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IMPACT OF MINERAL AND BIO NITROGEN FERTILZATION ON PRODUCTION EFFICIENCY OF MAIZE (*Zea mays L.*)

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ABSTRACT: *Field experiment was conducted in the Experimental Farm, Faculty of Agriculture, Minufiya University, Shebin El-Kom, Egypt to study the physiological attributes, yield and yield components and economic evaluation of maize as affected by the application of mineral nitrogen (N) at different levels (0, 25, 50, 75 and 100 %) of recommended nitrogen levels (RNL) as well as grain inoculation with the biofertilizer included N_2 fixing bacteria (NFB) during 2011 and 2012 seasons. The results could be summarized as follows:*

A- The values of physiological attributes studied (CGR, RGR and NAR) were significantly increased with increasing the mineral nitrogen fertilization levels and / or grain inoculation with NFB compared to the control treatment in favour of the plants fertilized with 100 % of RNL and inoculated with NFB at most growth stages (45-60, 60-75 and 75-90 DAS) in the first and/or second season.

B- Grain inoculation with NFB significantly increased the number of grains/ear, 100-grain weight, grain yield and relative grain yielding ability / plant and yields/ha (grain, ear and stover) as well as crop index compared to uninoculated plants (control treatment) in the first and / or second season. However, there are no significant differences among the application of 75 % from RNL with NFB inoculation and that of 100 % from RNL in the presence with and / or without absence of NFB inoculation mostly in both seasons.

C- The recommended level of mineral N fertilizer (90 Kg N / fed) can be reduced by about 25 % by adopting the technique of inoculation with nitrogen fixing bacteria. This reflects directly on reducing fertilizer costs with producing approximately the same values of return effectiveness (benefit/cost ratio) in the first season.

Key words : *Maize – N fixing bacteria – N mineral fertilizer – Physiological attributes - yield*

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in the world, where it used for human consumption and animal and poultry feeding. In Egypt, it is necessary to increase maize production to face the wide gap between the production and consumption. Improving cultural practices like fertilization as a mineral and / or biofertilizer found to be increased the productivity of maize.

Nitrogen is an essential element required for maize plant. The abundance of nitrogen nutrition caused an increase in the capacity of maize plants in building metabolites, physiological attributes and vegetative growth characters and consequently encouragement of the yield and its components. Therefore, its one of the most important factors for increasing the productivity of maize crop as previously reported by Attia *et al* (2008), El-Sherief *et al* (2008), Hamada *et al* (2008), El-Ganbeehy *et al* (2009), Leilah *et al* (2009), Nawar *et al* (2009), Bamuaafa *et al* (2010), El-Naggar *et al* (2012) and Gomaa *et al* (2013).

The application of high levels of mineral N fertilizer may be led to an increase in the production costs as well as environmental pollution leading to harmful and negative impact on human health. Therefore, it can be needed to reduce the dependence on chemical fertilizers for maize production. In this respect, considerable saving in nitrogen fertilizer can be made using some biofertilizers included nitrogen fixing bacteria (NFB) which can supply the soil in both macro and micronutrients quantities, and also release some plant promoting substances such as indole acetic acid, gibberellic acid and cytokinin besides N_2 fixation which might be increased the metabolites synthesized and consequently stimulated plant growth and dry matter accumulation (Kennedy and Tchan, 1992 ; Kotb, 2005 and Hassan *et al,* 2006). Other investigators previously reported that grain inoculation with NFB caused an increase in the productivity and / or reduced mineral N fertilization rate and production costs of maize as reported by El-Nagar (2003), Abd-Alla (2005), Rizk *et al* (2006), Abd El-Maksoud and Sarhan (2008), El-Basuony *et al* (2009) , El-Danasoury (2009), Yazdani *et al* (2009) and Yazdani *et al* (2011) .

Therefore, the present investigation aimed to study biofertilization included some nitrogen fixing bacteria (NFB) for reducing the N mineral fertilizer used in maize fertilization keeping on the high productivity of maize plants.

MATERIALS AND METHODS

Field experiment was conducted in the Experimental Farm, Faculty of Agriculture, Minufiya University, Shebin El-Kom (latitude 30.5361° and longitude 30.7820°), Egypt to study the physiological attributes, yield and yield components and economic evaluation of maize (*Zea mays L.*) as affected by mineral and bio-fertilization of nitrogen (N) during 2011 and 2012 seasons. The levels of N mineral fertilization were 0, 25, 50, 75 and 100 % from recommended N levels (RNL), i.e 90 Kg N / fed. The tested biofertilizer included the mixture of non – symbiotic nitrogen fixing bacteria (NFB), i.e *Azotobacter chroococcum, Azospirillum brasilense* and *Bacillus polymyxa.*

The experiment included seven treatments which are as follows:

1- Zero RNL + without NFB inoculation (control)
2- Zero RNL + NFB inoculation
3- 25 % RNL + NFB inoculation
4- 50 % RNL + NFB inoculation
5- 75 % RNL + NFB inoculation
6- 100 % RNL + NFB inoculation
7- 100 % RNL + without NFB inoculation

The mineral N fertilizer was soil applied at the tested levels in the form of urea (46.5 % N) in one dose after plant thinning (21 days after sowing, DAS). The grains were inoculated with the tested biofertilizer at a rate of 30 g / kg grains using sugar solution as an adhesive agent. Grains were left for drying before sowing far from direct sunlight and irrigated directly after sowing. The tested biofertilizer used in this study were produced by Microbiological Dept., Soil, Water, Environ. Research Institute, Agricultural Research Center, Ministry of Agriculture and Land Reclamation, Arab Republic of Egypt. The preceding crop was Egyptian clover (*Trifolium alexandrinum L*) and wheat (*Triticum aestivum L*) in the first and second season, respectively. The experimental design was randomized complete block design with four replicates. The size of each plot was 14.7 m^2 included 7 rows , 3 m length and 0.7 m width for each. The maize grains, i.e single cross 128 cultivar (S.C. 128) were sown in hills 25 cm apart at 19 and 15 May in 2011 and 2012 seasons, respectively at a rate of 10 Kg grains/fed in both seasons. The experiment was irrigated six times, where the first irrigation was applied 21 days after sowing and the following irrigations were applied every 14 days. The plants were thinned to one plant / hill before the first irrigation producing 24000 plants/fed. The other mineral fertilizers were soil applied at their recommended levels , i.e 30 Kg P_2O_5 / fed and 24 Kg K_2O / fed in one dose after thinning for each in the forms of calcium superphosphate (15 % P_2O_5) and potassium sulphate (48 % K_2O), respectively. The plants were harvested at 8 and 6 September in the first and second seasons, respectively. The physical and chemical properties of the experimental soil during the two growing seasons are shown in Table (1).

Table (1): Physical and chemical properties of the experimental soil during 2011 and 2012 seasons.

A- Physical properties:

Properties / Seasons	Sand %	Silt %	Clay %	Texture class
2011	20.58	40.42	39.00	Clay loam
2012	21.30	41.32	37.38	Clay loam

B- Chemical properties:

Properties / Seasons	pH	E.C	O.M %	Available (ppm)		
				N	P	K
2011	7.6	0.42	1.90	30.2	8.4	285.2
2012	7.5	0.44	1.80	31.5	8.6	290.1

Measurement:

A- Physiological attributes :

At the period of 45- 60, 60-75 and 75-90 DAS the following attributes were estimated

1- Crop growth rate (CGR) =

$$\frac{W_2-W_1}{T_2-T_1} \quad \text{(g/plant/day)}$$

2- Relative growth rate (RGR) =

$$\frac{\log_e W_2-\log_e W_1}{T_2-T_1} \quad \text{(mg/g/day)}$$

3- Net assimilation rate (NAR) =

$$\frac{(W_2-W_1)(\log_e A_2-\log_e A_1)}{(T_2-T_1)(A_2-A_1)} \quad \text{(g/m2/day)}$$

Where: W_1 and W_2 = total dry weight / plant (g) at T_1 and T_2 (date of sampling), respectively

A_1 and A_2 = leaf area / plant " cm^2 " at T_1 and T_2 (date of sampling), respectively

$\log_e$ = logarithm to the base 'e' where e is the base of the natural logarithm (2.71828)

The basic formula of physiological attributes studied was used according to Radford (1967)

B- Yield and yield components:

At harvest, , five plants were taken from the three inner rows in each plot at random to determine the following characters of ear as well as yield / plant and its components, while the characters of yield / fed were determined from the rest plants of the three inner rows:

1- No. of grains / ear
2- 100 – grain weight " g "
3- Grain yield / plant (adjusted to 15.5 % moisture) " g "

4- Relative grain yielding ability =

$$\frac{\text{Grain yield / plant}}{\text{No. of days from planting to harvesting}} \quad \text{"g/plant/day"}$$

5- Grain yield / fed (adjusted to 15.5 % moisture) " ton "
6- Ear yield / fed (grain + cob) " ton "
7- Stover yield / fed (stem + leaves + tassel) " ton "
8- Crop index %

C-Economic evaluation :

Economic analysis of crop budget was conducted to evaluate the total return and costs of production and return effectiveness of all tested treatments. The following characters were estimated:

1- Total return of production (EGP/fed) : The main product represented from maize crop (grains) was used to estimate the total return of production using the following formula .

Total return of yield = grain yield (ton/fed) x the price of one ton (1871 EGP)

2- Total costs of production (EGP/fed) :

A- Costs of the tested mineral fertilizer = The rate of urea fertilizer used/fed x price of 1 Kg of the urea fertilizer. Where 1 Kg from urea equal 1.60 EGP

B- Costs of the tested biofertilizer : It was calculated on the basis of 300 g of the tested biofertilizer (N_2 fixing bacteria) equal 10 EGP .

C- Other costs : Other costs included land preparation , seeding , planting , pest control, other fertilizers , irrigation, weed control, land rent , harvesting , labor wages , machinery and other expenses .

The costs of production was calculated from the data presented in the bulletin of Agricultural Statistics (October, 2011), Ministry of Agriculture and Land Reclamation, Economic Affairs Sector , A.R.E.

3-Net return (EGP/fed) = Total return of production / fed – Total costs of production / fed

4-Change in total return (%) =

$$\frac{\text{Total return of treatment} - \text{Total return of control}}{\text{Total return of control}} \times 100$$

5- Benefit / cost ratio (EGP return / EGP cost): It was estimated by the following formula described by John and Frank (1987)

Benefit / cost ratio =

$$\frac{\text{Total return of production}}{\text{Total costs of production}}$$

Statistical analysis :

The data were statistically analyzed according to the methods described by Snedecor and Cochran (1967). Duncan`s multiple range test (Duncan,1955) was used to compare the treatment means. The mean values designated by the same letter (s) in each column are not significantly at 5 % level .

RESULTS AND DISCUSSION

1- Physiological attributes :

The results of the physiological attributes studied herein, i.e crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) as affected by different mineral nitrogen fertilization levels in the presence or absence of biofertilization with N fixing bacteria (NFB) at three growth periods (45-60, 60-75 and 75-90 DAS) in 2011 and 2012 seasons are presented in Table (2).

The results clearly indicate that the values of CGR and RGR were significantly affected by the application of N fertilization levels combined with NFB inoculation in the three growth stages in both seasons for CGR and in the first season only for RGR. Moreover, the data show that the maximum values for CGR and RGR were recorded by the application of mineral N fertilizer at the highest rate (100 % from RNL) in the presence of NFB inoculation at 45-60 and 75-90 DAS in the first season for the two traits and at 45-60, 60-75 and 75-90 DAS in the second season for CGR only. However, it can be noticed that the differences between the plants fertilized with 100 % of RNL without NFB inoculation and those fertilized by 75 % from RNL with NFB inoculation were not significant for CGR and RGR at all growth stages in both seasons. In this respect, Soliman and Gharib (2011) found that CGR values of maize plants were significantly increased with increasing mineral nitrogen fertilization up to 100-120 Kg N/fed.

Table 2

Concerning the results of NAR, the data show that the values were mostly increased with the application of mineral N fertilization at any level in the presence of inoculation with NFB as compared with the control treatment. However, it is clear that the there are no significant differences mostly among the different tested mineral N levels either in presence or absence of the NFB inoculation. In this concern, Ahmed (1990) reported that the values of CGR, RGR and NAR were not significantly affected by increasing mineral N fertilization from 90 to 120 Kg N/fed

From the abovementioned results, it can be concluded that there are a beneficial effect of bio-fertilization with NFB inoculation on the physiological attributes studied herein. This beneficial might be attributed to vigorous growth of bio-fertilized plants and to the increase in the amount of metabolites synthesis of these plants, as well as to the role of bio-fertilizer in improving the nutrients absorption which increased the activation of metabolic processes (Mohamed, 2000).

2- Yield and yield components :

The results in Table (3) show that number of grains/ear and 100-grain weight were significantly responded to the tested treatments of mineral N fertilization and biofertilization with NFB inoculation in the two seasons. The results indicated that inoculation of maize grains with NFB only led to an increase in the same characters studied as compared with the uninoculated and unfertilized plants (control treatment). This increase amounted to 11.93 and 3.09 % for number of grains/ear and 100-grain weight, respectively more than the control treatment, as an average of the two seasons. Moreover, it can be found that the maximum values of the ear characters studied were recorded by the application of 100 % from RNL (90 Kg N/fed) in the presence of NFB inoculation which amounted to 39.64 and 22.73 % for the same abovementioned characters, respectively more than the control treatment, as an average of the two seasons. The pronounced superiority of ear characters obtained herein by the application of high mineral N fertilization level and inoculation with NFB may be due to the increase in physiological attributes (crop growth rate , relative growth rate and net assimilation rate) as shown in Table (2) and this in turn might result in an increase in the weight and number of grains per ear. On the other hand, it can be noticed that there are no significant differences between application of N fertilization at 100 % of RNL without inoculation and N fertilization at 75 % from RNL with NFB inoculation for same abovementioned characters studied mostly in the two seasons, indicating to the importance of grain inoculation for saving about 25 % from mineral N fertilization. Similar results were obtained by many investigators who found that application of N mineral fertilization caused an increase in number of grains/ear (Kumar and Puri , 2001 ; Abd El-Maksoud and Sarhan, 2008 ; El-Ganbeehy *et al,* 2009 and Mansour and Abd El-Maksoud , 2009) and 100-grain weight (El-Metwally, 2001 ; El-Sayed, 2006 ; El-Sherief *et al,* 2008 ; Ibrahim *et al,* 2010 ; Abdou *et al,* 2012 ; El-Naggar *et al,* 2012 and Gomaa *et al,* 2013). Other investigators found that grain inoculation of maize with biofertilizers including NFB caused an increase in seed index (Atta-Allah, 1998 ; El-Rewainy and Galal, 2004 ; Abd-Alla, 2005 and El-Danasoury, 2009) and no. of grains/ear (Abd El-Maksoud and Sarhan, 2008) .

Results presented in the same table revealed that grain yield/plant was significantly affected by the tested treatments of mineral N fertilization and NFB inoculation during the two growing seasons. It is evident from the results that grain inoculation with biofertilization of NFB significantly increased grain yield/plant by 22.76 and 9.34 % more than the untreated plants in the first and second seasons, respectively. Moreover, it is clear that the application of 100 % from RNL associated with NFB inoculation significantly increased the grain yield/plant by 94.03 and 50.95 % more than the control treatment in the first

Table 3

and second seasons, respectively. From these results, it can be concluded that maize grain inoculation with NFB either alone or associated with mineral N fertilization had a beneficial effect on the grain yield/plant especially at high N fertilization level. This promising effect on grain yield/plant may be due to the increase in the ear weight and its main components (number of grains/ear and 100-grain weight). Similar results were obtained by many researchers who found that grain yield/maize plant was increased by the application of mineral N fertilization as reported by El-Nagar (2003), Mohamed (2004) , Rizk *et al* (2006) , Ibrahim *et al* (2010), Abdou *et al* (2012) and El-Naggar *et al* (2012) and N fixing bacteria as recorded by Atta-Allah (1998), Abd-Alla (2005), Abd El-Maksoud and Sarhan (2008) and El-Danasoury (2009) as well as the combined of both mineral N fertilization and N fixing bacteria inoculation as obtained by Ragab and Ibrahim (2009) compared to untreated plants.

Concerning the relative grain yielding ability/plant, the data in the same table indicate that significant differences among the tested treatments of mineral N fertilizer and NFB inoculation were detected for such trait in both seasons. Worthy to note that raising the mineral N fertilization from zero to 25, 50, 75 and 100 % from RNL in the presence of N biofertilizer inoculation produced values of relative grain yielding ability / plant amounted to 1.14, 1.27, 1.39, 1.57 and 1.67 g grain/day compared to the untreated plants (no inoculation and no fertilization), i.e 0.99 g grain/day, as an average for the two growing seasons. This means that each maize plant can be produced 1.67 g grain/every day from sowing to harvest when it was fertilized with 100 % from RNL in the presence of NFB inoculation compared to 0.99 g grain/every day when it was not fertilized and uninoculated. However, the data indicate that there are no significant differences between the application of 75 % from RNL with NFB inoculation and that of 100 % from RNL without inoculation. This means that using NFB inoculation can be compensate the low N fertilizer for producing the same significant values of relative grain yielding ability/plant obtained by the application of high N fertilizer only .

It is evident from the same table that the grain and ear yields/fed were significantly increased with increasing mineral N levels up to 100 % of RNL in the presence of NFB inoculation in the two seasons. This increase amounted to 86.65 and 72.87 % in the first season as well as 50.69 and 52.12 % in the second season more than the control treatment for grain and ear yield/fed, respectively. However, there are no significant differences among the application of 75 % from RNL with NFB inoculation and that of 100 % from RNL with and/or without NFB inoculation in both seasons. This means that the application of 75 % from RNL was relatively sufficient for producing the high yield of ears/fed and its main components. The superiority of ear yield/fed by the application of N fertilization and/or biofertilizer inoculation may be attributed to the increase in each of ear weight and its components (number of grains/ear and 100-grain weight) as well as grain yield/plant as previously discussed. In this concern, many investigators found favorable effect due to mineral N application for grain yield/fed (Attia *et al,* 2008 ; El-Sherief *et al,* 2008 ; Hamada *et al,* 2008 ; El-Ganbeehy *et al,* 2009 ; Leilah *et al,* 2009 ; Nawar *et al,* 2009; Bamuaafa *et al,* 2010 ; El-Naggar *et al,* 2012 and Gomaa *et al,* 2013) and ear yield/fed (Darwish , 2003 ; El-Sayed, 2006 and Abdou *et al* , 2012) as well as due to N biofertilizer inoculation for grain yield/fed (Abd El-Maksoud and Sarhan, 2008; El-Basuony *et al,* 2009; El-Danasoury, 2009 and Yazdani *et al,* 2009) and for ear yield/fed (Rizk *et al,* 2006).

With regard to the stover yield/fed, the data indicate that maize plants obtained from biofertilized grains gave insignificant increases in stover yield/fed in the two seasons compared to the plants obtained from uninoculated grains. However, it can be noticed that the values of this trait was significantly increased with increasing mineral N fertilization levels from zero up to 75 % from RNL combined with NFB inoculation in the two seasons. The increments in stover yield/fed due to the application of such treatment was 38.61 % more than the control treatment (no inoculation and no N fertilization) , as an average of both seasons. However, it is clear that there are no significant differences between the application of N level of 75 % from RNL combined with NFB inoculation and 100 % from RNL either in the presence or absence of inoculation for stover yield/fed in the two growing seasons. In this respect, several investigators found that stover yield/fed was increased by the application of mineral N fertilizer (Darwish, 2003 ; Hamada *et al,* 2008 ; Ibrahim *et al,* 2010 and Abdou *et al,* 2012) and nitrogen fixing bacteria inoculation (Rizk *et al,* 2006).

The results presented in the same table included the values of crop index as influenced by mineral N fertilization and NFB inoculation treatments in the two growing seasons. The data show that the crop index was significantly increased with increasing N fertilizer levels from zero up to 50 % from RNL (45 Kg N/fed) in the first season and up to 100 % from RNL (90 Kg N/fed) in the second season in the presence of NFB inoculation with each of them compared to the control treatment . On the other hand, it can be found that increasing nitrogen fertilizer level from 45 up to 90 Kg N/fed insignificantly increased the values of crop index in the first season only. This means that the translocation rate of dry organic matter from vegetative plant organs to the fruiting ones were differently accelerated with raising N fertilizer levels up to 45 - 90 Kg N/fed in combination with NFB inoculation according to the growing season. In this concern, Abd El-Maksoud and Sarhan (2008) found that the values of harvest index was increased by the application of mineral N fertilizer and/or inoculation with some commercial biofertilizers included N_2-fixing bacteria compared to unfertilized and uninoculated plants

3- Economic evaluation :

The data presented in Table (4) included the values of economic evaluation for maize crop (total return and costs of production/fed as well as net return/fed , change in total return % and benefit / cost ratio) as affected by mineral N fertilization and NFB inoculation in 2011 and 2012 seasons .

From the economic point of view, the net return/fed (not take into the consideration the price of stover yield) have been optimized to 2873 and 3182 EGP/fed in the first and second seasons, respectively when the maize plants were fertilized with 100% of RNL (90 Kg N/fed) in the presence of NFB inoculation compared to 122 and 1170 EGP/fed for the untreated plants (control treatment) in both seasons. This led to an increase in the change in total return % amounted to 86.66 and 50.70 % as well as benefit/cost ratio amounted to 1.772 and 1.855 (EGP return/EGP cost) more than the control treatment in the first and second seasons, respectively. However, it can be noticed that, as an average of both seasons, the application of 75% from RNL with NFB inoculation and 100% of RNL without NFB inoculation produced change in total return % being 57.36 and 61.26 % as well as benefit/cost ratio being 1.724 and 1.743 (EGP return/EGP cost) , respectively , as an average of both seasons . This means that the abovementioned two treatments produced approximately the same values of return effectiveness (benefit/cost ratio). From these results, it can be concluded that the recommended rate of mineral N fertilizer can be reduced by about 25 % by adopting the technique of inoculation with nitrogen fixing bacteria (NFB). This reflects directly on reducing fertilizer costs and decreasing the environmental pollution. In this concern, many investigators previously reported that grain inoculation with NFB caused an increase in the productivity and/or reduced mineral N fertilizer rate and production costs of maize as reported by El-Nagar (2003), Abd-Alla (2005) and Yazdani *et al* (2011).

Table 4

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تأثير التسميد الازوتي المعدني والحيوى علي الكفاءة الانتاجية لمحصول الذرة الشامية

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الملخص العربى

أجريت تجربة حقلية بمزرعة كلية الزراعة جامعة المنوفية بشبين الكوم (جمهورية مصر العربية) خلال موسمي الزراعة 2011 , 2012 بهدف دراسة تأثير التسميد الازوتي المعدني والحيوى علي بعض الصفات الفسيولوجية ، المحصول ومكوناته ، العائد الاقتصادى للذرة الشامية (صنف هجين فردى 128). وقد اشتملت هذه التجربة علي مستويات مختلفة من التسميد المعدني النيتروجيني الارضي وهي صفر ، 25 % ، 50 % ، 75 % ، 100 % من المستوى الازوتي الموصي به (90 كجم نتروجين / فدان) بالاضافة الي تلقيح الحبوب قبل الزراعة بالبكتريا المثبتة للنتروجين اللا تكافلية (ازوتوباكتر كروكوكم ، ازوسبريلليم براسيلنس ، باسيلس بوليمكسا) هذا وقد اشتملت هذه التجربة علي سبع معاملات وهي :

1- بدون تسميد معدني نيتروجيني + بدون تلقيح بالبكتريا المثبتة للنتروجين (كنترول)
2- بدون تسميد معدني نيتروجيني + تلقيح بالبكتريا المثبتة للنتروجين
3- 25 % من كمية السماد المعدني النتروجيني الموصي به + تلقيح بالبكتريا المثبتة للنتروجين
4- 50 % من كمية السماد المعدني النتروجيني الموصي به + تلقيح بالبكتريا المثبتة للنتروجين
5- 75 % من كمية السماد المعدني النتروجيني الموصي به + تلقيح بالبكتريا المثبتة للنتروجين
6- 100 % من كمية السماد المعدني النتروجيني الموصي به + تلقيح بالبكتريا المثبتة للنتروجين
7- 100 % من كمية السماد المعدني النتروجيني الموصي به + بدون تلقيح بالبكتريا المثبتة للنتروجين

ويمكن ايجاز أهم النتائج المتحصل عليها علي النحو التالي :

1) تشير النتائج الي ان قيم الصفات الفسيولوجية المدروسة (سرعة نمو المحصول و السرعة النسبية لنمو المحصول و معدل الكفاءة التمثيلية) قد زادت زيادة معنوية بزيادة مستويات التسميد المعدني النتروجيني مع تلقيح البذور بالبكتريا المثبتة للنتروجين وذلك بالمقارنة بالنباتات غير الملقحة وغير المسمدة (معاملة الكنترول) هذا وقد تم الحصول علي اعلي زيادة معنوية لهذه الصفات عند زيادة مستويات التسميد المعدني الازوتي الي 100 % من الكمية الموصي بها مع تلقيح الحبوب بالبكتريا المثبتة للنتروجين وذلك خلال فترات النمو تحت الدراسة (45-60 , 60-75 , 75-90 يوم بعد الزراعة) سواء في الموسم الاول او في الموسم الثاني أو في كليهما .

2) ادى تلقيح الحبوب بالبكتريا المثبتة للنتروجين الي زيادة معنوية في عدد الحبوب/كوز ووزن 100 حبة و محصول الحبوب للنبات والقدرة النسبية لمحصول حبوب النبات ومحصول كل من الحبوب والكوز والقش

للفدان بالاضافة الي دليل المحصول % وذلك مقارنة بالنباتات التي لم تسمد تسميدا معدنيا ولم تلقح تلقيحا بكتيريا خلال موسمي الزراعة. هذا وتشير النتائج الي انه لم يكن هناك اى اختلافات معنوية بين مستوي التسميد الازوتي بمعدل 75 % في وجود التلقيح بالبكتريا المثبتة للنتروجين و التسميد الازوتي بمعدل 100 % من الجرعة الموصي بها في وجود او غياب التلقيح بالبكتريا المثبتة للنتروجين وذلك لمعظم صفات المحصول ومكوناته المدروسة خلال موسمي الزراعة .

3) تشير النتائج الي امكانية تقليل كمية السماد المعدني الموصي به (90 كجم نتروجين/فدان) الي 75 % من هذه الكمية وذلك من خلال استخدام تقنية تلقيح الحبوب بالبكتريا المثبتة للنتروجين مما يؤدى الي امكانية تقليل تكاليف التسميد المعدني النتروجيني مع الحصول علي نفس قيمة معدل العائد / معدل التكاليف المتحصل عليه تقريبا عند اضافة كمية السماد المعدني الموصي به بدون التلقيح الحيوى كمتوسط لموسمي الزراعة .

Table (2) : Effect of mineral and bio fertilization of nitrogen on some physiological attributes of maize plant at period of 45- 60 , 60-75 and 75- 90 days after sowing in 2011 and 2012 seasons

Characters	N treatments			2011 season			2012 season		
	Mineral		Bio	Days after sowing			Days after sowing		
				45-60	60-75	75-90	45-60	60-75	75-90
Crop growth rate "CGR" (g/plant/day)	0	+	0	4.62 d	1.31 c	1.75 c	5.91 c	6.21 de	0.98 b
	0	+	NFB	5.49 c	3.68 bc	2.34 c	7.88 b	4.88 e	4.41 a
	25 %	+	NFB	6.91 b	2.17 c	5.37 b	8.33 ab	9.75 c	4.58 a
	50 %	+	NFB	6.85 b	3.79 bc	5.97 b	9.63 a	8.86 cd	4.96 a
	75 %	+	NFB	7.15 b	7.09 a	7.60 ab	9.90 a	11.33 bc	4.88 a
	100 %	+	NFB	10.24 a	4.92 ab	8.80 a	10.03 a	15.55 a	7.03 a
	100 %	+	0	7.02 b	7.20 a	6.73 ab	9.96 a	13.01 ab	4.26 a
Relative growth rate "RGR" (mg/g/day)	0	+	0	53.60 ab	9.97 c	11.17 bc	58.60 a	31.90 a	3.85 a
	0	+	NFB	46.12 d	20.57 abc	9.85 c	60.70 a	21.10 a	14.15 a
	25 %	+	NFB	51.70 bc	10.67 c	20.05 ab	57.00 a	34.50 a	11.57 a
	50 %	+	NFB	48.65 cd	16.62 abc	19.95 ab	59.40 a	28.90 a	12.07 a
	75 %	+	NFB	46.85 cd	27.10 ab	20.30 ab	58.50 a	34.10 a	10.62 a
	100 %	+	NFB	58.02 a	16.25 bc	22.02 a	54.50 a	41.50 a	12.67 a
	100 %	+	0	47.45 cd	27.97 a	18.42 ab	56.70 a	37.20 a	8.72 a
Net assimilation rate "NAR" ($g/m^2/day$)	0	+	0	11.32 a	2.16 d	4.25 bc	9.661 a	7.818 bc	1.308 b
	0	+	NFB	10.05 ab	5.02 abc	3.75 c	10.978 a	5.497 c	5.027 a
	25 %	+	NFB	10.73 a	2.45 cd	7.08 abc	9.831 a	9.643 ab	4.894 a
	50 %	+	NFB	9.50 abc	3.89 bcd	6.94 abc	10.440 a	8.231 bc	4.928 a
	75 %	+	NFB	7.98 c	6.52 ab	8.05 a	10.229 a	9.794 ab	4.700 a
	100 %	+	NFB	10.06 ab	3.77 bcd	8.49 a	9.610 a	12.415 a	5.770 a
	100 %	+	0	8.53 bc	7.04 a	7.69 ab	9.945 a	10.972 ab	3.804 a

0, 25 ,50 ,75 and 100 % RNL (recommended mineral N level) = 0, 22.5 , 45 , 67.5 and 90 Kg N/fed, respectively

NFB : N_2 Fixing bacteria (*Azotobacter chroococcum* + *Azospirillum brasilense* + *Bacillus polymyxa*) at a rate of 30 g / Kg grains

Table (3): Effect of mineral and bio fertilization of nitrogen on yield and yield components of maize during 2011 and 2012 seasons

Characters / N treatments (Mineral + Bio)	No. of grains/ear	100-grain weight (g)	Grain yield /plant (g)	Relative grain yielding ability (g/plant/day)	Yield / fed (ton)			Crop index
					Grain	Ear	Stover	
2011 season								
0 + 0	351.25 c	26.47 c	92.25 f	0.82 f	1.888 e	2.518 e	3.533 d	52.94 c
0 + NFB	414.50 b	27.24 c	113.25 e	1.00 e	2.417 d	3.065 d	3.966 cd	61.02 ab
25 % + NFB	479.50 a	28.39 c	136.00 d	1.20 d	2.758 cd	3.444 cd	4.563 bc	60.62 ab
50 % + NFB	488.50 a	30.56 b	149.25 cd	1.32 cd	3.113 bc	3.819 bc	4.763 b	65.55 a
75 % + NFB	509.50 a	33.61 a	171.00 ab	1.51 ab	3.329 ab	4.056 ab	5.873 a	57.07 bc
100 % + NFB	517.50 a	34.61 a	179.00 a	1.58 a	3.524 a	4.353 a	5.933 a	59.51 ab
100 % + 0	486.75 a	32.94 a	160.00 bc	1.42 bc	3.306 ab	4.024 ab	5.475 a	60.56 ab
2012 season								
0 + 0	427.25 c	31.40 f	134.35 e	1.17 e	2.448 e	2.881 e	4.707 c	52.00 f
0 + NFB	452.25 bc	32.43 e	146.90 d	1.28 d	2.680 de	3.183 d	4.829 c	55.50 e
25 % + NFB	467.25 bc	33.02 d	154.40 d	1.34 d	2.898 cd	3.410 cd	4.926 bc	58.77 d
50 % + NFB	496.00 b	34.02 c	168.92 c	1.47 c	3.067 c	3.608 c	5.034 bc	60.90 c
75 % + NFB	541.00 a	34.46 c	186.50 b	1.62 b	3.387 b	3.984 b	5.224 ab	64.90 b
100 % + NFB	563.75 a	36.02 a	202.80 a	1.76 a	3.689 a	4.384 a	5.436 a	67.82 a
100 % + 0	562.00 a	35.36 b	198.50 ab	1.73 ab	3.608 ab	4.243 ab	5.382 a	66.95 a

0, 25 ,50 ,75 and 100 % RNL (recommended mineral N level) = 0, 22.5 , 45 , 67.5 and 90 Kg N/fed, respectively
NFB : N_2 Fixing bacteria (*Azotobacter chroococcum* + *Azospirillum brasilense* + *Bacillus polymyxa*) at a rate of 30 g / Kg grains

Table (4) : Economic evaluation of maize as affected by the mineral and bio fertilization of nitrogen in 2011 and 2012 seasons

Characters / N treatments Mineral + Bio	Total return of yield (EGP/fed)	Total costs of production (EGP/fed)				Net return (EGP/fed)	Change in total return %	Benefit / Cost ratio (EGP return / EGP cost)
		N fertilizers		Other costs	Total			
		Mineral	Bio					
2011 season								
0 + 0	3532	0	0	3410	3410	122	-	1.035
0 + NFB	4522	0	10	3410	3420	1102	28.03	1.322
25 % + NFB	5160	75	10	3410	3495	1665	46.09	1.476
50 % + NFB	5824	150	10	3410	3570	2254	64.89	1.631
75 % + NFB	6229	225	10	3410	3645	2584	76.36	1.709
100 % + NFB	6593	300	10	3410	3720	2873	86.66	1.772
100 % + 0	6186	300	0	3410	3710	2476	75.14	1.667
2012 season								
0 + 0	4580	0	0	3410	3410	1170	-	1.343
0 + NFB	5014	0	10	3410	3420	1594	9.48	1.466
25 % + NFB	5422	75	10	3410	3495	1927	18.38	1.551
50 % + NFB	5738	150	10	3410	3570	2168	25.28	1.607
75 % + NFB	6337	225	10	3410	3645	2692	38.36	1.739
100 % + NFB	6902	300	10	3410	3720	3182	50.70	1.855
100 % + 0	6750	300	0	3410	3710	3040	47.38	1.819

0, 25 ,50 ,75 and 100 % RNL (recommended mineral N level) = 0, 22.5 , 45 , 67.5 and 90 Kg N/fed, respectively
NFB : N_2 Fixing bacteria (*Azotobacter chroococcum* + *Azospirillum brasilense* + *Bacillus polymyxa*) at a rate of 30 g / Kg grains