *Azospirillum brasilense*, and B2 refers to fertilization with *Pseudomonas fluorescens* B3 refers to interference between the two mentioned bacteria. N0 refers to not spraying with Magnesium and Calcium, N1 refers to a concentration of 25 mg.l^{-1}, and N2 refers to a concentration of 50 mg.l^{-1} for each of the each element.

Table 2. Effect of bacterial biofertilizers and spraying with Magnesium and Calcium and the interaction between them on Number of days from planting to 50% silking (day) of sweet corn hybrids for the Fall season 2021 and the Spring season 2022

The Fall Season 2021							The Spring Season 2022						
Hybrids	Foliar Spraying	Bacterial Bio Fertilizer B0	B1	B2	B3	Interaction HxN	Hybrids	Foliar Spraying	Bacterial Bio Fertilizer B0	B1	B2	B3	Interaction H×N
H1	N0	42.667	42.000	41.667	42.000	42.083	H1	N0	49.000	48.333	48.000	48.333	48.417
	N1	41.667	42.000	42.000	41.667	41.833		N1	49.000	49.000	48.667	48.333	48.750
	N3	41.667	41.667	41.333	41.000	41.417		N3	47.667	48.333	47.667	47.667	47.833
H2	N0	56.667	54.667	54.667	55.000	55.250	H2	N0	58.667	58.667	57.667	55.667	57.667
	N1	55.667	54.333	55.667	54.333	55.000		N1	58.000	56.667	56.333	55.333	56.583
	N2	54.667	55.667	55.000	54.667	55.000		N2	58.333	56.333	55.333	55.333	56.333
						Means N							Means N
Interaction B×N	N0	49.667	48.333	48.167	48.500	48.667	Interaction B×N	N0	53.833	53.500	52.833	52.000	53.042
	N1	48.667	48.167	48.833	48.000	48.417		N1	53.500	52.833	52.500	51.833	52.667
	N2	48.167	48.667	48.167	47.833	48.208		N2	53.000	52.333	51.500	51.500	52.083
						Means H							Means H
Interaction B × H	H1	42.000	41.889	41.667	41.556	41.778	Interaction B × H	H1	48.556	48.556	48.111	48.111	48.333
	H2	55.667	54.889	55.111	54.667	55.083		H2	58.333	57.222	56.444	55.444	56.861
	Means B	48.833	48.389	48.389	48.111			Means B	53.444	52.889	52.278	51.778	
LSD	H B	N	B×H	N×H	N×B	N×B×H	LSD	H B	N	B×H	N×H	N×B	N×B×H
5%	1.2130 0.4230	0.3663	0.9163	0.9170	0.7326	1.1733	5%	1.3469 0.4065	0.3520	1.0147	1.0365	0.7041	1.1945

H1 refers to CASH hybrid and H2 refers to ROI SOLEIL hybrid

B0 refers to no bacterial fertilization, B1 refers to fertilization with *Azospirillum brasilense*, and B2 refers to fertilization with *Pseudomonas fluorescens* B3 refers to interference between the two mentioned bacteria

N0 refers to not spraying with Magnesium and Calcium, N1 refers to a concentration of 25 mg.l^{-1}, and N2 refers to a concentration of 50 mg.l^{-1} for each of the each element

seasons respectively, while non significant differences were shown in the coefficients of folier spraying with Magnesium and Calcium for both seasons. The second interaction H1B3 had significantly impact and produced 4.846 and 5.111 cm compared to H2B0 which gave 3.994 and 4.044 cm for the two seasons, respectively. H1N2 recorded 4.627 and 4.908 cm compared to the treatment H2N0 which gave 4,000 and 4.183 cm in the two seasons, respectively.Plants of the B2N2 recorded 4.445 and 4.733 cm, but, did not differed significantly from B3N2, B1N2, B2N1 and B3N0 compared to B0N0 which produced 4.022 and 4,300 cm for the two seasons, respectively. The triple interaction, H1B3N2 had significantly impact (4.877 and 5.133 cm), which did not differed significantly from treatments H1B3N1, H1B2N2 and H1B3N0 compared to H2B0N0, which gave 3.900 and 4,000 cm for the two seasons, respectively.

Number of rows.ear^{-1}

The results in Table 5 show that hybrid H1 had a significant impact in number of rows.ear^{-1} which recorded 15.661 and 17.591 rows.ear^{-1}, Compared to the H2 which gave 14.892 and 16.787 rows.ear^{-1} for the two seasons, respectively, The bacterial biofertilizers fertilizer B3 had significant impact, which gave 16.439 and 17.694 rows.ear^{-1} compared to control treatment B0 which gave 13.683 and 16.787 rows.ear^{-1} for the two seasons, respectively. The foliar spraying treatment with Magnesium and Calcium N2 had significant impact which gave of 15.950 and 17.624 rows.ear^{-1} compared to the control treatment N0, which gave 14.483 and 16.708 rows.ear^{-1} for the two seasons, respectively, The treatment of the secondary interaction H1B3 had significant effect had gave 17.278 and 18.054 rows.ear^{-1} compared to the plants of H2B0 which gave 13.078 and 16.462 rows.ear^{-1} for the two seasons, respectively. H1N2 had significantly effect with 16.508 and 17.873 rows.ear^{-1} compared to the H2N0, which gave 14.125 and 16.167 rows.ear^{-1} for the two seasons, respectively. The plants of B3N2 and B2N2 were recoreded 18.027 rows.ear^{-1}, which did not differed significantly from treatment B3N1 compared to plants of control treatment B0N0, which had 16.417 rows. ear^{-1} in the spring season. The triple interaction H1B3N2 had asignificant effect which recoreded 18.033 and 18.387 rows.ear^{-1}, but did not differed significantly from treatment H1B3N2 compared to treatment H2B0N0, which gave 11.833 and 16.000 rows.ear^{-1} for the two seasons, sequentially.

Number of grains.ear^{-1}

The results in Table 6 shows that there were no significant differences in number of grains.ear^{-1} of the two hybrids in the Fall season, but H1 hybrid recorded 573.4 grains.ear^{-1} compared to the H2 hybrid, which had 553.6 grains.ear^{-1} in the spring season, The bacterial biofertilizers B3 had significant impact, which recorded 581.3 and 612.8 grains.ear^{-1} compared to B0, gave 379.5 and 494.5 grains.ear^{-1} for the two seasons, respectively. The foliar spray treatment with Magnesium and Calcium N2 had a significant impact, which recorded 550.3 and 604.4 grains.ear^{-1} compared to the control treatment N0 gave 454.2 and 523.7 grains.ear^{-1} for the two seasons, respectively. The two interaction treatment H1B3 had significant impact, which produced 595.3 and 624.2 grains.ear^{-1} compared to the plants of H2B0, which produced 396.3 and 490.4 grains.ear^{-1} for the two seasons, respectively. The plants of treatment H1N2 recorded 560.8 and 611.6 grains.ear^{-1}, which did not differed significantly from H2N2 compared to the treatment H2N0, which gave 445.5 and 509.2 grains.ear^{-1} for the two seasons, respectively. B3N2 was recorded 623.8 and 655.0 grains.ear^{-1}, which did not differed significantly from B2N2 compared to B0N0 which had 290.3 and 453.7 grains.ear^{-1} for the two seasons, respectively. The triple interaction H1B3N2 had 636.6 and 661.9 grains.ear^{-1}, which did not differed significantly from H1B2N2, H2B3N2 and H2B2N2 compared to treatment H1B0N0

Table 3. Effect of bacterial biofertilizers and spraying with Magnesium and Calcium and the interaction between them on ear length (cm) of sweet corn hybrids for the Fall season 2021 and the Spring season 2022

The Fall Season 2021								The Spring Season 2022							
Hybrids	Foliar Spraying	Bacterial Bio Fertilizer B0	B1	B2	B3	Interaction H×N		Hybrids	Foliar Spraying	Bacterial Bio Fertilizer B0	B1	B2	B3	Interaction H×N	
H1	N0	17.000	18.333	20.167	20.500	19.000		H1	N0	15.167	15.667	17.667	17.167	16.417	
	N1	17.333	20.000	20.667	20.000	19.500			N1	15.667	16.833	17.667	18.000	17.042	
	N3	19.167	19.000	20.167	21.000	19.833			N3	16.000	17.167	18.333	19.000	17.625	
H2	N0	18.833	22.500	21.333	22.167	21.208		H2	N0	17.167	20.333	21.000	20.333	19.708	
	N1	21.833	22.000	22.333	22.667	22.208			N1	18.833	20.500	21.000	20.500	20.208	
	N2	22.500	22.500	22.667	22.000	22.417			N2	19.000	20.333	21.333	21.167	20.458	
						Means N								Means N	
Interaction B×N	N0	17.917	20.417	20.750	21.333	20.104		Interaction B×N	N0	16.167	18.000	19.333	18.750	18.062	
	N1	19.583	21.000	21.500	21.333	20.854			N1	17.250	18.667	19.333	19.250	18.625	
	N2	20.833	20.750	21.417	21.500	21.125			N2	17.500	18.75	19.833	20.083	19.042	
						Means H								Means H	
Interaction B × H	H1	17.833	19.111	20.333	20.500	19.444		Interaction B × H	H1	15.611	16.556	17.889	18.056	17.028	
	H2	21.056	22.333	22.111	22.278	21.944			H2	18.333	20.389	21.111	20.667	20.125	
Means B		19.444	20.722	21.222	21.389			Means B		16.972	18.472	19.500	19.361		
LSD	H B	N	B×H	N×H	N×B	N×B×H		LSD	H B	N	B×H	N×H	N×B	N×B×H	
5%	0.179 0.454	0.394	0.562	0.462	0.787	1.069		5%	0.830 0.458	0.3970	0.719	0.66	0.794	1.146	

H1 refers to CASH hybrid and H2 refers to ROI SOLEIL hybrid

B0 refers to no bacterial fertilization, B1 refers to fertilization with *Azospirillum brasilense*, and B2 refers to fertilization with *Pseudomonas fluorescens* B3 refers to interference between the two mentioned bacteria

N0 refers to not spraying with Magnesium and Calcium, N1 refers to a concentration of 25 mg.l^{-1}, and N2 refers to a concentration of 50 mg.l^{-1} for each of the each element

Table 4. Effect of bacterial biofertilizers and spraying with Magnesium and Calcium and the interaction between them on ear diameter (cm) of sweet corn hybrids for the Fall season 2021 and the Spring season 2022

The Fall Season 2021							The Spring Season 2022						
Hybrids	Foliar Spraying	Bacterial Bio Fertilizer B0	B1	B2	B3	Interaction H×N	Hybrids	Foliar Spraying	Bacterial Bio Fertilizer B0	B1	B2	B3	Interaction H×N
H1	N0	4.143	4.487	4.167	4.830	4.407	H1	N0	4.600	4.833	5.033	5.100	4.892
	N1	4.347	4.413	4.407	4.832	4.500		N1	4.633	4.600	4.900	5.100	4.808
	N3	4.393	4.517	4.723	4.877	4.627		N3	4.700	4.700	5.100	5.133	4.908
H2	N0	3.900	4.050	4.000	4.050	4.000	H2	N0	4.000	4.267	4.267	4.200	4.183
	N1	4.050	4.085	4.150	4.100	4.096		N1	4.067	4.300	4.233	4.300	4.225
	N2	4.033	4.100	4.167	4.150	4.112		N2	4.067	4.133	4.367	4.300	4.217
						Means N							Means N
Interaction B×N	N0	4.022	4.268	4.083	4.440	4.203	Interaction B×N	N0	4.300	4.550	4.650	4.650	4.537
	N1	4.198	4.249	4.278	4.466	4.298		N1	4.300	4.450	4.567	4.700	4.517
	N2	4.213	4.308	4.445	4.513	4.370		N2	4.300	4.417	4.733	4.717	4.562
						Means H							Means H
Interaction B × H	H1	4.294	4.472	4.432	4.846	4.511	Interaction B × H	H1	4.644	4.711	5.011	5.111	4.869
	H2	3.994	4.078	4.106	4.000	4.070		H2	4.044	4.233	4.289	4.267	4.208
Means B		4.144	4.275	4.269	4.473		Means B		4.344	4.472	4.650	4.689	
LSD	H B	N	B×H	N×H	N×B	N×B×H	LSD	H B	N	B×H	N×H	N×B	N×B×H
5%	0.281 0.122	N.S	0.221	0.213	0.211	0.318	5%	0.1062 0.0752	N.S	0.1068	0.0942	0.1302	0.1831

H1 refers to CASH hybrid and H2 refers to ROI SOLEIL hybrid. B0 refers to no bacterial fertilization, B1 refers to fertilization with *Azospirillum brasilense*, and B2 refers to fertilization with *Pseudomonas fluorescens* B3 refers to interference between the two mentioned bacteria. N0 refers to not spraying with Magnesium and Calcium, N1 refers to a concentration of 25 mg.l^{-1}, and N2 refers to a concentration of 50 mg.l^{-1} for each of the each element.

which gave 288.0 and 447.3 grains.ear^{-1}for the two seasons, respectively. The results refer to that the Bacterial biofertilization had a significant effect on plants fruit growth of sweet corn hybrids with half recomended of the fertilizer, which could be attributed to the relationship between different microorganisms and the role of the stimuli they secrete on the growth of microbial species and colonizing plants (21) and (13). The mechanisms of various PGPR bacteria differed, which could be effect acumulatively or sequentially, which include the excretion of phytohormones produced by bacteria, especially indole acetic acid, gibberellins and cytokinins (21), Which in turn increases the rates of absorption of water and minerals by the plants, thus contributing to the growth and elongation of roots and increasing the branching of root hairs (11), *Azospirillum brasilense* increases the fixation of atmospheric nitrogen on the plant, making the plant more active and more productive, as the rates of photosynthesis improve, water content increases and the size of the plant increases. plant and reduce carbon accumulation in plant leaves due to increased metabolism and (18, 20) which is reflected in the grain yield. Phosphate compounds processed by *Pseudomonas fluorescens* bacteria could be play an important role in the physiological processes inside the plant and stimulate the adventitious and fibrous roots to grow and the transfer of carbohydrates from the leaves to other parts of the plant to be used in energy production and building processes, so the plant needs phosphorus in large quantities as a second largest element after nitrogen (19). As well as fixing nitrogen as a sustainable alternative to chemical nitrogen fertilizers, and phosphorous is a source of living energy needed to carry out the process of nitrogen fixation and increases of its efficiency (7). The use of PGPR bacteria contributes to an increases in the concentration of ready elements such as nitrogen, phosphorous and potassium in the soil, thus an increases in the elements absorbed by the plants, which is positively reflected in supporting plant growth and production. The significant differences in the foliar spray treatments could be due to the importance of Magnesium, which is included in the composition of the chlorophyll molecule, which is the center of the photosynthesis process. and photosynthesis and enhances the regulation of the movement of sugars within the plant (9), Calcium fertilization also regulates the osmotic and ionic processes in cells and has an effect on the processes of pollination and fertilization, which have a direct effect on the flowering and formation of grains. In the ear, which is one of the main components of the grains yield (22), this result is consistent with Al-Khafaji, and Al-jubouri (5), in which calcium had a significant effect on reproductive biology. The importance of Magnesium and Calcium together during the flowering stage, the formation of grains, the completion and ripening of the corneas (2, 14). The differences in the interaction coefficients between the treatments of bio-bacterial fertilizers and the spraying with elements of Magnesium and Calcium in grains yield such as ear length and diameter for hybrid plants is explained by the role of the phytohormones nitrogen and phosphorous provided by the microorganisms of the plant, which contribute to increasing the efficiency of carbon metabolism and increasing its outputs represented in improving vegetative growth and then activating the transmission of these outputs with the help of Magnesium and Calcium as well as an increase in the absorbed amounts of nutrients, and the interaction between bacterial fertilization and the genotype of each plant and each plant variety differs (17). The combined experiment factors had a role in improving the vegetative growth and health status of the plant, which increased the resistance to environmental conditions and stress conditions that could be cause pollination and fertilization failure. Rather, it worked to provide the formed grains with quantities of nutrients, which positively affected the number of rows and the number of grains in the ear, which led to an increase in plant yield components.

Table 5. Effect of bacterial biofertilizers and spraying with Magnesium and Calcium and the interaction between them on Number of Rows.Ear-1 of sweet corn hybrids for the Fall season 2021 and the Spring season 2022.

The Fall Season 2021							The Spring Season 2022						
Hybrids	Foliar Spraying	Bacterial Bio Fertilizer B0	B1	B2	B3	Interaction H×N	Hybrids	Foliar Spraying	Bacterial Bio Fertilizer B0	B1	B2	B3	Interaction H×N
H1	N0	12.700	15.000	15.100	16.567	14.842	H1	N0	16.833	17.000	17.387	17.777	17.249
	N1	14.333	15.333	15.633	17.233	15.633		N1	17.167	17.433	18.000	18.000	17.650
	N3	15.833	16.300	15.867	18.033	16.508		N3	17.333	17.500	18.277	18.387	17.874
H2	N0	11.833	14.667	15.333	14.667	14.125	H2	N0	16.000	16.000	16.000	16.667	16.167
	N1	13.667	15.333	15.867	15.767	15.158		N1	16.443	16.500	16.667	17.667	16.819
	N2	13.733	15.833	15.633	16.367	15.392		N2	16.943	17.110	17.777	17.667	17.374
						Means N							Means N
Interaction B×N	N0	12.267	14.833	15.217	15.617	14.483	Interaction B×N	N0	16.417	16.500	16.693	17.222	16.708
	N1	14.000	15.333	15.750	16.500	15.396		N1	16.805	16.967	17.333	17.833	17.235
	N2	14.783	16.067	15.750	17.200	15.950		N2	17.138	17.305	18.027	18.027	17.624
						Means H							Means H
Interaction B × H	H1	14.289	15.544	15.533	17.278	15.661	Interaction B × H	H1	17.111	17.311	17.888	18.054	17.591
	H2	13.078	15.278	15.611	15.600	14.892		H2	16.462	16.537	16.814	17.333	16.787
Means B		13.683	15.411	15.572	16.439		Means B		16.787	16.924	17.351	17.694	
LSD	H B	N	B×H	N×H	N×B	N×B×H	LSD	H B	N	B×H	N×H	N×B	N×B×H
5%	0.723 0.556	0.482	0.772	0.673	0.963	1.346	5%	0.395 0.318	0.276	0.437	0.379	0.552	0.769

H1 refers to CASH hybrid and H2 refers to ROI SOLEIL hybrid

B0 refers to no bacterial fertilization, B1 refers to fertilization with *Azospirillum brasilense*, and B2 refers to fertilization with *Pseudomonas fluorescens* B3 refers to interference between the two mentioned bacteria

N0 refers to not spraying with Magnesium and Calcium, N1 refers to a concentration of 25 mg.l^{-1}, and N2 refers to a concentration of 50 mg.l^{-1} for each of the each element

Table 6. Effect of bacterial biofertilizers and spraying with Magnesium and Calcium and the interaction between them on The Number of Grains in The Ear of sweet corn hybrids for the Fall season 2021 and the Spring season 2022

The Fall Season 2021							The Spring Season 2022						
Hybrids	Foliar Spraying	Bacterial Bio Fertilizer B0	B1	B2	B3	Interaction H×N	Hybrids	Foliar Spraying	Bacterial Bio Fertilizer B0	B1	B2	B3	Interaction H×N
H1	N0	292.7	497.3	492.7	568.6	462.8	H1	N0	460.0	532.7	567.9	592.4	538.2
	N1	411.7	516.0	553.4	580.6	515.4		N1	503.7	563.8	600.0	618.2	571.4
	N3	464.8	565.0	576.9	636.6	560.8		N3	532.0	603.7	648.8	661.9	611.6
H2	N0	288.0	481.0	495.0	518.0	445.5	H2	N0	447.3	485.3	554.7	549.7	509.2
	N1	388.7	505.7	528.8	573.0	499.0		N1	498.7	517.7	594.3	606.3	554.3
	N2	431.2	559.2	557.8	611.0	539.8		N2	525.1	576.1	640	648.0	597.3
Interaction B×N						Means N	Interaction B×N						Means N
	N0	290.3	489.2	493.8	543.3	454.2		N0	453.7	509.0	561.3	571.0	523.7
	N1	400.2	510.8	541.1	576.8	507.2		N1	501.2	540.7	597.2	612.2	562.8
	N2	448.0	562.1	567.4	623.8	550.3		N2	528.5	589.9	644.4	655.0	604.4
Interaction B × H						Means H	Interaction B × H						Means H
	H1	389.7	526.1	541.0	595.3	513.0		H1	498.6	566.7	605.6	624.2	573.8
	H2	369.3	515.3	527.2	567.4	494.8		H2	490.4	526.4	596.3	601.3	553.6
Means B		379.5	520.7	534.1	581.3		Means B		494.5	546.5	600.9	612.8	
	H B	N	B×H	N×H	N×B	N×B×H		H B	N	B×H	N×H	N×B	N×B×H
LSD 5%	N.S 33.33	28.86	44.52	38.08	57.73	79.91	LSD 5%	16.02 15.59	13.50	20.60	17.52	27.00	37.27

H1 refers to CASH hybrid and H2 refers to ROI SOLEIL hybrid

B0 refers to no bacterial fertilization, B1 refers to fertilization with *Azospirillum brasilense*, and B2 refers to fertilization with *Pseudomonas fluorescens* B3 refers to interference between the two mentioned bacteria

N0 refers to not spraying with Magnesium and Calcium, N1 refers to a concentration of 25 mg.l^{-1}, and N2 refers to a concentration of 50 mg.l^{-1} for each of the each element

Environmental factors had effected on the growth and productivity of hybrids, and the difference in the genetic response to the characteristics of the plant and the yield according to the influence of the environment in which that hybrid is planted, while the differences in the studied qualities of the hybrids of sweet corn may be due to the genetic difference between the two hybrids (American and Dutch) (15), and this indicates the importance and necessity of introducing and selecting different hybrids and generalizing the cultivation of the superior ones suitable for the conditions of cultivation in Iraq, pending the development of local varieties or hybrids.

REFERENCES

1. Abbas, M.; A. Hashim, and S. Mohamed. 2021. Ameliorative effects of calcium sprays on yield and grain nutritional composition of maize (*Zea mays* L.) cultivars under drought stress. Agriculture, 11(4): 285-298. Doi: 10.3390/agriculture11040285.

2. Al-Mharib, M. Z. K., M. M. A. Alrawi, A. R. Naser, A. M. Alwan and M J. Farhan .2021. Effect of foliar spray with magnesium and boron on growth and yield of broad bean. International Journal of Agricultural and Statistical Sciences, 17: 1787–1792.

3. Al-Khafaji, A. M.H. H., K D. H. Al-jubouri, F. Y. Baktash, I. J. Abdul Rasool, and Z. J. Al-Mousawi. 2024. Amelioration potato plant performance under drought conditions in iraq by using titanium dioxide, and biodegrading, biodegradable treatments. Iraqi Journal of Agricultural Sciences, 55(6), 1885-1893. https://doi.org/10.36103/03fway21

4. Al-Khafaji, A. M. H. H., and K. D. H. Al-jubouri. 2024. Individual and interactive utility of biological and physical invigoration for various carrots seeds orders and study their field performance. Iraqi Journal of Agricultural Sciences, 55(4) :1566-1573. https://doi.org/10.36103/66873c67

5. Aseel M.H. H. Al-Khafaji, and K. D. H. Al-jubouri. 2024. Developmental control of some physiological factors on reproductive biology and rudimentary embryos phenomenon in carrot seeds . Iraqi Journal of Agricultural Sciences, *55*(3), 1038-1047. https://doi.org/10.36103/zvrre033

6. Al-Sahoki, M. and K. M. Waheeb. 1990. Applications in The Design and Analysis of Experiments, Ministry of Higher Education and Scientific Research, University of Baghdad, pp: 488.

7. Al-Samarrai, I. K. and F. M. S. Al-Tamimi. 2018. Soil Microbiology Concepts and Applications. The Republic of Iraq. Ministry of Higher Education and Scientific Research. Diyala University. pp: 516.

8. Aslam, M. R. ; M. Muhammad., A. Zahoor., A. Sajjad, R. Muhammad., and U. H. Muhammad. 2018. Effect of foliar applied magnesium sulphate and irrigation scheduling on quality and yield of maize hybrid. Pakistan Journal of Agricultural Research. 31(2): 173-179. DOI: 10.17582/journal.pjar/2018/31.2.173.179

9. Cakmak, I.; and A. M. Yazici,; 2010. Magnesium: a forgotten element in crop production. Better Crops. 94(2): 23-25. DOI: 10.1094/BC-2010-2-023

10. Chu, T.N.; B. Le Van,; and H. Minh,; 2020. Pseudomonas PS01 isolated from maize rhizosphere alters root system architecture and promotes plant growth. Micro organisms 8(4): 471. DOI: 10.3390/microorganisms8040471

11. Dardanelli, M. S.;F. J. F. Córdoba,; de; M. R. Espuny,; M. A. R. Carvajal,; M. E. S. Díaz,; A. M. G. Serrano,; Y. Okon,; and M. Megías,; 2008. Effect of *Azospirillum brasilense* coinoculated with rhizobium on *Phaseolus vulgaris* flavonoids and nod factor production under salt stress. Soil Biology And Biochemistry. 40(11):2713-2721. https://doi.org/10.1016/j.soilbio.2008.06.016

12. El-Gizawy, N.K.B.; and S.A.S. Mehasen. 2009. Response of faba bean to bio, mineral phosphorus fertilizers and foliar application with zinc. World Applied Sciences Journal 6(10): 1359-1365. DOI: 10.5829/idosi.wasj.2009.6.10.1125

13. Fukami, J.; M. A. Nogueira,; R. S. Araujo,; and M. Hungria,; 2016. Accessing inoculation methods of maize and wheat with *Azospirillum brasilense*. AMB express. 6(1):3-16. https://doi.org/10.1186/s13568-015-0171-y

14. Gaj R., A. Budka,; D. Górski,; K. Borowiak,; A. Wolna-Maruwka, and K. Bąk; 2018. Magnesium and calcium distribution in maize under differentiated doses of mineral

fertilization with phosphorus and potassium. J. Elem., 23(1): 137-150.
DOI: 10.5601/jelem.2017.22.1.1420
15. Hallauer, A. R. 1990. Methods used in developing maize inbreds" Maydica 35(1): 1-16. DOI: 10.1007/BF00037906
16. Hassan, A .2004. The Production of Secondary and Non-Traditional Vegetables, Part 3. The Arab House for Publishing and Distribution. Cairo, pp. 424.
17. Lana, M. C. do; J. Dartora,; D. Marini,.and J. E. H. Hann,. 2012. Inoculation with Azospirillum, associated with nitrogen fertilization in maize. Revista Ceres, 59(3):399-405.
DOI: 10.1590/S0034-737X2012000300016
18. Pankievicz; V.; F. P. do Amaral; K. Santos,; and M. Schueller,; 2015. Robust biological nitrogen fixation in a model grass-bacterial association. The Plant Journal. 81(6):907-19. DOI: 10.1111/tpj.12777
19. Pereira, N.C.M, F.S Galindo; R.P.D Gazola; E. Dupas, P.A.L Rosa., E.S. Mortinho, and M.C.M.Teixeira Filho; 2020. Corn yield and phosphorus use efficiency response to phosphorus rates associated with plant growth promoting bacteria. Front. Environ. Sci. 8(40): 1-12. DOI: 10.3389/fenvs.2020.00040
20. Saeed, N. Dheyab, A M.H. H. Al-Khafaji, I. J. Abdul Rasool, K. D. H. Al-jubouri, F. Y. Baktash, Z. J. Al-Mousawi, and D. A. Hanoon. 2025. Reducing water consumption and improving soil, root quality of potato via environmentally sustainable treatments. Iraqi Journal of Agricultural Sciences, 55(special):1-9.
https://doi.org/10.36103/przef771
21. Spaepen, S.; S., Dobbelaere; A., Croonenborghs, and J. Vanderleyden. 2008. Effects of *Azospirillum brasilense* indole-3-acetic acid production on inoculated wheat plants. Plant and Soil, 312(1): 15-23.
DOI: 10.1007/s11104-008-9560-1
22. White P. J., and M. R. Broadley; 2003. Calcium in plants. Ann.Bot., 92(4): 487-511.
DOI: 10.1093/aob/mcg164
23. Wasan, S. M. K. and A. W. A. Al-Juboori. 2023. Effect of biofertilizers and spraying with magnesium and calcium on vegetative growth indicators of sweet corn. IOP Conf. Ser.: Earth Environ. Sci. 1225 012031.
DOI 10.1088/1755-1315/1225/1/012031
24. Wang, Y., Zhang, W., & Li, C. (2016). Effects of biofertilizer containing nitrogen-fixing bacteria on maize yield and nitrogen uptake. Journal of Plant Nutrition and Soil Science, 179(3), 377–383.
https://doi.org/10.1002/jpln.201500589
25. Wu, S. C., Z. Cao, H., Z. Li, G., K. C. Cheung, and M. H. Wong, 2005. Effects of biofertilizer containing N-fixer, P and K solubilizers and AM fungi on maize growth: A greenhouse trial. Geoderma, 125(1–2), 155–166.
https://doi.org/10.1016/j.geoderma.2004.07.003
26. Wani, S. P., and K. K. Lee,(1995. Biofertilizers for sustaining cereal crops production. Proceedings of the Indian National Science Academy, 61(3), 91–108.
27. Wu, F., Li, J., and S. Wu, 2018. Effects of bio-organic fertilizer on pepper growth and Fusarium wilt biocontrol. Scientia Horticulturae, 235, 379–388.
https://doi.org/10.1016/j.scienta.2018.03.033
28. Wang, R., L. Zhang, and L. Sun, 2019. Application of biofertilizer containing Bacillus subtilis reduces the nitrogen loss in agricultural soil. Applied Soil Ecology, 138, 123–128.
https://doi.org/10.1016/j.apsoil.2019.02.017
29. Zahir, Z. A., M. Arshad, and W. T. Frankenberger, 2004. Plant growth promoting rhizobacteria: Applications and perspectives in agriculture. Advances in Agronomy, 81, 97–168.
https://doi.org/10.1016/S0065-2113(03)81003-9
30. Zhang, F., G. Yang, and Y. Zhang, 2018. Trichoderma biofertilizer links to altered soil chemistry, altered microbial communities, and improved grassland biomass. Frontiers in Microbiology, 9, 1-10.
https://doi.org/10.3389/fmicb.2018.01061
31. Zeynu, S., and T. Rezika, 2021. Production of nitrogen-fixing and phosphorus-solubilizing liquid bio-fertilizer for the improvement of crop growth and yield. *Modern Chemistry*, *9*(3), 25–32.
https://doi.org/10.11648/j.mc.20210903.13