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Research article

Effect of bio and mineral nitrogen fertilizer with different levels on growth, yield and quality of maize plants

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Abstract

A field experiment was conducted to evaluate the effect of nitrogen fertilizers sources as bio and mineral form on growth, yield and quality of corn. Ammonium sulphate fertilizer with 20% N (AS) was used as a mineral nitrogen source with 3 levels of application, where as azotobacter was a biological source of nitrogen used in 3 levels. Experiment was a factorial arrangement in complete randomized block design with 3 replicates. Corn plants cultivar Giza10 were fertilized with ammonium sulphate at levels: 50, 100 and 125 kg/fed and treatments of azotobacter at levels: 0, 5 and 10 Kg/fed. The results showed that application of bio-fertilizer with mineral nitrogen increased plant growth compared with mineral nitrogen alone. The highest values of plant height, leaf area, dry weight, yield components as ear weight, ear length, number of rows, weight of 100 grains, ear yield and weight of straw and chemical concentration in leaves and grains were obtained by the application of azotobater at 5Kg/fed with 100Kg/fed ammonium sulphate compared with other treatments.

Introduction

Maize is the most important crop as cereal crops in human food production that contains 55% of the protein [1] which is third plant in crop production after wheat and rice [2]. It is powerful and greater crop and improving the absorption the nutrients and release energy in the earth and the grains of maize is a high-energy food compared to other grains [1]. During growth maize needs different sources of mineral fertilizers. Nitrogen is one of the mineral fertilizers very important element which affects maize cultivation [3]. Nitrogen fertilizers increase the grains yield and quality [4]. When nitrogen is available for plants, the vegetative growth will be increase and improve the percent of protein in the grains [5]. The effective of nitrogen role in the soil by the time and the application increased the residual effect of fertilizers caused the pollution for soil and water. The problems for health and environment increased by application of mineral fertilizers and the mineral fertilizers very high costs. For these reasons the application of bio fertilizers was very important [6]. The production of maize increased by application of fertilizer (bio fertilizers especially), is the most important method of the improving products [7-8]. The use of nitrogen fertilizers in soil through bio-application can be decrease the environmental pollution by washing the nitrate from the soil [9]. Chemical and physical properties of Soil were improved by use the bio-fertilizer. These results limited of using of mineral fertilizers and crop production will be free from contaminants [10-11]. Bio-fertilizer is a substance contains living microorganisms which applied to seeds, plant surfaces, or soil increase growth by increasing the availability of nutrients to the plant. The using of bio-fertilizers increasing the biological nitrogen fixation, growth hormone and plant antibiotics which improve the evolution of root systems of corn and this method is very important for the environment protection from pollution [12]. Through the use of bio-fertilizers the healthy plants can be grown while enhancing the sustainability and the health of the soil. The bio-fertilizers play several roles for activates the beneficial bacteria and improve the soil fertility by increase the plant nutrient requirements. Bio-fertilizers do not contain any chemicals which are harmful to the living microorganisms soil. Van Oosterom *et al.* [13] reported that effect of using of bio-fertilizers such as azotobacter bacteria had a positive effect on corn yield. Also, the application of azotobacter to seeds increased the growth and yield of corn [14]. Akbari *et al.* [15] found that the combination of bio and chemical fertilizers increased grain yield and plant height of corn. The biological fertilizer with 50% of mineral fertilizers from nitrogen, phosphorus and potassium increased the growth of safflower compared with application of mineral fertilizers alone, also application of azetobacter as bio-fertilizer with half rate of mineral fertilizer increased the grain yield of safflower [16]. The growth of maize plant and grain yield increased by application of bio-fertilizer [17].

This information for bio-fertilizers and mineral fertilizers therefore, this study was done in order to evaluate the effect of bio-nitrogen fertilizers as azotobacter and mineral nitrogen fertilizer as ammonium sulphate on the growth and yield of maize yield.

Experimental

Materials and methods

Field experiment was conducted in the summer season of 2015 at Diarb Nigm district, Sharkia Governorate, Egypt to investigate the effect of bio-nitrogen fertilizers and mineral nitrogen fertilizers. A field experiment was conducted on a clay soil by cultivating corn plants (Giza10) seeds in the soil. The seeds were obtained from Agricultural Research Center, Giza, Egypt. The soil samples were air – dried and ground to pass through a 2 mm sieve. Some physical – chemical characteristics of the studied soil are presented in table 1. Main and interaction effects of different rates of ammonium sulphate (as a source of mineral nitrogen fertilizers) and azotobacter (as source of bio-nitrogen fertilizers) on corn yield and its components and nutrients content of corn plant were achieved. The experiment was carried out following the randomized complete block design with three replicates for each experimental unit. Ammonium sulphate fertilizer with 20% N (AS) was used with 3 rates of application: 50, 100 and 125 Kg/fed and azotobacter used in 3 levels: 0, 5 and 10 Kg/fed. The nitrogen fertilizer has been added to the soil at 3 different stages.

The experimental plots were sampled initially before corn planting to determine some physical and chemical properties according to the standard procedures outlined by Cottenie [18]. Plant samples were collected from mature corn pants at harvest stage for analysis. Plant samples were dried at 65C° for 48 hrs, ground and wet digested using H_2SO_4: H_2O_2 method [18]. The digests samples were then subjected to measurement of N using Micro- Kjeldahle method; P was assayed using molybdenum blue method and determined by spectrophotometer and K was determined by Flame Photometer [19]. After 60 and 90 days from planting, three plants were randomly chosen from each plot and taken for determinations:- Leaf area (cm^2), Fresh and dry weight of leaves (g $plot^{-1}$), Plant height (cm $plant^{-1}$). Also, samples of corn plants were collected at harvest parameters were recorded: Grain yield (ton fed^{-1}), Weight of 100 grains (g), Number of rows in ear, Ear length (cm). The data obtained was subjected to analysis variance procedure using SAS [20]. Duncan's Multiple Range Test was adopted for the means comparison among treatments showing significant difference. Effect of N and P fertilizer was partitioned into linear and quadratic components and regressions were calculated for effects significant at 0.05 level of probability.

Results and discussion

Vegetative growth

Data in table 2 showed that the effects of mineral nitrogen fertilizers and bio-fertilizers were revealed that the highest value of plant height, leaf area and dry weight were increased by using of bio-fertilizers such as azotobacter with nitrogen fertilizers after 60 and 90 days from planting. The maximum values of plant height, leaf area and dry weight obtained with the application of azotobacter at 5Kg/fed with 100Kg/fed ammonium sulphate. On the other hand, the lowest values of plant height, leaf area and dry weight obtained with 50 kg/fed ammonium sulphate and without any fertilizer from azotobacter. These results are obtained by Alnoaim *et al.* [21] who reported that the application of bio-fertilizers using N fertilizer increased the plant height, leaf area and dry weight of corn. The application of azotobacter with nitrogen fertilizers to the soil not only increased the nutritious elements which the plant needed but also improved the physical conditions and living processes of the soil.

Table 1. Chemical and physical properties of the study area soil.

Soil property	Value	Soil property	Value
Particle size distribution %		pH (1:2.5 soil suspension)	8.01
Fine sand %	24.66	EC(dSm-1), soil paste extract	0.15
Coarse sand %	9.92		
Silt %	12.80		
Clay %	52.62	Soluble ions (mmol L-1)	
Textural	Clayey		
$CaCO_3$ %	0.22	Ca^{++}	0.46
Organic matter %	1.88	Mg^{++}	0.28
Available N (mg kg-1)	3.61	Na^{+}	0.84
Available P (mg kg-1)	1.62	K^{+}	0.08
Available K (mg kg-1)	0.81	CO_3^{--}	-
		HCO_3^{-}	0.56
		Cl^{-}	0.40
		SO4--	0.70

Table 2. Means of bio-fertilizer and mineral nitrogen fertilizer effect on vegetative growth characters of corn plant.

Nitrogen fertilizer (Ammonium sulphate) Kg/fed	Bio-fertilizer (Azotobacter) Kg/fed	60 days			90 days		
		Leaf area (cm^2)	Plant height (cm)	Dry weight (g)	Leaf area (cm^2)	Plant height (cm)	Dry weight (g)
50	0	305.1	214.4	62.89	421.3	234.6	84.17
	5	326.5	221.3	68.12	422.5	237.2	87.51
	10	327.2	229.1	71.24	359.2	241.6	86.34
100	0	357.2	225.4	69.45	435.6	247.1	95.64
	5	366.8	233.6	73.54	455.2	251.3	98.58
	10	324.6	238.1	70.29	436.1	239.6	92.41
125	0	324.1	217.4	59.47	423.7	245.7	84.26
	5	312.8	223.8	68.21	411.9	244.6	87.36
	10	335.4	219.2	69.47	371.5	248.2	82.34
LSD at 0.05		1.22	1.54	0.31	0.26	1.51	0.11

Application of biological fertilizers increased the plant height, leaf area and dry weight which increased photosynthesis and dry matter accumulation [9]. Furthermore, the application of azotobacter also supports the conditions for root growth and increase the growth of the organs which up the soil and increase the dry materials and finally improve the biological functions of the plant. These results are obtained the similar to the results of Cavender *et al.* [22]. They reported that bio-fertilizers when added with nitrogen fertilizers increased the plant's component functions and biological function of maize plant by activating the soil's useful micro organism activities and persistent feeding of mineral elements especially nitrogen for the plant. These results can be due to the effect of bio-fertilizers on biological nitrogen fixation, production of growth hormone (auxin) and secretion of antibiotics leads to the development of root systems of corn, which increase the vegetative growth and yield [12]. Nitrogen is a macronutrient necessary for plant growth and increased the growth and yield components and seed yield. So, the biological nitrogen fertilizer as azotobacter completed the deficiency of this element to crops and increases the growth and improved yield [23]. These results can be concluded that the application of bio-fertilizers to available the nitrogen for plant and increase production and reduce the cost of production and use of nitrogen fertilizers is mentioned. This result may be due to biological fertilizer as azotobacter increased the concentration of beneficial soil organisms or the nutrients is available for plants. The application of bio-fertilizer increased the plant growth that increased hormones production such as GA and IAA hormones effects on plant growth [24].

Yield components

The recorded results in table 3 indicate that there are significant differences within the averages of yield components expressed as ear weight, ear length, number of rows, weight of 100 grains, ear yield and weight of straw at harvest stage as affected by bio and mineral nitrogen fertilizers. The maximum values of ear weight and ear length were obtained using of bio-fertilizer Azotobacter at 5 Kg/fed with nitrogen fertilizers 100 Kg/fed Ammonium sulphate. On the other hand, the lowest values of ear weight and ear length were obtained by 50 kg/fed Ammonium sulphate and without any fertilizer from Azotobacter. These results may be attributed to the increased activity and efficiency of bacteria in reduction of soil pH by secreting organic acids and consequently more solubility and availability of nutrients for plants. So, the application of bio-fertilizers can cause a positive effect on plant growth through increasing the phytohormones, enzymes activity, N2-fixation and the reduction in root membrane potential. Yadav *et al.* [25] and Eidi zadeh *et al.* [26] reported that the application of chemical and bio-fertilizers increased the biological yield and grain yield of corn plants. The maximum values of number of rows, weight of 100 grains, ear yield and weight of straw were increased using bio-fertilizers such as azotobacter at 5 Kg/fed with nitrogen fertilizers with 100 Kg/fed ammonium sulphate. In addition, the lowest values of number of rows, weight of 100 grains, ear yield and weight of straw were obtained by 50 kg/fed ammonium sulphate without any fertilizer from azotobacter. The noticeable increases of growth of plants by the increase in the applied bio-fertilizer dose may be confirmed by the progressive increase in the nutritional elements in the soil and plants. Our results indicated that, bio-N is beneficial for sustainable agriculture and human healthy nutrition as a partial alternative to mineral-N fertilizer [27]. Also, the application of biological fertilizer increased plant growth and yield by increasing plant hormones production such as IAA and GA [28]. The application of bio-fertilizer and mineral nitrogen fertilizer to plant compensate the deficiency of the nutrients to crops and of corn plants increased the vegetative growth and improved the yield. Saini *et al.* [29] reported that using 50 percent of mineral fertilizers and bio-fertilizer increased the grain yield of corn. According to Hanafy *et al.* [30] the application of

bio and chemical fertilizers increased grain yield, plant height and biological yield. The application of azotobacter increased the ear weight, ear length, number of rows, weight of 100 grains, ear yield and weight of straw in maize by promoting plant growth as production of phytohormones [31].

Chemical concentration

Results in table 4 show that under bio-fertilizer and mineral nitrogen fertilizer, values of N content in leaf after 60 and 90 days from planting and in grains at harvest were increased by increasing the level of bio-fertilizer to mineral nitrogen fertilizer. The N content values in leaf and grain steadily increased as the rate of applied azotobacter at 5 Kg/fed with 100 Kg/fed from ammonium sulphate compared with other treatments. Moreover, the lowest values of N content in leaf and grain were recorded by plants which supplied by ammonium sulphate at 50 Kg/fed without any fertilizer from azotobacter [32]. Eidi zadeh *et al.* [26] reported that the application of bio-fertilizer increased the availability of N and convert N_2 to NH_4 increasing N available to the plant. The bio-fertilizers increased the plant growth through increased the synthesis of phytohormones, N_2 fixation, reduction in membrane potential of roots and synthesis of some enzymes. Free living N-fixing bacteria such as azotobacter not only to increase nitrogen but also to release certain phytohormones which improve the plant growth and increase the availability of nutrients for plant [33].

Under both the bio-fertilizer and mineral nitrogen fertilizer, significant increases in P content of leaf and grain occurred under increasing bio- fertilization rate applied with mineral nitrogen fertilizer. The P content values in leaf and grain steadily increased as the rate of applied azotobacter at 5 Kg/fed with 100 Kg/fed from ammonium sulphate compared with other treatments. On the other hand, the lowest values of P content in leaf and grain were recorded by plants which fertilized by ammonium sulphate at 50 Kg/fed without any fertilizer from azotobacter. Nanjappa *et al.* [34] and Jayanthi *et al.* [35] suggested that application of bio-fertilizer and manure together showed a positive effect in the maize growth that the application of bio-fertilizer caused significant increases in the population of beneficial microorganism such as mycorrhizal fungi and phosphate dissolving bacteria and fungi in the soil which increased the available nutrients such as nitrogen, transferable phosphor, magnesium, dissolved potassium required for the plants [36-38].

The application of azotobacter with ammonium sulphate significant increases in K content of leaf and grain at 5 Kg/fed with 100 Kg/fed from ammonium sulphate. The K content values in leaf and grain steadily increased as the rate of applied azotobacter at 5 Kg/fed with 100 Kg/fed from ammonium sulphate compared with other treatments. On the other hand, the lowest values of K content in leaf and grain were recorded by plants which fertilized by ammonium sulphate at 50 Kg/fed without any fertilizer from azotobacter. According to Colomb *et al.* [39] the application of bio-fertilizer and chemical nitrogen increased the plant growth, photosynthesis rates, available of nutrients (N, P and K) and yield of corn increased. Eidi zadeh *et al.* [26] revealed that application of chemical nitrogen fertilizer and bio-fertilizers increased the biological yield, grain yield and nutrients content of corn.

Table 3. Means of bio-fertilizer and mineral nitrogen fertilizer effect on yield and its components characters of corn plant.

Nitrogen fertilizer (Ammonium sulphate) Kg/fed	Bio-fertilizer (Azotobacter) Kg /fed	At harvest					
		Ear length (cm)	Number of rows	Weight of 100 grains (g)	Ear weight (g)	Grain yield (ton fed^{-1})	Weight of straw (ton fed^{-1})
50	**0**	15.22	10.25	12.44	231.14	2.19	3.14
	5	15.74	10.36	12.65	235.46	2.44	3.22
	10	16.32	11.41	13.14	233.21	2.46	3.54
100	**0**	16.41	11.34	12.55	236.41	2.54	3.68
	5	16.55	12.48	13.28	242.51	2.63	4.25
	10	15.39	12.19	13.13	238.63	2.41	4.23
125	**0**	15.11	11.53	12.61	224.67	2.34	3.61
	5	16.23	11.64	13.21	237.22	2.39	4.11
	10	16.42	11.45	13.11	233.82	2.39	4.21
LSD at 0.05		0.51	0.12	0.17	2.31	0.28	0.11

Table 4. Means of bio-fertilizer and mineral nitrogen fertilizer effect on chemical composition in leaf and grain of corn plant.

Nitrogen fertilizer (Ammonium sulphate) Kg/fed	Bio-fertilizer (Azotobacter) Kg/fed	Leaf						Grain		
		60			90					
		N%	P%	K%	N%	P%	K%	N%	P%	K%
50	**0**	1.25	0.11	1.02	1.23	0.25	1.24	1.35	0.22	0.26
	5	1.28	0.17	1.15	1.38	0.28	1.26	1.49	0.25	0.28
	10	1.31	0.18	1.18	1.40	0.31	1.28	1.51	0.26	0.31
100	**0**	1.56	0.19	1.28	1.66	0.35	1.28	1.63	0.29	0.29
	5	1.67	0.24	1.36	1.74	0.36	1.44	1.66	0.33	0.34
	10	1.61	0.22	1.31	1.71	0.33	1.41	1.54	0.30	0.33
125	**0**	1.34	0.21	1.32	1.63	0.31	1.39	1.51	0.27	0.28
	5	1.44	0.22	1.35	1.65	0.32	1.43	1.53	0.31	0.32
	10	1.49	0.24	1.34	1.66	0.34	1.41	1.58	0.32	0.33
LSD at 0.05		0.11	0.04	0.06	0.01	0.02	0.03	0.12	0.04	0.01

Conclusion

Bio-fertilization could be used for reduce mineral fertilizer use and reducing production costs. Bio-application of azotobacter plays an important role in the production of good crop and higher yield. The obtained results show that the vegetative growth, yield and quality of mazie plants were enhanced by bio-nitrogen fertilizers. It is concluded that mazie plants could be inoculated by azotobacter at 5 Kg/fed and cultivated in a combined with 100 Kg/fed from ammonium sulphate.

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