

EFFICIENCY OF USING BIOFERTILIZATION IN REDUCING NITROGEN FERTILIZER APPLICATION AND THEIR EFFECT ON GERMINATION, GROWTH AND YIELD OF MAIZE (*Zea mays* L.)

Aml E. A. El-Saidy and F. I. Yousof

Department of Seed Tech. Res., Field Crops Res. Institute, ARC, Giza

ABSTRACT

A laboratory study was designed to investigate the influence of seed inoculation treatments with cerialein (*Azospirillum brasilense*), phosphorein (*Bacillus megaterium*) and mixture from both on germination and seed vigor of maize (SH. 166 cultivar, yellow kernel) as compared with uninoculated seed during 2012 season. Also, field experiments were conducted to evaluate efficiency of *Azospirillum brasilense* (Ab), *Bacillus megaterium* (Bm) and mixture from both in reducing nitrogen fertilizer levels (120, 90, 60, 30 kg N/fed and without N application as a control) and their effect on emergence, growth and yield during 2012 and 2013 seasons. The results indicated that seed inoculated with combination of *Azospirillum brasilense* & *Bacillus megaterium* significantly increased seed vigor as compared with uninoculated seed. The results showed the role of *Azospirillum brasilense* & *Bacillus megaterium* in enhancing and promoting germination, activation seed vigor and development of maize. The results revealed that seed inoculated with *Azospirillum brasilense* & *Bacillus megaterium* and adding 90 kg N/fed produced good growth and yield approaching 120 kg N/fed without significant differences between both. The lowest values of growth and yield were obtained from the uninoculated treatment and without nitrogen fertilization. It could be concluded that seed inoculated with *Azospirillum brasilense* and *Bacillus megaterium* beside addition 90 kg N/fed achieved high productivity of maize.

Keywords: *Zea mays* L., biofertilization, nitrogen fertilizer, germination, field emergence, growth and yield

INTRODUCTION

Nitrogen and phosphorus are essential nutrients required by both plants and microorganisms, their major physiological roles are the accumulation and release of energy during cellular metabolism (Marchner, 1995). In Egypt, chemical fertilizers, especially nitrogen fertilizer has become an economic problem for farmers because they become more expensive, in addition to its environment pollution. So, it was an urgent need to reduce chemical fertilizers and provide alternatives as biofertilizer technique. Increases in plant growth have been attributed either to nitrogen fixation by the associated bacteria or to an increase in the absorbing surface of the root system due to growth substances produced by the bacteria, inoculation of plants with *Azospirillum* could result in significant changes in various growth parameters such as increase in plant biomass, nutrient uptake, tissue N content, plant height, leaf size and root length of cereals (Bashan *et al.*, 2004). Maize seed inoculation with *Azospirillum lipoferum* DSM 1691, *Abrasilense* DSM 1690 significantly enhanced seed germination and seedling

vigor, bacterial treatments had a more stimulating effect on growth and development of plants and significantly increased plant height, 100 seed weight, number of seeds per ear and leaf area, the results also showed significant increase in ear and shoot dry weight of maize (Gholami *et al.*, 2009).

Phosphorus is generally deficient in most natural soils, because it is fixed as water-insoluble iron and aluminum phosphates in acidic soils or calcium phosphate in alkaline soils (Singh and Kapoor, 1994). However, calcium phosphate, which is of low solubility, can be dissolved and made available to plants by soil rhizosphere microorganisms through the production of organic acids (Rodriguez and Fraga, 1999). The inoculation of seed with phosphate solubilizing microorganisms may alleviate this problem.

Therefore, a promising trend for increasing nitrogen and phosphorus availability to plants has been increased using combined inoculation of nitrogen fixing and P-dissolving organisms. There have been many successful attempts to improve plant development by using mixtures of *Azospirillum* and VA mycorrhiza (Alarcon *et al.*, 2002). Similarly, the combined inoculation of *Azospirillum* and P-solubilizing bacteria was successfully used for plant N, P nutrition and growth yield (Belimov *et al.*, 1995).

This study was aimed to evaluate the efficiency of inoculation with *Azospirillum brasilense* and *Bacillus megaterium* in reducing nitrogen fertilizer for alleviation soil pollution.

MATERIALS AND METHODS

Laboratory experiment was implemented at Seed Technology Research Unit Mansoura, Dakahlia Governorate, Seed Technology Research Department, Field Crop Research Institute, Agricultural Research Center during 2012 season to evaluate the effect of seed inoculation treatments with cerialein (*Azospirillum brasilense*), phosphorein (*Bacillus megaterium*) and combination of both on germination behavior and seedlings vigor of maize (SH. 166 cultivar) single hybrid cross 166 which is a yellow kernel. A completely randomized design with four replicates was used. Field experiments were conducted at the experimental Farm of Tag AL - Ezz, Agric. Res. Station, ARC, Dakahlia Governorate, Egypt during 2012 and 2013 seasons to evaluate efficiency using of biofertilization and nitrogen fertilizer levels and their interactions on growth and yield of maize (SH. 166 cultivar). A strip plot design as factorial with two factors at four replicates was used in each season and combining analysis for two seasons was done. The horizontal plots were devoted to the four biofertilization treatments, i.e. inoculated with *Azospirillum brasilense* (Ab), inoculated with *Bacillus megaterium* (Bm), inoculated with mixture from *Azospirillum brasilense* & *Bacillus megaterium* and uninoculated seed. The vertical plots were devoted to the nitrogen fertilizer levels (120, 90, 60, 30 kg N/fed and without N application as a control).

Seed treatments:

Seed sample of maize was divided into four parts. One part was inoculated with cerialein (*Azospirillum brasilense*). Second part was inoculated with phosphorein (*Bacillus megaterium*). Third part was inoculated with mixture from *Azospirillum brasilense* (Ab) & *Bacillus megaterium* (Bm). Fourth part was uninoculated seed as a control. Using Arabic gum as sticker agent during inoculation seed with different biofertilization treatments. The rates of cerialein and phosphorein both (10^8 CFU/mL) were 120 and 300 g /fed, respectively for field experiments.

Laboratory experiment:

Four hundred seeds from each treatment were placed in eight sterilized Petri dishes (15 × 1.5 cm) on Whatman No.1 filter paper that was moistened with 10 ml of water. Each Petri-dish kept close together and incubated at 25 ± 2 °C, with a 12 h photoperiod and 70 % relative humidity, then, four replications were used to evaluate subjected to standard germination test as the rules of International Seed Testing Association (ISTA, 1999).

Seed and seedlings vigor characters:

Counts of germinating seeds were taken daily up to 7 days after the start of germination. Speed germination index (SGI), germination rate (GR), Co-efficient of germination, germination percentage, root length (cm), shoot length (cm) and seedlings dry weight (gm) were determined in this experiment.

1-SGI was calculated as described in the Association of Official Seed Analysis (AOSA, 1983) by following formula:

$$SGI = \frac{\text{number of germinated seed}}{\text{days of first count}} + \dots + \frac{\text{number of germinated seed}}{\text{days of final count}}$$

Seeds were considered germinated when the radicle was at least 2 mm. long.
2- Germination rate (GR) was defined according to the following formula of Bartlett, 1937.

$$GR = \frac{a + (a + b) + (a + b + c) \dots \dots (a + b + c + m)}{n (a + b + c + m)}$$

Where a, b, c are number of seedlings in the first, second and third count, m is the number of seedlings in the final count and n is the number of counts.

3- Co-efficient of germination (CG) was calculated using the following formula (Copeland, 1976).

$$\text{Co-efficient of germination} = \frac{100 (A_1 + A_2 + \dots \dots A_n)}{A_1 T_1 + A_2 T_2 + \dots \dots A_n}$$

Where,

A = Number of seeds germinated.

T = Time (days) corresponding to A.

n = No. of days to final count.

4- Germination percentage was defined as the total number of normal seedlings at the end of the test after seven days and then seedling characters were taken.

Field experiments:

The soil was clay loam and characterized by pH, 8; E.C, 3.0 dS/m. wheat (*Triticum aestivum* L.) was the preceding winter crop in all seasons of experimentation. The experimental field well prepared through two ploughing, leveling, compaction, ridging and divided into the experimental units. Seeds of maize were inoculated with the bacterial as mentioned before. Uninoculated seeds as control (without biofertilization) were also included. Five-ridges of plot were prepared with ridge width and length space of 0.7 and 3.0 m, respectively to gave (3.5 × 3.0) 10.5 m² for plot area. Maize seeds were sown on 5th and 15th May in 2012 and 2013 seasons, respectively. Seeds were sown in hills spaced of 30 cm apart with two seed/hill at 5 cm depth at a rate of 10 kg /fed. At three leaves stage plants were thinned to one plant per hill. Nitrogen fertilizer in the form of urea (46.5 % N) at the different rates under study (120, 90, 60, 30 kg N/fed and without N application as a control) was added in two equal portions after 21 (after thinning to one plant /hill before the first irrigation) and 36 days from planting (before second irrigation). Calcium Superphosphate (15.5% P₂O₅) and Potassium Sulphate (48 % K₂O) was added at the rate of 200 kg/fed and 50 kg/fed , respectively on the dry soil before ploughing. Other cultural practices for growing maize were conducted as recommended by Ministry of Agricultural and Land Reclamation.

Studied characters

Field emergence, growth and yield characters:

Field emergence percent was determined after 7 days from planting and emergence index was calculated using the formula of Scott *et al.*, 1984:

$$EI = \{TiNi/S\}.$$

where Ti is the number of days after sowing, Ni is the number of seeds germinated on day i, and S is the total number of seeds planted.

At harvesting time, the inner ridges were chosen from each plot to determine the plant height (cm), ear leaf area (cm²), plant dry weight (g), ear length (cm), ear diameter (cm), ear weight (g) , number of rows/ear, number of grains/row and grain yield (kg /fed).

Statistical analysis:

All obtained data of characters were subjected to the statistical analysis according to the technique of analysis of variance (ANOVA) of completely randomized design and strip plot design for laboratory and field experiment, respectively, as described by Gomez and Gomez (1984).

RESULTS

Seed and seedling vigor measurements:

Seed germination percentage, speed germination index and germination rate of maize inoculated with *Azospirillum brasilense* (Ab) or *Bacillus megaterium* (Bm) alone or in combination of both, are shown in Fig.1. Inoculation with mixture from *Azospirillum brasilense* and *Bacillus megaterium* enhanced germination %, as compared with control

(uninoculated seeds). In other words, germination percentage of control seeds was lower as compared with inoculated seed. Such results indicate that *Azospirillum brasilense* and *Bacillus megaterium* have promotion effects in early growth stages. Also, faster germination and early seedling growth were obtained by inoculated with mixture from *Azospirillum brasilense* and *Bacillus megaterium* as shown in speed germination index and germination rate characters supporting the potential role of bacterial growth regulators in enhancing germination rate and early development of plant structures. At contrary uninoculation maize seed with bacteria showed slower germination as compared with inoculated seed. The obtained results stated the role of biological fertilizers in stimulation and improvement field emergence and seedling vigor.

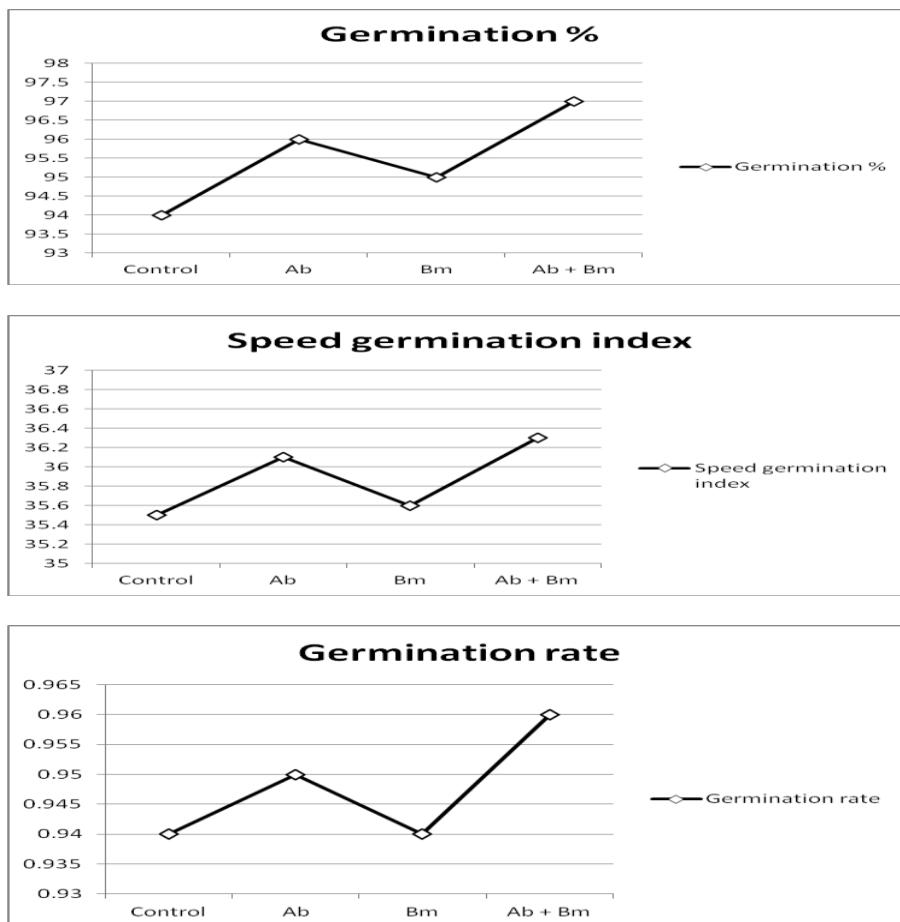


Fig.1: Germination %, speed germination index and germination rate of maize seed as affected by inoculation with *Azospirillum brasilense* (Ab), *Bacillus megaterium* (Bm) and mixture of both.

Fig. 2 showed increment in co-efficient of germination, field emergence and index emergence of maize seed inoculated with combination of *Azospirillum brasilense* & *Bacillus megaterium* as compared with uninoculated seed. Hence, uninoculated seed recorded the lowest values of aforementioned characters. Increasing the speed of germination by inoculation seed with *Azospirillum brasilense* & *Bacillus megaterium* led to longer root length, shoot length and heavier seedling dry weight as compared with uninoculated seed as illustrated in Fig.3.

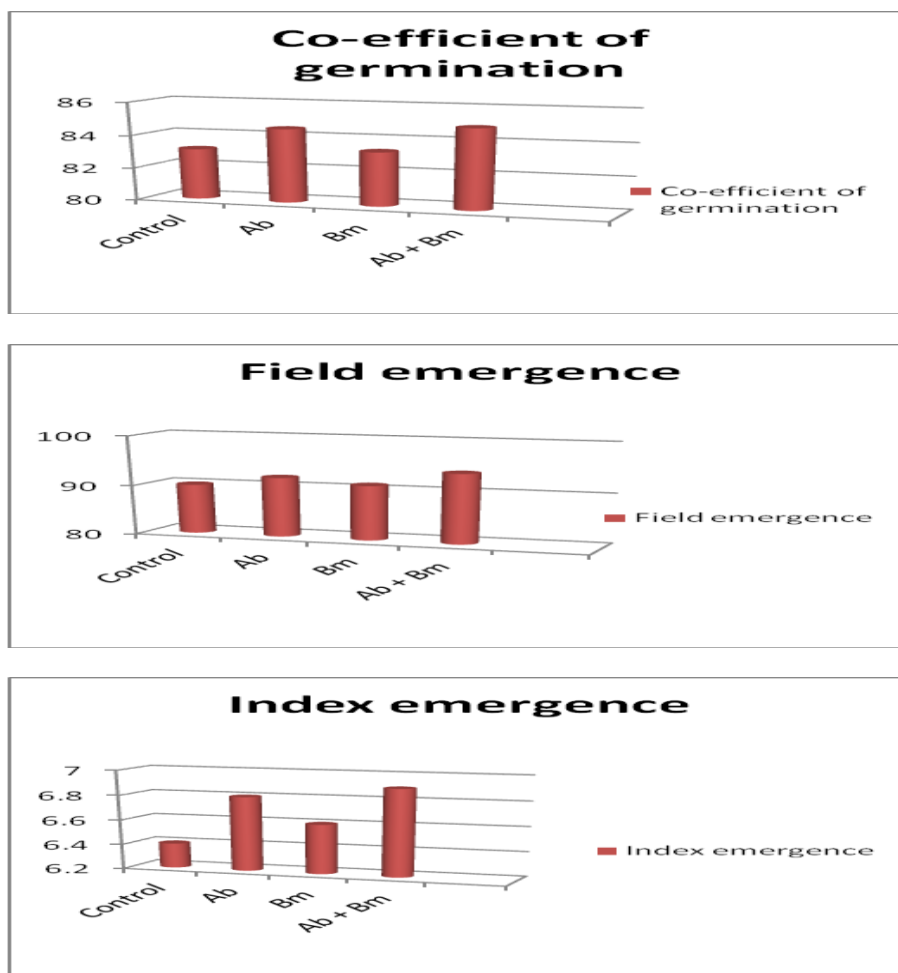


Fig.2: Co-efficient of germination, field emergence and index emergence of maize seed as affected by inoculation with *Azospirillum brasilense* (Ab), *Bacillus megaterium* (Bm) and mixture of both.

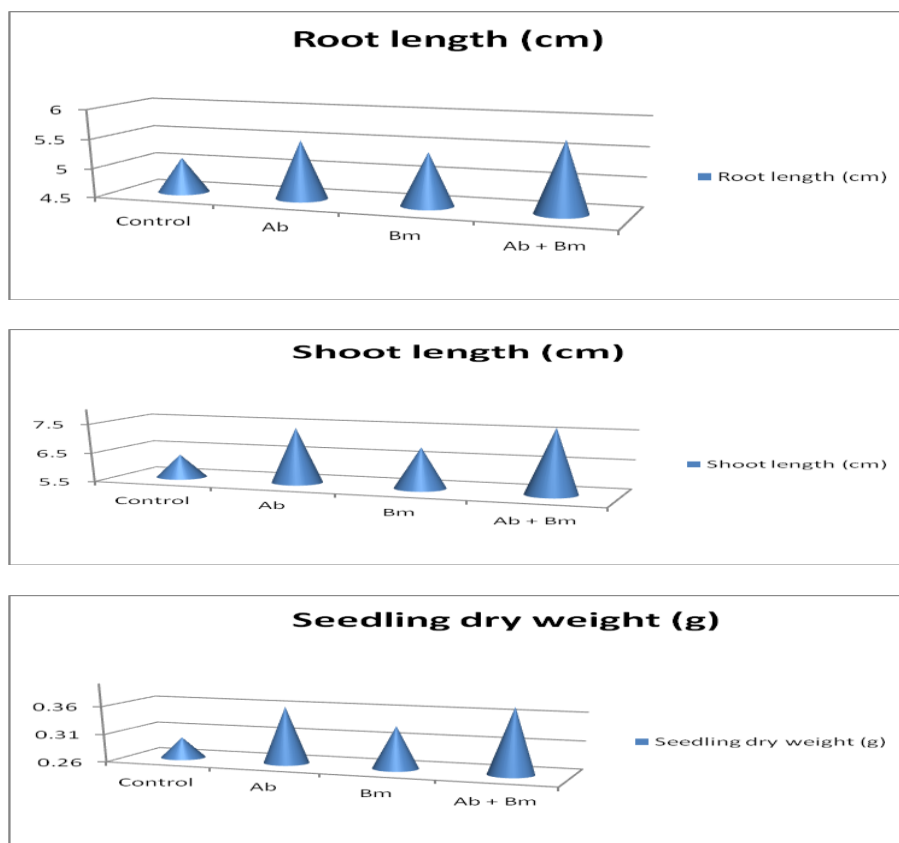


Fig.3: Root length (cm), shoot length (cm) and seedling dry weight (g) of maize seed as affected by inoculation with with *Azospirillum brasilense* (Ab), *Bacillus megaterium* (Bm) and mixture of both.

Field experiments:

Results in Tables (1,2 and 3) revealed that plant height (cm), ear leaf area (cm²), plant dry weight (g), ear length (cm), ear weight (g), number of grains/row and grain yield (kg/fed) significantly affected by biofertilizers inoculation of maize seed.

Whereas, the combination of *Azospirillum brasilense* & *Bacillus megaterium* achieved the highest values of aforementioned characters of Tables (1, 2 and 3), followed by *Azospirillum brasilense*, then by *Bacillus megaterium*. Otherwise, uninoculated maize seed recorded the lowest values of all aforementioned characters as could be seen in Tables (1, 2 and 3). Regarding to nitrogen fertilizer effect, the full dose of nitrogen fertilization (120 kg N/fed) showed the best results of growth and yield attributes as shown in Tables (1,2 and 3), followed the application of 90 kg/fed of nitrogen fertilizer. The lowest results of previously characters were obtained by (without nitrogen fertilizer) treatment, regarding the combined analysis.

Table 1: Plant height (cm), ear leaf area (cm²) and plant dry weight (g) characters of SH 166 maize cultivar as affected by biofertilization and nitrogen fertilizer levels in both seasons and combined data.

Characters	Seasons			Ear leaf area (cm ²)			Plant dry weight (g)		
	2012	2013	Comb.	2012	2013	Comb.	2012	2013	Comb.
Biofertilization treatments (B):									
Inoculation with Ab	195.4	200.6	198.0	193.9	198.6	196.3	309.8	320.6	315.2
Inoculation with Bm	191.0	198.6	194.8	186.7	193.1	189.9	308.5	316.7	312.6
Inoculation with Ab & Bm	197.0	203.2	200.1	201.6	206.0	203.8	320.7	326.5	323.6
Uninoculation	189.6	196.8	193.2	183.1	187.6	185.3	304.8	313.2	309.0
F. test	**	**	**	**	**	**	**	**	**
LSD at 5 %	0.9	1.8	1.4	1.3	2.6	2.3	1.2	2.3	1.8
Nitrogen fertilizer levels (N):									
120 kg N/fed	210.0	214.0	212.0	232.6	238.2	235.4	337.6	344.4	341.0
90 kg N/fed	203.5	209.5	206.5	213.9	217.8	215.9	327.8	334.8	331.3
60 kg N/fed	189.0	196.0	192.5	181.9	187.6	184.8	304.0	310.0	307.0
30 kg N/fed	184.0	191.6	187.8	168.4	173.2	170.8	294.1	305.5	299.8
Without nitrogen fertilizer	179.5	188.5	184.0	159.9	164.8	162.4	291.2	301.5	296.3
F. test	**	**	**	**	**	**	**	**	**
LSD at 5 %	0.8	2.8	0.9	1.1	3.8	1.5	1.1	3.5	1.2
Interactions of (B × N)	**	**	**	**	**	**	**	**	**

* =significant ** = high significant NS= Non significant

Table 2: Ear length (cm), ear diameter (cm) and ear wight (g) characters of SH 166 maize cultivar as affected by biofertilization and nitrogen fertilizer levels in both seasons and combined data.

Characetrs	Seasons			Ear diameter (cm)			Ear weight (g)		
	2012	2013	Comb.	2012	2013	Comb.	2012	2013	Comb.
Biofertilization treatments (B):									
Inoculation with Ab	22.1	23.3	22.7	14.6	14.6	14.6	140.5	146.1	143.3
Inoculation with Bm	21.9	22.3	22.1	14.3	14.5	14.4	138.3	144.5	141.4
Inoculation with Ab & Bm	23.0	23.8	23.4	14.6	14.8	14.7	142.0	148.0	145.0
Uninoculation	21.8	22.2	22.0	14.3	14.5	14.4	135.5	143.9	139.7
F. test	**	**	*	NS	NS	NS	**	**	**
LSD at 5 %	0.4	0.6	0.6	-	-	-	0.8	1.2	1.2
Nitrogen fertilizer levels (N):									
120 kg N/fed	23.6	25.0	24.3	15.4	15.6	15.5	163.2	171.2	167.2
90 kg N/fed	23.3	23.5	23.4	15.0	15.4	15.2	160.5	163.9	162.2
60 kg N/fed	21.6	23.2	22.4	14.5	14.9	14.7	143.4	150.8	147.1
30 kg N/fed	21.5	21.8	21.6	14.0	14.1	14.1	125.9	132.7	129.3
Without nitrogen fertilizer	20.9	21.3	21.1	13.1	13.3	13.2	102.4	109.8	106.1
F. test	**	**	**	**	**	**	**	**	**
LSD at 5 %	0.4	0.9	0.4	0.4	0.7	0.5	0.7	1.8	0.8
Interactions of (B × N)	*	*	*	NS	NS	NS	**	**	**

* =significant ** = high significant NS= Non significant

Table 3: Number of rows/ear, number of grains/row and grain yield (kg/fed) characters of SH 166 maize cultivar as affected by biofertilization and nitrogen fertilizer levels in both seasons and combined data.

Characters	Seasons			Seasons			Seasons		
	2012	2013	Comb.	2012	2013	Comb.	2012	2013	Comb.
Biofertilization treatments (B):									
Inoculation with Ab	14.2	15.0	14.6	33.9	37.3	35.6	2827.7	2867.9	2847.8
Inoculation with Bm	13.0	15.0	14.0	33.8	37.2	35.5	2804.2	2850.3	2827.2
Inoculation with Ab & Bm	14.4	15.2	14.8	36.3	36.9	36.6	2860.0	2910.4	2885.2
Uninoculation	13.0	15.0	14.0	33.0	36.0	34.5	2780.9	2824.7	2802.8
F. test	NS	NS	NS	*	*	*	**	**	**
LSD at 5 %	-	-	-	0.1	0.2	0.2	7.5	11.0	10.5
Nitrogen fertilizer levels (N):									
120 kg N/fed	15.0	17.0	16.0	36.8	39.6	38.2	3120.4	3246.6	3183.5
90 kg N/fed	14.6	16.0	15.3	35.1	37.9	36.5	3110.5	3148.9	3129.7
60 kg N/fed	13.8	15.2	14.5	34.2	36.4	35.3	2820.8	2826.8	2823.8
30 kg N/fed	13.4	13.7	13.5	33.8	35.6	34.7	2702	2717.6	2709.8
Without nitrogen fertilizer	12.0	13.0	12.5	31.3	34.5	32.9	2342.5	2371.3	2356.9
F. test	**	**	*	**	**	**	**	**	**
LSD at 5 %	0.8	0.9	0.8	0.1	0.3	0.1	6.8	16.4	7.0
Interactions of (B × N)	NS	NS	NS	*	*	*	**	**	**

* =significant ** = high significant NS= Non significant

The interaction effects between biofertilizers and nitrogen fertilizers on plant height (cm), number of grains/row and grain yield/fed (kg) are shown in Fig.4.

It is clear that the nitrogen fertilizer level (120 kg /fed) recorded the highest values of growth and yield measurement as could be noticed in Fig. 4. But, inoculation with combination of *Azospirillum brasilense* & *Bacillus megaterium* and adding 90 kg N/fed succeeded to be approximately equivalent it , at plant height and number of grains/row characters. However, no significant differences could be detected between the application 120 kg N/fed level and (90 kg N/fed + combination of *Azospirillum brasilense* & *Bacillus megaterium*) at grain yield/fed, regarding the interaction between biofertilization and nitrogen treatments. On the other direction, the interaction between both control treatments (uninoculation + without N application) recorded the lowest values of these characters as illustrated in Fig.4.

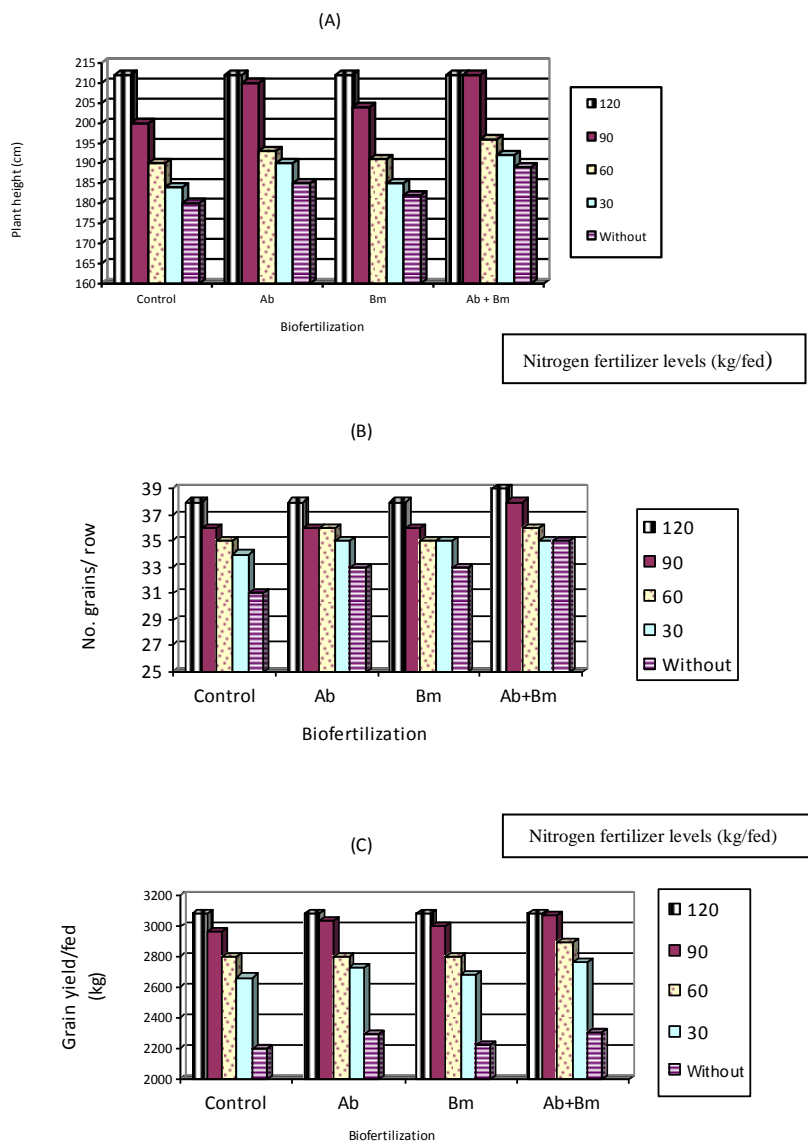


Fig. 4: Effect of the interactions between *Azospirillum brasilense* (Ab), *Bacillus megaterium* (Bm) and nitrogen fertilizer levels on (A) plant height (cm), (B) number of grains/row and (C) grain yield/fed (kg) over both seasons.

DISCUSSION

Results of this study indicated that inoculation maize seed of SH 166 cultivar with *Azospirillum brasilense* or *Azospirillum brasilense* & *Bacillus megaterium* made enhancement in germination characters. It may be due to that *Azospirillum spp.* are known for their ability to produce plant hormones, as well as polyamines and amino acids in culture media (Thuler *et al.*, 2003). Among these hormones, indoles, mainly indole-3-acetic acid (IAA); Spaepen *et al.*, 2007), and gibberellins (GAs) of several kinds (Bottini *et al.*, 2004) may play a larger role. These phytohormones alter metabolism and morphology of plants, leading to better absorption of minerals and water, consequently larger and healthier plants. The ability to form plant hormones is a major property of many microorganisms and plant growth-promoting bacteria (PGPB) in general and specifically, species of *Azospirillum* that stimulate and facilitate plant growth (Tsavkelova *et al.*, 2006). These results are in accordance with (El-Komy ,2005) who reported that wheat inoculated with mixed inoculation azospirillum and bacillus exhibited high shoot dry weight.

Inoculation of maize seeds with mixed of *Azospirillum brasilense* & *Bacillus megaterium* and 90 kg/fed of nitrogen fertilizer resulted in a more visible increase nearing full dose from nitrogen fertilizer (120 kg/fed) of growth and yield characters. *Azospirillum* inoculation had a significantly positive effect on the activity of the enzymes glutamine and glutamate synthesis (Saikia *et al.*,2007). Many studies show that the contribution of nitrogen fixation by *Azospirillum* to the plant is minimal and ranged, at best, from 5% to 18% of the total N increase in the plant (Bashan *et al.*, 2004). Measurement of nitrogen fixation after inoculation with *A. lipoferum* and *A. brasilense* in rice showed that the N derived from the atmosphere were 20.0% (*A. lipoferum*) and 19.9% (*A. brasilense*) in basmati rice and 58.9% (*A. lipoferum*) and 47.1% (*A. brasilense*) in super-basmati rice (Mirza *et al.*, 2000).

The PSB *Bacillus megaterium* var. Phosphaticum Solubilising Bacteria play an important role through several ways, *Bacillus megaterium* promotes plant growth by producing 2-Pentylfuran which increased the growth (Zou *et al.*,2010). The principal mechanism for mineral phosphate solubilization is the production of organic acids, and acid phosphatases play a major role in the mineralization of organic phosphorous in soil (Rodríguez and Fraga,1999).

The results indicated that the role of *Azospirillum brasilense* & *Bacillus megaterium* in enhancing and promoting the germination stage by activation seed vigor and development of maize. This early studies reveal to the possibility of using these promising inoculants under field conditions.

So, it could be concluded that inoculation maize seed with *Azospirillum brasilense* & *Bacillus megaterium* beside adding 90 kg/fed of nitrogen fertilizer was good treatment to reduce chemical nitrogen fertilizer as well as satisfactory high growth and yield.

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كفاءة التسميد الحيوي في تقليل استخدام السماد النيتروجيني وتأثيره على الانبات، النمو والمحصول للذرة الشامية

أمل الصعيدي عبد ربه الصعيدي و فيصل إبراهيم يوسف السيد .
قسم بحوث تكنولوجيا البذور- معهد بحوث المحاصيل الحقلية- مركز البحوث الزراعية .

أجريت تجربة معملية بمعمل قسم بحوث تكنولوجيا البذور بالمنصورة خلال عام ٢٠١٢ م في تصميم التام العشوائية في أربع مكررات بهدف دراسة تأثير التلقيح البكتيري على تقاوي الذرة الشامية الصفراء هجين ١٦٦ بالسيريلين الذي يحتوى على بكتريا الأزوسبيريللم ، الفوسفورين الذي يحتوى على بكتريا الباسيلس ، خليط الأزوسبيريللم + باسيلس و تقاوي غير ملقحة (كنترول) على إنبات تقاوي الذرة الشامية الصفراء ، كما أجريت تجربة حقلية بمحطة بحوث تاج العز الزراعية خلال عامي ٢٠١٢ و ٢٠١٣ م في تصميم الشرائح المتعامدة في أربع مكررات لدراسة التلقيح البكتيري ببكتريا (الأزوسبيريللم ، الباسيلس ، خليط الأزوسبيريللم + باسيلس و تقاوي غير ملقحة) و مستويات التسميد الأزوتي (١٢٠ ، ٩٠ ، ٦٠ ، ٣٠ كجم نيتروجين للفدان و بدون إضافة ككنترول) على بعض صفات النمو والمحصول للذرة الشامية الصفراء هجين فردى ١٦٦ ويمكن تلخيص أهم النتائج فيما يلي :-

- ١- أظهرت النتائج أن التلقيح البكتيري بمخلوط الأزوسبيريللم + باسيلس أدى إلى ارتفاع النسبة المئوية للإنبات وصفات قوة البذور و البادرات والتي تم قياسها بواسطة (دليل سرعه الإنبات ، معدل الإنبات ، معامل الإنبات، نسبة الإنبات، دليل الإنبات ، طول الجذر ، طول الريشة و الوزن الجاف للبادرات) .
- ٢- أوضحت النتائج أن التلقيح البكتيري بخليط (الأزوسبيريللم + باسيلس) سجل أعلى القراءات في صفات ارتفاع النبات ، مساحة ورقة الكوز ، الوزن الجاف للنبات ، طول الكوز ، قطر الكوز ، عدد السطور/ الكوز ، عدد الحبوب/ سطر و محصول الحبوب/فدان مقارنة بالتقاوي الغير ملقحة.

- ٣- لقد أدى التسميد النيتروجيني (١٢٠ كجم/فدان) إلى الحصول على أفضل النتائج في صفات النمو والمحصول السالف ذكرها.
- ٤- أشارت النتائج أن التفاعل بين التلقيح البكتيري والتسميد النيتروجيني أثر معنويًا على صفات النمو والمحصول تحت الدراسة ، وحققت المعاملة الأزوسبيريللم + باسيلس + ٩٠ كجم نيتروجين/فدان نتائج لا تختلف معنويًا عن المعاملة (١٢٠ كجم نيتروجين/فدان) .
- توصي الدراسة بمعاملة التقاوي قبل الزراعة بمخلوط بكتيري من الأزوسبيريللم + باسيلس مع إضافة السماد النيتروجيني بمعدل ٩٠ كجم/فدان لتحقيق أفضل تكشف حقل والحصول على أعلى إنتاجية لمحصول الذرة الشامية الصفراء.

قام بتحكيم البحث

كلية الزراعة – جامعة المنصورة
كلية الزراعة – جامعة الزقازيق

أ.د / علي السعيد شريف
أ.د / احمد عبد الغنى على