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Research Article

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Potential for improving sorghum productivity and quality by organic – bio and mineral fertilizers under soil lands conditions

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Abstract

Two field experiments were conducted in the sandy soil of privet farm, Fayoum government, Egypt, during the two summer seasons (2017 and 2018) to study the effect of using bio – organic and mineral fertilizers on some growth and yield parameters of variety Giza 15 (*Sorghum bicolor* L. moench). The study included five fertilization treatments: T_1: (Recommended N, P and K 100%), T_2: (Compost + PGPR + 25 % N mineral), T_3: (Compost + PGPR + 50% mineral), T_4: (Compost + PGPR + 75% N mineral) and T_5: (Compost + PGPR). A randomized complete block design was used in three replications. The obtained results clearly showed that application of bio and organic fertilization with different levels of mineral N, P and K fertilizers led to scored significant differences among all tested parameters as compared to applied the recommended mineral NPK fertilizers dose. The treatment which received bio and organic fertilizers in combination with NPK mineral fertilizers at 75% gave the higher values for grain weigh / head (52.03 gm), 1000 grain weight (31.56 gm) and grain yield (20.43 ardab fed^{-1}). N, P and K nutrient uptake (%) for grain sorghum was affected by application of bio and organic fertilizers and recorded higher values at the treatment plants with 75% recommended NPK mineral fertilizers. Therefore, it could be possible to replace 25% of the recommended N mineral fertilization by a mixture of bio and organic fertilization. Grain yield/fed^{-1} (ardab) was significantly positively correlated with each of plant height, number of green leaves, stem diameter, leaf area/plant, forage yield, protein %, phosphor and potassium.

Keywords: Sorghum- Biofertilizers- Organic fertilizers- Mineral fertilizers- Soil- Productivity

Introduction

Grain sorghum (*sorghum bicolor* L.) is an annual cereal crop. It comes at the fifth order after rice, wheat, corn and barley, it is grown in diverse ports of the tropical and sub-tropical regions of the world because, grain of sorghum is one of the most yield crops which tolerant to stress conditions (drought , salinity and temperature,… etc.) [1,2]. Chemical fertilizers are used to enhance plant growth and increase crop yield but their excessive application led to raise cost of crop production and caused environment pollution. Thus, application both organic and bio fertilizers can help to decrease the harmful effect, as well as increased crop production and quality [3,4]. Application of organic fertilizers (compost) improve the physical properties of soil, i.e. clay and silt percentages, bulk density (B.D.), hydraulic conductivity (H.C.) total porosity (T.P.), soil moisture contents at field capacity (F.C.), wilting point (W.P.), available water (A.W.) and chemical properties, *i.e.* pH, electrical conductivity (E.C.), organic matter (O.M.) and available nitrogen (N), phosphorus (P) and potassium (K), as well as enhancement plant vegetative growth and increased yield production [5]. Bio and organic fertilizers, besides providing nutrients in available farms, can produce beneficial substances such as the plant hormones include acetic acid (IAA), gibberellins (GA) and cytokinins (CK) [6]. Bhardwaj et al. [7] and Abd El-Salam et al. [8] reported that application of bio-organic fertilizers led to scored yield increases of 2 to 45% in vegetable, 9 to 24% in sugarcane and up to 31% maize, sorghum and mustard. Bio fertilizers (N2 fixers, phosphate dissolving and potassium releasing bacteria) on sorghum plants were manifested by their positive effect on both plant growth and grain yield [4,9, 10]. The current study aims at assessing both bio and organic fertilizers as replacement by mineral N, P and K fertilizers on some vegetative growth and yield parameters of sorghum.

Materials and Methods

Field experiments was carried out in sandy soils at own farm, Fayoum Governorate during the two-successive seasons of 2017 and 2018 to investigate the response of sorghum to application with bio and organic fertilizers. Variety Giza15 was provided from Sorghum Res. Dept., Field Crops Res. Inst., A.R.C., Egypt. Sandy soil was used and some physical and chemical soil properties were found at Table (1) according to Jackson [11] and Ryan et al. [12].

Table 1: Mechanical, physical and chemical properties of the studied soil

Properties	Values
Mechanical analysis	
Sand (%)	72.70
Salt (%)	17.40
Clay (%)	9.90
Texture	Sandy loam
Physical – chemical analysis	
pH	7.65
E.C.	1.30
Saturation (%)	29
Organic matter (%)	0.71
Total nitrogen (%)	0.013
Total soluble N (ppm)	37
Total soluble P (ppm)	4.57
Total soluble K (ppm)	3.43
Soluble cations and anions ($Megl^{-1}$)	
Ca^{++}	1.95
Mg^{++}	2.36
Na^{+}	5.54
K^{+}	0.47
CO_3^{-}	2.95
Cl^{-}	3.47
SO_4^{-2}	3.90

(T_1) recommended 100% N, P and K (100 kg N, 30 kg P_2O_5 and 24 K_2O fed^{-1})

(T_2) 25 % of recommended N + Compost (10 ton fed^{-1}) + PGPR

(T_3) 50 % of recommended N + Compost (10 ton fed^{-1}) + PGPR

(T_4) 75% of recommended N + Compost (10 ton fed^{-1}) + PGPR

(T_5) Compost (10 ton fed^{-1}) + PGPR

A randomized complete block design with three replications was used in both seasons. With plot size (3 X 3.5 m) containing bridges planting was done in hills 20 cm apart on one side of the ridge. Number of grains / hill was 5-8 seeds. After 18 days from planting dates, weed control was performed by hoeing and seedlings were thinned to two plants / hill. Planting dates were 15th and 24th June in 2017 and 2018 seasons, respectively. Organic fertilizers using plant – animal compost at rate 10 ton and added 15 days before sowing. Some physical and chemical properties for compost were found at Table (2) according to Jackson [11].

Bio fertilizers: three types of microorganisms were used as bio fertilizers namely *Azotobacter chroococcoium* as a source for nitrogen, *Bacillus megaterium* as phosphate dissolving bacteria and bacillus circulans as potassium releasing bacteria used as peat mixed inoculate at the time of planting at rate 4 g inoculate per 100-gram grains. Bacterial cultures were kindly obtained from Bio Fertilizers Production Unit, Agric. Microbiol. Dept., Soil, Water and Environment Res. Inst., A.R.C., Egypt. Nitrogen fertilizer was applied in the form of ammonium nitrate (33.5%) and divided to three equal doses. The first dose was added after 20 days from sowing while the other two doses were added every 10 day. Phosphor, and potassium fertilizers were added in the form of calcium supper– phosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O) respectively were applied before sowing. Number of days to 50 % flowering was recorded at flowering stage. At harvest time (120 days after sowing), ten random guarded plants were taken from each plot (the two middle rows to avoid plant competition effects) to estimate: plant height (cm), number of green leaves/plant, leaf area/plant (cm^2), stem diameter (cm), grain weight / head (gm) 1000 – grain weight (gm), forage yield fed^{-1} (ton) and grain yield fed^{-1} (ardab). The all above mentioned characters were according to A.O.A.C. [13]. Statistical analysis of the results was performed using analysis of variance ANOVA and least significant differences (L.S.D.) were calculated from ANOVA tables [14].

Results and Discussion

Data in Table (3) show effect of fertilization treatments on plant height, number of green leaves/plant and leaf area/plant for sorghum in both seasons. The obtained results indicated that application of bio and organic fertilizers treatment in combination with different levels of mineral N fertilizers (25, 50 and 75 % from full dose) led to scored significant increase as compared with application of the full (recommended) N, P and K mineral fertilizers in both seasons. T_5 treatment had lower values of plant height (215.98 and 221.73 cm), number of green leaves/plant (5.33 and 5.33), leaf area / plant (571.11 and 589.18 cm^2) in the first and second seasons, respectively.

The treatment which received bio-and organic fertilizers in combination with 75% from mineral N- fertilizers recorded the highest values for the plant height, number of green leaves/plant and leaf area/plant of the Giza 15 variety among the two tested seasons as compared to the other mineral N level treatments

Table 2: Some physical and chemical properties of compost used during this study

Analysis	Values
Bulk density (M^3)	620
Moisture content (%)	29
pH	8.81
E.C.	6.13
Organic matter (%)	45.6
Organic carbon (%)	26.4
Ash (%)	71.3
Total N (%)	1.2
Total P (%)	0.75
Total K (%)	0.80
NO_3^- (ppm)	50
NH_3^+ (ppm)	70
C/N ratio	22:1
Seed weed	Nil
E. Coli	Nil
Nematode	Nil

(25 and 50%). Application of high levels of N fertilizers with or without adding bio and or organic agricultural practices led to scored positive effect on vegetative growth parameters of sorghum plants [2,14-18]. Application of bio-organic N, P and K fertilizer led to increase plant growth as compared to other treatments.

Data in Table (4) show effect of fertilization treatments on stem diameter and days to 50% flowering for sorghum in both seasons. The obtained data indicated that the treatment which received bio and organic fertilizers recorded the lowest values for stem diameter and days to 50% flowering followed by the treatment which received 25% N fertilizers in combination with bio and organic fertilizers in both seasons. The highest values were found at the treatment which received bio and organic fertilizers in presence of 75 N mineral fertilizers and these values were (11.30 and 11.60 cm) for stem diameter and (65.3 and 65.2) for days to 50% flowering in the first and second seasons, respectively. Generally, application of both bio and organic fertilizers led to scored significant differences and gave more short time to get 50% flowering in the second season than the other one.

Data in Table (5) show effect of fertilization treatments on grain weight/head and 1000-grain weight for sorghum in both seasons. The obtained data clearly revealed that application of bio and organic fertilizers in combination with different levels of N-mineral fertilizers increased grain weight/head and 1000-grain weight as compared to the treatments which received bio and organic fertilizers only or recommended N, P and K mineral fertilizers. The grain weight / head ranged from 43.20 to 52.75 gm, meanwhile 1000-grain weight ranged from 29.99 to 23.17 gm by application bio and organic fertilizers in combination with difference levels of mineral N - fertilizers.

Higher grain yield was obtained at the treatment which treated with 75% mineral N – fertilizers in combination with bio and organic fertilizers and these values were 51.30 and 52.75 gm for sorghum in the first and second seasons, respectively. The application of bio and organic fertilizers enhancement and improving the growth stage and gave positive effect on 50%

Table 3: Plant height, no. of green leaves/plant and leaf area/plant for sorghum as affected by the tested fertilization treatments in 2017 (S1) and 2018 (S2) summer seasons.

Trait	Plant height (cm)			No. of green leaves/plant			Leaf area/plant (cm^2)		
Treatment	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
T_1	247.82	262.71	252.27	5.83	6.73	6.28	694.11	731.15	712.63
T_2	230.43	241.83	236.13	5.42	5.53	5.48	602.27	622.71	612.49
T_3	238.92	251.77	245.35	5.67	6.33	6.00	682.73	793.11	737.92
T_4	253.75	271.85	262.80	5.88	6.33	6.11	755.40	821.75	788.58
T_5	215.98	221.73	218.86	5.33	5.33	5.33	571.11	589.18	580.15
L.S.D. 0.05	**14.33**	**17.95**	**--**	**n.s**	**n.s**	**--**	**24.71**	**51.77**	**--**

(T_1) recommended 100% N, P and K (100 kg N, 30 kg P_2O_5 and 24 K_2O fed^{-1})
(T_2) 25 % of recommended N + Compost (10 ton fed^{-1}) + PGPR
(T_3) 50 % of recommended N + Compost (10 ton fed^{-1}) + PGPR
(T_4) 75% of recommended N + Compost (10 ton fed^{-1}) + PGPR
(T_5) Compost (10 ton fed^{-1}) + PGPR

flowering, grain weight/ head and 1000-grain weight [19-23].

Data in Table (6) show effect of fertilization treatments on grain yield fed^{-1} and forage yield fed^{-1} for sorghum in both seasons. The obtained results indicated that the application of bio and organic fertilizers with different levels of mineral N – fertilizers gave higher values of grain and forage yields fed^{-1} as compared to untreated ones. Generally the highest values of grain yield fed^{-1} (ardab) and forage yield fed^{-1} (ton) were 20.43 and 18.21 for sorghum that received 75% N mineral fertilizers in combination [4, 23 – 25]. These results are in agreement with Eweis et al. [26] who reported that application of bio and organic fertilizers considered being the two major limiting factors in combination with decreased N- mineral fertilizers to enhancement vegetative growth as well as yield of sorghum plants. The highest values of growth and yield parameters were given by using bio and / or organic fertilizers for sorghum plant as compared to un treatment ones.

The grain quality and nutrient uptake (%) as protein, phosphorus and potassium results are shown in Table (7) and the obtained data indicated that application of bio and organic fertilizers in combination led to give significant increases in protein, phosphorus and potassium up take (%) as compared to un treated ones. These results are in agreement, season two gave the higher values for nutrients uptake as compared to these recorded at season one and the highest values were (8.79 and 0.22) and (0.17) for protein, phosphorus and potassium for sorghum at the treatment which received 75% N- mineral fertilizer in combination with bio and organic fertilizers [27 - 29]. The correlation coefficients among all studied parameters for sorghum are presented in table (8). The table data show that Grain yield ardab fed^{-1} correlated positively and significantly with plant height (0.570*) number of green leaves (0.715**), leaves area (0.787**) stem diameter (0.663**) and forage yield (0.685**). The correlation was positively and significantly among grain yield and its content from protein %, phosphor and potassium was (0.886**), (0.848**) and (0.888**) respectively.

Table 4: Stem diameter and days to 50 % flowering for sorghum as affected by tested fertilization treatments in 2017 (S1) and 2018 (S2) summer seasons.

Trait	Stem diameter (cm)			Days to 50% flowering		
Treatment	S1	S2	Mean	S1	S2	Mean
T1	10.91	11.21	11.06	69.5	68.3	68.9
T2	10.13	10.33	10.23	68.8	68.5	68.7
T3	10.49	10.63	10.56	66.5	66.1	66.3
T4	11.30	11.60	11.45	65.3	65.2	65.3
T5	9.89	10.10	9.99	68.5	68.1	68.3
L.S.D. 0.05	**0.31**	**0.45**	**--**	**0.11**	**0.17**	**--**

(T_1) recommended 100% N, P and K (100 kg N, 30 kg P_2O_5 and 24 K_2O fed^{-1})
(T_2) 25 % of recommended N + Compost (10 ton fed^{-1}) + PGPR
(T_3) 50 % of recommended N + Compost (10 ton fed^{-1}) + PGPR
(T_4) 75% of recommended N + Compost (10 ton fed^{-1}) + PGPR
(T_5) Compost (10 ton fed^{-1}) + PGPR

Table 5: Grain weight/head and 1000-grain weight for sorghum as affected by tested fertilization treatments in 2017 (S1) and 2018 (S2) summer seasons.

Trait	Grain weight/head (gm)			1000-grain weight (gm)		
Treatment	S1	S2	Mean	S1	S2	Mean
T1	48.92	50.11	49.52	29.55	31.21	30.38
T2	45.20	46.71	45.96	30.41	31.95	31.18
T3	50.66	52.33	51.50	30.71	31.11	30.91
T4	51.30	52.75	52.03	30.95	32.17	31.56
T5	43.20	45.16	44.18	29.99	30.11	30.05
L.S.D. 0.05	**3.85**	**5.76**	**--**	**0.21**	**0.27**	**--**

(T_1) recommended 100% N, P and K (100 kg N, 30 kg P_2O_5 and 24 K_2O fed^{-1})
(T_2) 25 % of recommended N + Compost (10 ton fed^{-1}) + PGPR
(T_3) 50 % of recommended N + Compost (10 ton fed^{-1}) + PGPR
(T_4) 75% of recommended N + Compost (10 ton fed^{-1}) + PGPR
(T_5) Compost (10 ton fed^{-1}) + PGPR

Table 6: Grain yield fed^{-1} and forage yield fed^{-1} for sorghum as affected by tested fertilization treatments in 2017 (S1) and 2018 (S2) summer seasons.

Trait	Grain yield fed^{-1} (ardab)			Forage yield fed^{-1} (ton)		
Treatment	S1	S2	Mean	S1	S2	Mean
T_1	19.10	19.25	19.08	15.17	16.11	15.64
T_2	18.75	19.01	19.14	14.30	15.70	15.00
T_3	19.89	20.11	20.00	16.37	17.25	16.81
T_4	19.91	20.95	20.43	17.89	18.53	18.21
T_5	17.50	17.90	17.70	13.99	14.25	14.12
L.S.D. 0.05	**1.07**	**1.27**	**--**	**1.83**	**2.09**	**--**

(T_1) recommended 100% N, P and K (100 kg N, 30 kg P_2O_5 and 24 K_2O fed^{-1})
(T_2) 25 % of recommended N + Compost (10 ton fed^{-1}) + PGPR
(T_3) 50 % of recommended N + Compost (10 ton fed^{-1}) + PGPR
(T_4) 75% of recommended N + Compost (10 ton fed^{-1}) + PGPR
(T_5) Compost (10 ton fed^{-1}) + PGPR

Table 7: Protein, phosphorus and potassium content for sorghum as affected by tested fertilization treatments in 2017 (S1) and 2018 (S2) summer seasons.

Trait	Protein (%)			Phosphor (%)			Potassium (%)		
Treatment	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
T_1	8.59	8.63	8.61	0.22	0.22	0.22	0.15	0.16	0.16
T_2	7.25	7.46	7.31	0.18	0.18	0.18	0.14	0.14	0.14
T_3	8.05	8.84	8.45	0.20	0.19	0.20	0.15	0.15	0.15
T_4	8.69	8.98	8.79	0.22	0.22	0.22	0.17	0.17	0.17
T_5	7.89	7.94	7.92	0.19	0.19	0.19	0.14	0.14	0.14
L.S.D. 0.05	0.11	0.09	--	n.s	n.s	--	n.s	n.s	--

(T_1) recommended 100% N, P and K (100 kg N, 30 kg P_2O_5 and 24 K_2O fed^{-1})
(T_2) 25 % of recommended N + Compost (10 ton fed^{-1}) + PGPR
(T_3) 50 % of recommended N + Compost (10 ton fed^{-1}) + PGPR
(T_4) 75% of recommended N + Compost (10 ton fed^{-1}) + PGPR
(T_5) Compost (10 ton fed^{-1}) + PGPR

Table 8: Correlation coefficient among sorghum parameters

Parameters	2	3	4	5	6	7	8	9	10	11
1 plant height	0.892**	0.936**	0.959**	-0.569*	0.665**	0.506	0.789**	0.852**	0.888**	0.570*
2 no. of green leaves/plant		0.888**	0.882**	-0.381	0.283	0.808**	0.796**	0.899**	0.716**	0.715**
3 leaf area/plant			0.905**	-0.755**	0.585*	0.666*	0.836**	0.917**	0.953**	0.787**
4 Stem diameter				0.550*	0.525*	0.579*	0.917**	0.929**	0.841**	0.663**
5 Days to 50% flowering					-0.651**	-0.309	-0.599**	0.615*	-0.882**	-0.682**
6 1000-grain weight						-0.213	0.271	0.297	0.762**	0.057
7 Protein							0.718*	0.809**	0.443	0.886**
8 Phosphor								0.973**	0.759**	0.848**
9 Potassium									0.810**	0.888**
10 Forage yield fed^{-1}										0.685**
11 Grain yield fed^{-1}										

*,** denote significant at 0.05 and 0.01 levels of probability, respectively

Conclusion

The advantage affect as bio and organic fertilizers on sorghum plants grown in newly sandy soils that expressed plant height, number of green leaves/plant, leaf area/plant, stem diameter, as well as day to 50% flowering, at growth stage and grain yields (gm and ardab), forage yield fed^{-1} (ton), as well as grain nutrients up take (N, P and K), they increased significantly by adding bio fertilizers (at rate 4g Per 100g grain) and organic fertilizers (at rate 10 ton compost) and 75% mineral fertilizers from recommended dose and recorded the highest values for the all tested parameters

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