Comparative Study of New Commercial Organic and Microbial Fertilizers to Conventionally Used Fertilizers in Sudan on Wheat and Millet Grown on Three Types of Soils

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Abstract- Two pot experiments were carried out to study the effect of organic chemical and microbial fertilizers on the growth of millet and wheat grown on three types of soils.

The results showed that the organic fertilizers significantly ($p \leq 0.05$) increased most of the measured parameters for both crops compared to the unfertilized control. The organic fertilizers showed similar positive significant effects, and Elkhaseeb was the best. Effective microorganisms (EM) showed no significant improvements in most of the measured parameters for both crops compared to the untreated control. The results also showed significant differences between soils, with Shambat soil being the best followed by Gerif and Elrawakeeb soils. These results should be confirmed under field conditions.

Key words - Soil types, Organic fertilizers, EM, Cereals.

1. INTRODUCTION

Cereals are crucial to human survival and are the main components of human diets (1). Cereal grains provide a major source of energy, protein, and dietary fiber in human nutrition. Wheat (*Triticum aestivum* L.) conistitutes the second food grain in Sudan and traditionally has been the staple food in the northern states and it recently became the staple food in urban areas. Universally, cereals are important food crops, among which millet

(*Pennisetuim glancum* L.) is the sixth most important cereal in the world. Millet is the major staple food in western Sudan.

Fertilizers are sources of plant nutrients that can be added to soil to supplement its natural fertility. They are intended to supply plant needs directly rather than indirectly through modification of soil properties (reaction and structure). Organic fertilizers coming from fermented and decomposed organic materials are very nutritious and safe. They improve soil texture and preserve the soil life. Addition of organic manures to the soil increases the reservoir of organic nitrogen and many other essential plant nutrients (2).

There is usually a very dramatic improvement in both quantity and quality of plant growth when appropriate fertilizers are added. Proper use of fertilizers leads to the production of more nutritious food. The objectives of this work were (i) to compare the effect of microbial fertilizer (EM), different new commercial organic amendments "Elkhaseeb", "Elkhairat", and "Abu floos" on millet and wheat grown on Shambat, Elrawakeeb and Gerif soils and (ii) to compare the efficiency of new commercial organic and microbial fertilizers to conventionally used fertilizers (chicken manure and urea).

11. MATERIALS AND METHODS

Wheat seeds variety "Elnilain" were obtained from the Agricultural Research Corporation Wad Madani, Sudan, whereas millet seeds variety "Sh 9/96" were obtained from the Desertification Research Institute, National Centre for Research, Khartoum, Sudan.

Urea, four organic fertilizers and one microbial fertilizer were used in this study. Urea (80 Kg N/ha) was applied two weeks after sowing. Microbial

fertilizer EM is a liquid microbial consortium based on diluted molasses. It contains yeast: (*Saccharomyces cerevisiae*), bacteria: lactic acid bacteria, photosynthetic bacteria (*Rhodopseudomonas palustris* and *Rhodobacter sphaeroides*). It was obtained from Elmurug Company Khartoum at Elselate Scheme. Diluted EM (5 ml to 1 liter water) was applied two weeks after sowing and then every two weeks till 8 weeks after sowing.

Chicken manure (Table 1) was collected from the poultry farm, Faculty of Animal Production, University of Khartoum, Shambat, Sudan. Elkhaseeb a composted organic fertilizer was obtained from Elkaseeb factory at Elbagir. This organic fertilizer was prepared as a mixture of sheep manure, farmyard manure and chicken manure in 1:2:1 ratio. Elkhairat, a composted organic fertilizer, was obtained from Elkhairat factory at Elselate Scheme. It consists of cow dung manure, chicken drops and agricultural residues. Abu floos, a composted organic fertilizer, was obtained from the local market. Abu floos is a mixture of chicken manure and cattle manure thermally treated and incompletely fermented. All organic fertilizers were applied at the rate equivalent to 80 Kg N/ha and were added two weeks before sowing, and the soil was irrigated twice before sowing.

Three types of soils (Table 2) were used in this study namely (i) Shambat soil from the field of the Faculty of Agriculture, University of Khartoum, Shambat, (ii) Elrawakeeb soil from Elrawakeeb Research Station, National, Centre for Research, and (iii) Gerif soil from the River Nile bank. The soils from different sites were collected from the depth of (0-30 cm). Soils were cleaned from debris, lumps broken with a wooden stick, and mixed thoroughly.

Two pot experiments were carried out at the Department of Horticulture, Faculty of Agriculture, University of Khartoum, Shambat. Five Kg of soil were placed in plastic bags (30×40cm). Four small holes were made per bag for drainage of excess water to avoid water logging. Millet was sown on the 13th of August 2009, whereas wheat was sown on the 9th of December 2009. Seven seeds of each crop were sown in each bag and irrigated with tap water, at two days intervals. Plant samples were taken at ten weeks after sowing. Six fertilizers treatments namely, urea, EM, Elkhaseeb, Elkhairat, Abu floos, and chicken manure were used in addition to the control. Both experiments were arranged in a completely randomized design (CRD) with three replications.

Plant height was measured at ten weeks after sowing. After oven drying at 70°C for 72 hours, the root and shoot dry weights were recorded at ten weeks after sowing. After oven drying at 70°C for 72 hours, plants were ground to pass 0.50 mm sieve. Shoot nitrogen phosphorus and potassium content were determined at ten weeks after sowing according to (3).

Data collected for each plant were statistically analyzed using SAS statistical package program.

111. RESULTS

There were no significant differences in plant height of both crops between fertilizers, soil types or their interactions at ten weeks after sowing (Tables 3 and 4).

The root dry weights of both wheat and millet was neither significantly affected by the fertilizers nor by the soil types at ten weeks after sowing (Tables 3 and 4).

Application of fertilizers and soil types significantly ($p \leq 0.05$) affected the shoot dry weight of wheat, at ten weeks after sowing (Table 3). Elkhaseeb, Elkhairat, CM and Abu floos significantly increased shoot dry weight compared to control. Plants grown in Shambat and Gerif soils had significantly higher shoot dry weight than those grown in Elrawakeeb soil.

Application of Elkhaseeb significantly ($p \leq 0.05$) increased the shoot dry weight of millet at ten weeks after sowing compared to the control (Table 4). There were no significant differences in shoot dry weight between soil types and their interactions.

All fertilizers treatments except EM significantly ($p \leq 0.05$) increased the nitrogen content in the shoot of wheat compared to the control (Table 5). There were no significant differences between the soil types, however, significant differences were observed in the interactions.

Neither the fertilizers treatments nor the soil types significantly ($p \leq 0.05$) affected the phosphorus content of the shoot of wheat (Table 5).

The potassium content of wheat was significantly ($p \leq 0.05$) increased in Shambat and Elrawakeeb soils compared to Gerif soil. Fertilizers treatments had no significant effect on potassium content compared to the control, however significant differences were observed in the interactions (Table 5).

Elkhaseeb, Abu floos, CM and Elkhairat significantly ($p \leq 0.05$) increased the nitrogen content of millet compared to the control (Table 6). There were no significant differences between the soil types, however significant differences were observed when Elkhairat and Elkhaseeb were applied to Shambat, Elrawakeeb or Gerif soils respectively.

Elkhairat fertilizer applied on Shambat soil showed the highest nitrogen content.

Neither the fertilizers, nor the interactions significantly ($p \leq 0.05$) affected the phosphorus content of millet (Table 6). Phosphorus content of millet was higher for Elrawakeeb soil compared to Shambat and Gerif soils but not significant.

Elkhaseeb, CM, Abu floos and urea significantly ($p \leq 0.05$) increased potassium content of millet compared to the control (Table 6). Potassium content of millet was significantly higher for Elrawakeeb soil compared to Shambat and Gerif soils.

Table 1: Chemical composition of organic fertilizers used in this study

Fertilizers	N (%)	OC (%)	OM (%)	Na mmol/l	K mmol/l	P (%)	Ca (%)	Mg (%)
Chicken manure	2.80	28.6	49.2	5.34	6.84	0.70	8.30	2.53
Elkhaseeb	1.41	32.5	55.9	4.44	6.99	0.70	5.00	3.01
Elkhairat	1.02	11.7	20.1	1.98	4.35	0.30	5.82	4.50
Abu floos	1.03	10.4	17.9	1.80	7.11	0.28	8.30	1.51

Table 2 : Physical and chemical properties of soils used in this study

Soil Types	Particle size distribution (%)			pH (paste)	EC (dS/m)	Soluble cations (mmol/l)				P (%)	N (%)
	Sand	Silt	Clay			Na	K	Ca	Mg		
Shambat	28.7	29.8	41.5	7.54	1.33	10.63	0.38	5.16	1.00	0.41	0.07
Rawakeeb	81.7	3.3	15.0	7.00	0.18	0.73	0.10	1.33	0.83	0.34	0.01
Gerif	14.7	53.6	31.7	7.28	0.58	1.20	0.13	4.33	2.50	0.43	0.11

Table 3: Effects of organic chemical and microbial fertilizers on plant height (cm/plant), root dry weight (g/plant) and shoot dry weight (g/plant) of wheat grown in three soil types at 10 weeks.

Soils	Fertilizers							Soil means
	Control	Urea	EM	Elkhaseeb	Elkhairat	Abu floos	CM	
	Plant height							
Shambat	53.53a	50.53a	45.06a	54.43a	48.60a	54.20a	50.43a	50.97A
Rawakeeb	32.40a	44.36a	41.03a	52.96a	50.86a	48.33a	49.46a	45.63A
Gerif	50.66a	52.56a	41.50a	50.00a	44.46a	47.20a	55.66a	49.15A
mean	45.53A	49.15A	42.53A	53.13A	47.97A	49.91A	51.85A	
	Root dry weight							
Shambat	0.49a	1.11a	1.01a	0.85a	1.29a	0.91a	0.71a	0.91A
Rawakeeb	0.22a	1.49a	0.57a	1.33a	1.99a	1.23a	1.36a	1.17A
Gerif	0.64a	0.98a	2.38a	1.11a	2.62a	1.39a	1.77a	1.55A
mean	0.45A	1.19A	1.32A	1.10A	1.97A	1.18A	1.28A	
	Shoot dry weight							
Shambat	3.00bcdefg	3.28bcde	3.15bcdef	3.99ab	2.41bcdefghi	4.00a	2.89bcdefgh	3.24A
Rawakeeb	0.33j	0.81ij	1.28ghij	1.87defghij	2.28bcdefghi	1.49fghij	1.83efghij	1.41C
Gerif	1.13ghij	2.16cdefghi	1.21hij	3.73bc	3.72bc	1.61efghij	3.56bcd	2.47B
mean	1.54D	2.08BCD	1.88CD	3.20A	2.80AB	2.98AB	2.76ABC	

Means followed by the same letter(s) are not significantly different at $p \leq (0.05)$ according to Duncan′s Multiple Range Test.

Table 4: Effects of organic chemical and microbial fertilizers on plant height (cm/plant), root dry weight (g/plant) and shoot dry weight (g/plant) of millet grown in three soil types at 10 weeks.

Soils	Fertilizers							Soil means
	Control	Urea	EM	Elkhaseeb	Elkhairat	Abu floos	CM	
	Plant height							
Shambat	76a	90a	67a	95a	94a	89a	120a	90.10A
Rawakeeb	91a	95a	80a	84a	79a	96a	88a	87.56A
Gerif	92a	103a	99a	101a	101a	88a	100a	97.78A
mean	86.28A	96.02A	81.86A	93.44A	91.46A	90.86A	102.75A	
	Root dry weight							
Shambat	2.53a	6.40a	3.33a	3.96a	19.26a	4.76a	12.70a	7.56A
Rawakeeb	3.40a	6.83a	4.10a	12.03a	3.26a	5.30a	1.23a	5.16A
Gerif	2.16a	2.29a	2.40a	5.80a	2.06a	2.10a	0.76a	2.60A
mean	2.70A	5.37A	3.27A	7.26A	8.20A	4.05A	4.90A	
	Shoot dry weight							
Shambat	12.36a	17.33a	27.13a	20.76a	25.86a	14.56a	25.40a	20.49A
Rawakeeb	13.36a	16.93a	15.93a	34.30a	17.66a	20.93a	16.63a	19.39A
Gerif	12.73a	16.23a	19.33a	19.36a	10.83a	14.10a	7.50a	14.30A
mean	12.82B	16.83AB	20.80AB	24.81A	18.12AB	16.53AB	16.51AB	

Means followed by the same letter(s) are not significantly different at $p \leq (0.05)$ according to Duncan′s Multiple Range Test

Table 5: Effects of organic chemical and microbial fertilizers on nitrogen, phosphorus and potassium contents (%) of wheat grown in three soil types at 10 weeks.

Soils	Fertilizers							Soil means
	Control	Urea	EM	Elkhaseeb	Elkhairat	Abu floos	CM	
	Nitrogen							
Shambat	0.49f	3.57abc	3.59abc	2.24cde	2.61bcd	1.84de	2.14cde	2.35A
Rawakeeb	0.14f	2.05de	0.21f	3.66ab	2.52bcd	0.28f	3.71ab	1.79A
Gerif	0.28f	1.14ef	0.16f	3.87ab	3.12abcd	4.20a	3.50abc	2.32A
mean	0.30C	2.25AB	1.32BC	3.25A	2.75A	2.10AB	2.45AB	
	Phosphorus							
Shambat	0.07c	0.11bc	0.07c	0.08c	0.13ab	0.11bc	0.13ab	0.10A
Rawakeeb	0.08c	0.09bc	0.11bc	0.16a	0.16a	0.08c	0.07c	0.10A
Gerif	0.08c	0.11bc	0.11bc	0.11bc	0.08c	0.16a	0.09bc	0.10A
mean	0.07A	0.10A	0.10A	0.12A	0.12A	0.12A	0.10A	
	Potassium							
Shambat	2.62bc	2.53cd	1.67fghi	3.58a	1.85efgh	3.36a	1.31hijk	2.42A
Rawakeeb	0.95jkl	1.98cdefg	3.18ab	1.85efgh	2.36cde	2.05cdefg	2.26cdef	2.09B
Gerif	0.59 l	2.46cde	1.10ijkl	0.87kl	1.25hijk	1.53ghij	1.89defgh	1.38C
mean	1.38A	2.32A	1.98A	2.10A	1.82A	2.31A	1.82A	

Means followed by the same letter(s) are not significantly different at p≤ (0.05) according to Duncan′s Multiple Range Test

Table 6: Effects of organic chemical and microbial fertilizers on nitrogen, phosphorus and potassium contents (%) of millet grown in three soil types at 10 weeks.

Soils	Fertilizers							Soil means
	Control	Urea	EM	Elkhaseeb	Elkhairat	Abu floos	CM	
	Nitrogen							
Shambat	2.10def	2.45cdef	0.84f	3.03cdf	5.36a	3.64bcd	2.12def	2.79A
Rawakeeb	2.03def	1.82ef	2.31def	4.64ab	1.14f	2.47cdef	2.91cde	2.47A
Gerif	1.82ef	2.19def	1.89ef	2.87cde	1.58ef	3.94abc	3.08cde	2.48A
mean	1.98C	2.15BC	1.68C	3.51A	2.69AB	3.35A	2.70AB	
	Phosphorus							
Shambat	0.05a	0.12a	0.08a	0.09a	0.13a	0.14a	0.09a	0.10A
Rawakeeb	0.24a	0.21a	0.13a	0.16a	0.12a	0.14a	0.08a	0.15A
Gerif	0.11a	0.15a	0.13a	0.21a	0.09a	0.12a	0.11a	0.13A
mean	0.13A	0.16A	0.11A	0.15A	0.11A	0.13A	0.09A	
	Potassium							
Shambat	0.81hi	1.17fg	1.56bcde	1.2efg	1.06gh	1.27defg	1.45bcdef	1.22B
Rawakeeb	1.06gh	1.63bc	0.78hi	2.12a	1.60bcd	1.72b	1.42bcdef	1.47A
Gerif	0.61i	1.33bc	0.85hi	1.16fg	0.83hi	1.38cdefg	1.51bcde	1.10C
mean	0.82D	1.38AB	1.06 CD	1.51A	1.16BC	1.45AB	1.46AB	

Means followed by the same letter(s) are not significantly different at p≤ (0.05) according to Duncan′s Multiple Range Test

1V. DISCUSSION

Application of EM, in this study, did not significantly affect the studied parameters of wheat or millet crops grown on different soil types. Findings of some researchers showed that the effect of EM on crop yield was usually not evident or even negative particularly in the first test crop (4). Moreover, the source and amount of soil nutrients, soil type as well as the test crop may affect the establishment and efficacy of these microorganisms when these microorganisms are applied to the soil for the first time (5, 6). Foliar application of EM on two occasions after planting produced the lowest yields.

In this study, the application of different manufactured organic fertilizers (Elkhaseeb, Elkhairat and Abu floos) significantly increased most of the

measured parameters for wheat and millet crops. Generally, compost has a unique role in soil physical, chemical and microbial activity which helps in dissolving minerals in the soil resulting in more available nutrients to different crops (7). It was found that addition Elkhaseeb and Elkhairat significantly increased the plant dry weight (8). The preliminary results of the effect of Elkhairat on okra, wheat and cotton showed increments in crops yields in Khartoum and Gezira states (9).

Generally, the results of the experiments in this study indicated that chicken manure significantly increased various growth parameters of the tested crops. The positive effect of the organic fertilizers with respect to wheat production, in this study, is an added support to the similar results (10). This may be attributed to the fact that the addition of organic manure to the soil increases the reservoir of organic nitrogen and many other essential plant nutrients (2). Moreover, it was found that chicken manure application increased the soil N, P, and K concentration, whereas potassium was accumulated after burning residues (11). The fresh weight of maize (*Zea mays* L.) was significantly higher due to the application of organic fertilizers especially chicken manure compared to inorganic fertilizers and the leaf nitrogen, phosphorous and potassium contents were significantly increased by chicken manure compared to green manure and inorganic fertilizers (12).

In this study, urea significantly increased the root dry weight of wheat, shoot dry weight and potassium content of millet. Nitrogen as one of the macro-nutrients plays a great role in increasing plant production. However, nitrogen fertilizers (e.g. urea) are very expensive especially, in the developing countries because fertilizers are imported. In Sudan, the addition of nitrogen fertilizers is very important because Sudanese soils are deficient in nitrogen.

V. CONCULUSIONS

According to the findings of this study, the following conclusions could be pointed out: (i) Manufactured organic fertilizers (Elkhaseeb, Elkhairat and Abu floos) and Chicken manure significantly increased most of the measured parameters in both crops compared to the control and other fertilizers, (ii) Elkhaseeb significantly increased most of the measured parameters in both crops compared to Elkhairat and Abu floos (iii) Shambat soil showed the best growth performance for most of the measured parameters followed by Gerif and Elrawakeeb soils, respectively, (iv) aplication of urea significantly increased the root dry weight of wheat, shoot dry weight and potassium content of millet and (v) effective microorganisms (EM) showed no significant improvements in most of the measured parameters for both crops compared to the untreated control. It could also be suggested that local commercial production of organic fertilizers in Sudan should be encouraged and local factories to produce EM using local microorganisms should be established.

REFERENCES

[1] E. E. Ziegler, S. J. Fomon, S. E. Nelson, J.M. Jeter, and R. C. Theuer, "Dry cereals fortified with electrolytic iron or ferrous fumarate are equally effective in breast-fed infants", American Society for Nutrition, 2011, 141.pp243-248.

[2] R. Rasool, S.S. Kukal, and G. S. Hira, "Soil organic carbon and physical properties as affected by long-term application of FYM and inorganic fertilizers in maize - wheat system", Soil and Tillage Research, 2008, 101pp 31-36.

[3] AOAC, *Official Methods of Analysis*, 15th ed. Wilson Boulevard, Arlington, 1990. Virginia, USA.

[4] A. Javaid, and M. B. M. Shah, "Growth and yield response of wheat to EM (Effective Microorganisms) and parthenium green manure", African Journal Biotechnology, 2010, 9 pp 3378-3381.

[5] R.Bajwa, A. Javaid, and N. Rabbani, "EM and VAM technology in Pakistan, "Effect of organic amendments and effective microorganisms (EM) on VA mycorrhiza, nodulation and crop growth in (Trifolium alexandrianum) L", Pakistan Journal of Biological Sciences, 1999, 2 pp 590-593.

[6] A. Javaid, "Beneficial microorganisms for sustainable agriculture, In: Genetic Engineering, Biofertilisation, Soil Quality and Organic Farming, Sustainable Agriculture Reviews – 4. (Ed. E. Lichtfouse)", Springer Publishers, 2010, pp. 347-369.

[7] M. M. Wahbe, "Influence of compost on morphological and chemical properties of sandy soil. Egypt Journal Science Research", 2007, 11 pp 1490-1493.

[8] A. Y Awad Elkarim, A. G. Osman, and O. E. Nasr, "Effect of organic fertilizers on growth and yield of wheat. Journal of Islamic World Research and Studies Institute (IWRSI)", 2012, 9 pp 349-370.

[9] G. A. Elhassan, M. E. Abdelgani, , A. G. Osman, , S. S. Mohamed, and B. S. Abdelgadir, "Potential production and application of biofertilizers in Sudan. Pakistan Journal of Nutrition", 2010, 9 (9) pp 926-934.

[10] E. Elaagib, and I. Dawi, "Response of wheat to organic and inorganic fertilization in high terrace soils under New Hamdab conditions", Annual report (2005/2006) of Land and Water Research Center, Agricultural Research Corporation, Wad Medani, Sudan.

[11] A. L. Ortega, B. Govaerts, and K. Sayre, "Crop rotation, wheat straw management, and chicken manure effects on soil quality". Agronomy Journal, 2009, 101 pp 600-606.

[12] A. E. Elamin, and M. A. Elagib, "Comparative study of organic and inorganic fertilizers on forage corn (Zea mays L.) grown on two soil types", Qatar University Sciences Journal, 2001, 21 pp 47-54.