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Effect of Bio-Fertilizer on Growth and Yield of Two Maize (*Zea mays* L.) Cultivars at Shambat, Sudan

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Abstract: Two field experiments were conducted at Sudan University of Science and Technology, College of Agricultural Studies, the Demonstration Farm, Shambat, during two successive winter seasons of 2011/2012 and 2012/2013 under irrigation conditions to study the effect of bio-fertilizer (Effective Microorganisms, EM) on two maize (*Zea mays* L.) cultivars for some growth and yield characters using a split plot design with four replications. The liquid bio-fertilizer levels were (Zero, 06.25, 12.5, 18.75 and 25.00 L/Ha) corresponding to F1, F2, F3,F4 and F5 treatments. The two maize cultivars were HUDAIBA (HD) and MUGTAMA45 (MG). The results revealed that, Plant height, stem diameter, leaf area, 100-grain weight and grains number per cob were increased due to the increase in level of bio-fertilizer. Also, the aforementioned characters were significantly increased for HD cultivar particularly under application of F4 and F5 levels. Further, the highest grain yield was obtained from application of F4 dose to the two cultivars in the both seasons. This high response of the two maize cultivars to bio-fertilizer could be of a great value in using it in maize nutrition in the Sudan.
Keywords: Maize, Bio-Fertilizer, Cultivars, Growth, Yield

INTRODUCTION

Maize (*Zea mays* L.) is the third most important globally cereal crop (after wheat and rice), it is grown throughout a wide range of climates. A major shift in global cereal demand is underway and by 2020 the demand for maize in developing countries is expected to exceed the demand of both wheat and rice [1]. During the last four production seasons (2010-2014), the average world maize areas were about 176.19 million hectares producing 930.13 million metric tons with average yield estimated at 5.78 ton per hectare [2]. In Sudan, Maize is grown as a minor crop in rain-fed areas at the western states of Sudan (Kordofan and Darfur) and also as irrigated crop in small irrigated schemes in the Northern and Mid-States of Sudan and the average yield of it is about 0.697 ton/ha, [3]. Bio-fertilizer is defined as a substance, contains effective living microorganisms (EM) which colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or the availability of primary nutrient and/or growth stimulus to the target crop, when it is applied to seeds, plant surfaces and soil[4,5]. Bio-fertilizers contain beneficial bacteria and fungi that improve soil chemical and biological characteristics, phosphate solutions and agricultural production [6]. The efficiency of EM (Effective recommended Microorganisms) as a bio-fertilizer is attributed to its role in accelerating the mineralization processes of organic matter and helping the release of nutrients resulting in enhancing the utility values of soil organic matter contents and cations exchange capacity [7]. Therefore, bio-fertilizers are gaining importance as they are eco-friendly, nonhazardous and nontoxic products [8, 9]. Significant differences among maize genotypes in yield and its components were frequently detected by many investigators [10-14]. Moreover, several authors [11-17]. Suggested that hybrids produced more ear/plant, better ear characteristics, heavier weight of grains/plant and higher grain yield/hectare compared with the open pollinated varieties. Significant interactions between maize genotypes and N application were also detected by many authors' [12, 17-20]. The reasons for low yield are manifold: some are varietal and some are agronomic management especially improper fertilizers application. Costly and environmentally risky chemical fertilizers cause continuous problems for increasing maize production in developing countries including Sudan. These problems are likely to become serious in future. In Sudan, few studies have been conducted on the effects of bio-fertilizer compared to control on maize cultivars or hybrids. One of the most important means to achieve the goals of organic agriculture is to extent the application of biological fertilizers. Considering the above facts, the present study was undertaken to assess the effect of different levels (doses) of liquid bio-

fertilizer on growth and yield of two maize cultivars and to determine the optimum level suitable for improving maize production at Shambat location, Sudan.

MATERIALS AND METHODS

The two field experiments were conducted at the Experimental Farm, Sudan University of Science and Technology, College of Agricultural Studies, Shambat (Lat. 15^0 40′ N, Long.32^0 32′ E and at of 380 meters above sea level) during two successive winter seasons of the years of 2011/2012 and 2012/2013. The experiments were designed to study the effect of bio-fertilizer (Effective Microorganisms, EM) on two maize (*Zea mays* L.) HUDAIBA (HD) and MUGTAMA45 (MG) cultivars for some growth and yield characters using a split plot based on a randomized complete block design with four replications. The two maize cultivars were considered as main plots and the five levels of bio-fertilizer as sub-plots. The liquid bio-fertilizer levels were (Zero, 06.25, 12.5, 18.75 and 25.00 L/Ha) corresponding to F1, F2, F3,F4 and F5 treatments. These doses were applied to the plants at sowing and then together with irrigation every 10-12 days. Each cultivar was planted in 4 ridges, 5 meter-long, 70 cm between ridges and 20 cm between holes. Seeds rate was three seeds/hole, the seeds were sown manually and then thinned to two plants/hole three weeks after sowing. Weeding was done manually whenever needed. At harvest, the following characters were measured included: Plant height (cm), Stem diameter (cm), Leaf area (cm^2), Cob length (cm), Number of rows cob^{-1}, Number grains cob^{-1}, 100-grain weight (g) and Grain yield (kg ha^{-1}). The collected data of the two seasons were statistically analyzed separately according to the analysis of variance (ANOVA) by using MSTAT-C computer software packages. Mean comparisons were worked out by Duncan's Multiple Range Test (DMRT) at 5% level of probability according to [21].

RESULTS AND DISCUSSION

In this study, effects of the bio-fertilizer, maize cultivars and their interaction on growth characters for the two winter seasons of 2011/2012 and 2012/2013 were shown in table 1. In season 2011-2012 the plant height (cm) was increased from (105.79, 87.52 for F1) to (164.59, 117.59 for F4) in first and second seasons, respectively. While the stem diameter (cm) was increased from (6.94, 7.11 for F1) to (10.40, 9.69 for F5) and the leaf area (cm^2) was increased (from 155.54, 269.14 for F1 to 384.04, 555.39 for F5) in first and second seasons, respectively. However, the increase in aforementioned growth characters might be due to the promotion of nitrogen fixed by EM, in increasing of cell division and enlargement as well as its effect in metabolic processes in plant organs and consequently increased of leaf area per plant. These results are conformity with findings of [22] who reported that inoculation maize grain with bio-fertilizer (Azotobacter) was significantly resulted in the increasing of plant height and leaf area. In addition to the positive attributes of bio-fertilizer (EM) application enhanced growth and yield of maize due to the promotion of root system as reported by [23]. Also, [24] reported that Microorganisms are able to increase absorption of food elements, by solving insoluble phosphates through reactions in the rhizosphere and the absorption of elements became available and therefore result in the increase of growth and yield characters. On the other hand, the means of plant height, stem diameter and leaf area of the cultivar HUDAIBA as affected by the high doses bio-fertilizer (F4 and F5) were relatively higher than the means of mentioned characters of the cultivar MUGTAMA45 in the two seasons.

Effects of bio-fertilizers levels and maize cultivars on mean of yield and yield components in the two winter seasons of 2011/2012 and 2012/2013 were shown in Table 2. These results indicate that the increase of bio-fertilizer levels was resulted in the increase of the means of yield and yield components. In season 2011-2012 the Cob length (cm) was increased from 7.35 for F1 to 14.61 for F4, the number of rows/cob was increased from 10.52 for F1 to 27.92 for F4, the number of grains/cob was increased from 205.70 for F1 to 398.72 for F4, the 100-grain weight (gm) was increased from 19.84 for F1 to for 23.50 for F4 and the grain yield (Kg/ha) was increased from 3.21 for F1 to 5.76 for F4. In season 2012-2013 the Cob length (cm) was increased from 9.05 for F1 to 13.40 for F5, the number of rows/cob was increased from 9.13 for F1 to 13.40 for F5, the number of grains/cob was increased from 122.89 for F1 to 345.77 for F5, the 100-grain weight (gm) was increased from 12.87 for F1 to for 23.77 for F5 and the grain yield (Kg/ha) was increased from 4.12 for F1 to 5.27 for F5.

Further, the means of yield and yield components of the cultivar HUDAIBA as affected by the high levels bio-fertilizer (F4 and F5) were relatively higher than the means of yield and yield components of the cultivar MUGTAMA45 in the two seasons. In season 2011-2012, the highest grain yield of (5.88) Kg/Ha and (5.65) Kg/Ha were obtained by the treatments MG x F4 and HD x F4, respectively. In season 2012-2013, the highest grain yield of (5.74) Kg/Ha and (5.40) Kg/Ha were obtained by the treatments HD x F4 and MG x F4, respectively. The increase in the above mentioned yield components might be due to the increased of the availability of nitrogen which resulted in the increase of the leaf area. The obtained results were in agreement with findings of [25, 26] who reported that bio-fertilizer (Azotobacter) increases Nitrogen availability in the soil which could enhance the numbers of grains and 100-grain weight. [27-29] noticed positive effect of bio-fertilizer on yield and yield components of maize, they added that this positive effect might be attributed ability of bio-fertilizer to increase the availability of phosphorus and other nutrients in the soils characterized with low nutrients availability.

Table 1: Effects of bio-fertilizers levels and maize cultivars on mean of growth characters for the two winter seasons of 2011/2012 and 2012/2013.

		2011/2012			2012/2013		
		Plant height(cm)	stem diameter (cm)	leaf area (cm^2)	Plant height (cm)	stem diameter (cm)	leaf area (cm^2)
HD		136.70	8.70	285.5	99,98	8.56	474.15
MG		132.56	8.10	296.35	100.7	8.67	443.79
$LSD_{0.05}$		5.18	NS	2.99	NS	NS	78.68
F1		105.79	6.94	155.54	87.52	7.11	269.14
F2		126.22	6.52	215.47	97.35	7.67	300.04
F3		148.35	8.86	319.12	87.00	9.23	539.32
F4		164.59	9.45	380.48	117.59	9.96	604.00
F5		128.21	10.40	384.04	112.29	9.10	555.39
$LSD_{0.05}$		2.30	NS	5.14	43.35	0.65	50.88
HD	F1	106.09	7.23	136.76	80.33	7.25	295.8
	F2	125.30	7.43	214.21	108.67	6.75	310.63
	F3	150.98	8.55	322.02	87.20	9.64	580.60
	F4	174.50	10.10	394.62	113.92	9.43	656.50
	F5	126.65	9.48	394.04	109.00	10.43	527.78
MG	F1	105.48	6.95	174.33	94.71	6.63	296.62
	F2	127.15	7.93	216.73	86.03	6.38	289.45
	F3	145.73	9.93	366.35	86.80	8.09	497.90
	F4	154.68	9.83	316.22	121.25	9.43	551.90
	F5	129.75	8.73	374.05	114.79	10.40	583.00
$LSD_{0.05}$		5.92	1.24	2.96	21.74	0.50	73.68

Table 2: Effects of bio fertilizers levels and maize cultivars on mean of yield and yield components 2011/2012 and 2012/2013.

		2011/2012					2012/2013				
		Cob Length	No. rows per cob	No. grains per cob	100-grain weight	yield (kg/ha)	Cob Length	No. rows per cob	No. grains per cob	100-grain weight	yield (kg/ha)
HD		12.82	22.41	295.95	22.55	4.52	11.28	22.85	250.53	17.78	5.27
MG		11.20	19.95	292.72	22.75	4.56	12.14	18.57	253.70	18.22	5.18
$LSD_{0.05}$		0.53	0.86	NS	1.51	0.44	0.97	NS	7.73	NS	NS
F1		7.35	10.52	205.70	19.84	3.21	9.05	9.13	122.89	12.87	4.12
F2		11.46	15.50	256.38	23.96	4.11	10.22	19.51	201.26	13.75	5.50
F3		13.25	27.00	303.78	24.23	4.45	13.98	22.26	279.66	19.46	5.56
F4		14.61	27.92	398.72	23.50	5.76	11.88	25.57	311.00	20.65	5.57
F5		13.60	24.96	307.02	22.04	5.31	13.40	27.10	345.77	23.27	5.27
$LSD_{0.05}$		0.43	1.09	NS	2.04	NS	3.7	NS	26.98	2.03	NS
HD	F1	7.52	11.75	208.30	19.60	3.35	9.55	9.43	124.62	14.77	4.23
	F2	13.13	16.17	257.07	22.92	4.00	9.47	29.00	200.08	12.67	5.50
	F3	14.30	28.87	304.17	24.85	4,25	12.99	22.96	268.37	19.35	5.51
	F4	15.25	29.70	402.32	21.80	5.65	11.85	25.19	310.77	19.17	5.74
	F5	14.12	25.57	307.87	23.58	5.35	12.57	26.85	348.80	22.92	5.34
MG	F1	7.17	9.30	203.22	20.08	3.07	8.62	8.83	121.15	10.9	4.17
	F2	9.80	14.82	255.70	25.00	4.22	10.97	10.03	202.45	14.82	5.50
	F3	11.75	25.12	303.40	23.00	4.67	14.97	21.55	290.95	19.57	5.61
	F4	14.20	26.15	395.12	25.20	5.88	11.92	25.23	311.22	22.12	5.40
	F5	13.75	24.35	306.17	20.50	5.28	14.22	27.21	342.75	23.62	5.20
$LSD_{0.05}$		0.23	0.38	NS	NS	NS	0.43	NS	NS	2.03	NS

CONCLUSION

Based on the results obtained from this study, it could be concluded that the using of the bio-fertilizer (EM) was resulted significantly in the increase of growth, yield and yield components of maize cultivars. In season 2011-2012, the highest grain yield Kg/Ha (5.88) and (5.65) were obtained by the treatments MG x F4 and HD x F4, respectively. In season 2012-2013, the

highest grain yield Kg/Ha (5.74) and (5.40) were obtained by the treatments HD x F4 and MG x F4, respectively. The bio-fertilizer F4 (18.75) L/Ha is the best one for the nutrition of the two maize cultivars. These results confirm the importance of using the bio-fertilizer (EM) for maize nutrition in Sudan

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