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UTILITY AND NUTRITIVE VALUES OF ORGANIC AND INORGANIC FERTILIZATION ON TEFF GRASS (ERAGROSTIS TEFF ZUCC. TROTTER) GROWTH AND SOME SOIL CHEMICAL PROPERTIES

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Abstract: *Purpose*: The effort were made to study the effect of organic fertilization (compost and vermicompost) produced from cotton residues and farmyard manure as well as to compare between the effects of organic fertilizer in comparison with inorganic fertilizers on Teff grass (Eragrostis tef Zucc.Trotter) as a test crop.
Design: Two pot experiments were conducted using Teff grass for two seasons, during 2008-2009; the effect of the four organic fertilizers was compared to that chemical fertilizer and control. The treatments were: cotton residues (CR), cotton residues + earthworms (CR+E), cotton residues +farmyard manure (CR+FYM), cotton residues + farmyard manure + earthworms (CR+FYM+E), urea and Control (C) each treatments in two levels equivalent 1N (1N = 43 kg N/ha) and 2N (2N= 86 kg N /ha). In conclusion , results indicated that the highest values of plant height (84.02, 45.94) , leaves Number (6.44,8.44) and fresh weight (2.13, 1.75) were determined in CR+FYM+E equivalent 2N treatment during the two season.
Findings: Vermicompost had a significant effect compared to others treatments and a positive effect of the organic fertilizer application was clearly observed in the second season.

Keywords: *Compost; Vermicompost; Earthworms – Chemical Fertilizer; Tef grass.*

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INTRODUCTION

Agricultural production in Sudan is practiced under several types of farming systems, which include irrigated, rain fed and traditional sectors. The main cash crops are cotton, sesame, gum Arabic and sugarcane, cotton is the main cash crop for export and contributes positively to the economy of the country (Helen, 1991). Millions of tons of cotton residues are burnt annually in irrigated schemes of Gezira-Managil (one of the largest state owned farms in the world), Rahad and Souki and these schemes, with heavy clay soils, extend over 3 million hectares. Cotton residues are usually burnt in order to prevent spread of residue-borne diseases such as Bacterial Blight (Suleiman and Christian, 2010). This practice may lead to many environmental problems such as contamination of water, soil and plants since burning the crop residues together with the residual herbicides and insecticides produce toxic material and gases. Furthermore, burning of such residues interferes with natural decomposition of organic matter.

The majorities of the productive or arable lands in the Sudan have developed and are still developing under arid conditions (desert, semi-desert, arid, semi-arid and dry sub-humid climatic zones). Therefore, it is not unexpected that these soils are low in organic matter content. Addition of organic matter is expected to improve the soil physical properties and fertility status of the soil and hence improve the productivity of the land. It is preferable that addition of organic matter should be in compost form when it is feasible. It is worth mentioning that available literature of vermincomposting in Sudan is very rare. Therefore, the main objective of this reserch work is to scan the effect of addition of earthworms together with compost and vermincompost on pools of total nitrogen, available phosphorus and available potassium in soils and plants.

MATERIAL AND METHODS

MATERIALS

The clay loam soil samples used in this work were collected from the demonstration farm of the University of Khartoum. Compost (CR and CR+FYM) and vermicompost (CR+E and CR+FYM+E) materials were brought from the department of Soil and Environmental Sciences, University of Khartoum, Faculty of agriculture. The chemical characteristics of the soil, compost and vermicompost shown in table1. Urea mineral fertilizer was brought from local market. Teff grass (Eragrostis tef Zucc. A Trotter) seed which was obtained from the department of agronomy, University of Khartoum, was used as a test crop.

Table 1: Physiochemical of Soil and Different Types of Composts and Vermicompost Used for Experimentation.

Parameters	Soil	CR	CR+E	CR+FYM	CR +FYM+E
pH 1:5	7.65	7.21	7.15	7.17	7.14
EC 1:5 (dS/m)	0.14	0.92	2.51	0.94	2.10
TN (%)	0.05	0.28	0.48	0.32	0.42
P (mg/kg)	5.1	29.77	54.21	31.77	29.77
K^+ (mg/kg)	1.2	0.96	1.35	1.00	1.45
OC (%)	1.00	8.14	11.03	8.15	10.51
NH_4-N (mg/kg)	70.91	40.83	57.85	43.62	55.02
NO_3-N (mg/kg)	64.72	40.25	46.56	51.72	40.9
Zn (ppm)	0.08	0.07	0.073	0.073	0.066
Mn (ppm)	0.90	0.68	0.66	0.72	0.56
Fe (ppm)	58.29	36.01	46.45	46.45	38.67
Cu (ppm)	0.05	0.035	0.041	0.036	0.040

CR– Cotton residues, E – Earthworms, FYM– farmyard manure, EC– Electrical Conductivity, OC– organic carbon

METHODS

EXPERIMENTAL SITE AND DESIGN

Two seasons pots experiments were formulated at the demonstration farm of the Faculty of Agriculture, University of Khartoum, Sudan (latitude 15°:14´ N and longitude 32°:32´E and elevation of 380 meter above mean sea level). The experiments were designed as a complete randomized design (CRD) with four replicates. Soil weight was 7 kg per pot. Teff grass seeds were planted in different pots at seed rate of 0.51 gram /pot (Murtada, 2004). Compost, vermicompost and urea were mixtured with soils as follows: cotton residues equivalent 1N & 2N urea (CR eq 1N &2N), cotton residues +farm yard manure equivalent 1N &2N urea (CR+FYM eq 1N &2N), cotton residues + earthworms equivalent 1N &2N urea (CR+E eq 1N &2N), cotton residues +earthworms +farm yard manure equivalent 1N & 2N urea (CR + FYM+E eq 1N &2N), urea 1N &2N and un-amended soil was used as Control (C). Calculation of added quantities of different materials was done depending on nitrogen content as two levels (1N= 85 kg N ha-1, 2N=170kg N ha-1). Irrigation was done every three days at the regime of 1.6 liters/pot depending on field capacity of soil.

Plant growth parameters and mineral composition

At each end of season (time of harvesting) five plant were selected randomly from each experimental pot and some plant growth parameters namely: plant height, number of leaves/ plant, number of tillers/ plant and fresh weight / plant were recorded. Moreover, the plant samples were taken from each pot and dried in air oven at the 70^{o} C and then crashed, total nitrogen was determined using Micro-Kjeldahal methods

(Association of official analytical chemists, 2000) , dry ashing methods at 550º C to analyzing the phosphorus using spectrophotometer and potassium using flame photometer.

CHEMICAL ANALYSIS OF SOIL MIXTURES

The soil samples were taken at the end of each season tested in laboratory for pH, electrical conductivity (EC), total nitrogen, available phosphorus and soluble potassium. The pH and EC were measured in suspension 1:5 (w/v) distilled water using digital pH-meter for the pH, while digital EC- meter for the EC. Total nitrogen determined by following micro Kjeldahl methods (Jackson, 1975) and the Mineral nitrogen (NO3- and NH4+) were measured by steam distillation method according to Bremner and keeney (1965). The organic carbon was measured by the oxidation method using potassium dichromate and titration with excess dichromate with ammonium ferrousulfate (Kalembasa and Jenkinson, 1973). The available phosphorus was measured using the method described by Anderson and Ingram (Olsen et al., 1954). Fe, Zn, Mn and Cu were measured by atomic absorption spectrophotometer (AAS|) in DTPA (diethylene triaminepentaacetatic acid) extract.

Statistic analysis

Analysis of variance (ANOVA) was followed to test the significant of the differences among variables. Multiple range tests were followed to test differences among mean least significant differences (LSD) or Duncan. Unless otherwise indicated, null hypothesis was rejected at $P < 0.05$. SPSS packages were used for all analyses (SPSS version 13.0. SPSS Inc., Chicago IL, USA, 2006).

Results and discussion

Effect of different of compost, vermicompost and urea on Teff plant growth

As presented in table 2 the effect of the different fertilizers season one, showed no significant different (P≥0.05) in plant height, numbers of leaves, numbers of tillers and plant fresh weight of the Teff plant, in general, organic fertilizers release their nutrients slowly over a fairly long time and depend on microbial organisms in the soil to break down the material and make it available to plant roots (South orange county wastewater authority, 2007). In second season, significant differences were observed in different growth parameters in Teff plant except the number of leaves. The positive effect of compost and vermicompost fertilizers may be attributed to the fact that these types of fertilizers are rich of micro constituents that are usually available for plant and react with soil environment needing long time, therefore, it was highly efficient in the second season compared to the first one. These findings are supported by that reported by Ibrahim (1999) and Cecil et al (1997). However, no difference was observed in most parameters of the organic fertilizers as compared to urea. Esawy et al (2009) confirmed that the combination of organic and inorganic fertilizers could increase plant growth, yield, and quality soil fertility.

Concentration of nitrogen, potassium and phosphorus in teff grass as affected by compost, vermicompost and urea

Results in table 3 show that effect of treatments on concentration of nitrogen, phosphorus and potassium in Teff plant tissue. The recorded data revealed that, these were statistically differences (p≥0.05) among treatments for nutrient concentration of the two seasons. The highest value of nitrogen concentration (0.84%) in the first season was recorded in urea eq. 2N while for the second season (1.92%) which was recorded for CR+FYM+E eq. 2N treatment. Nitrogen content in teff grass in all treatments containing vermicompost and compost equivalent 2N, with exception of CR+Eeq. 2N, was significantly ($p \leq 0.05$) higher than other treatments. These results indicate that the loss of nitrogen from chemical fertilizer (urea) was faster than that of organic fertilizer. Esawy et al (2009) reported that growing crops with chemical fertilizer alone cannot mitigate the loss of nitrogen while combined application of organic manure and chemical fertilizer was effective in this respect. For the phosphorus concentrations in different treated teff plant in first season the results show that application of compost and vermicompost increased phosphorus concentration significantly as compared to the control. The highest concentration was that found in CR+E eq. 1N treatments (1.14%) followed by CR+FYM+ E treatments (0.6) and CR+FYM eq.1Ntreatment (0.58). Moreover, for the second season the phosphorus concentrations followed the same trend as that of the first season. The highest value was that recorded for the CR+FYM+E treatments followed by both organic fertilizer treatments there was no significant ($p>0.05$) different between them and the lowest values recorded for the chemical fertilizer and control. For the potassium concentrations teff plant of the first and second season followed the same trend of the phosphorus. In general relative increase for the concentration of phosphorus and potassium were observed in vermicompost treatments, compost treatments, urea treatments and control, these results are shown clearly in the second season. In agreement with these results were the findings reported by Nahed et al (2011) on vegetables pointed out that compost almost positive for the percentage and content of nitrogen, phosphorus and potassium.

Effect of compost and vermicompost on soil pH, electrical conductivity, total nitrogen, available potassium and available phosphorus for two seasons

Table 3 present the results of pH, electrical conductivity, total nitrogen, available phosphorus and available potassium content for the soil used for the pots experiment for the first and second season as effected by addition of compost and vermicompost respectively. The results revealed that for the first season there were no significant different ($p>0.05$) in pH between all treatments. The highest pH mean 8.26 was obtained by CR+E eq. 2N and the lowest value 8.09 was obtained by CR+E eq. 1N. Moreover, the results of the first season as compared to the second one were slightly different. For the second season the highest value 7.47 of pH was that of the treatments CR+FYM+E eq. 2N and the lowest value 7.12 was that of the control. The non significant change in pH values could be due to the buffer capacity of the soil used (Goh and Haynes, 1977). For the electrical conductivity the results illustrated that there was no significant difference between both treatments for the first season, the highest values of EC were observed in CR treatments and the lowest values were obtained by chemical fertilizer and control. For the second season the results indicated that slight differences were observed between some treatments. The highest values of EC1:5 0.34 dS/m were recorded in CR+FYM+E treatments and the lowest value 0.18 dS/m was that of the control. These results agree with that reported by Mohammed et al. (2009). For the nitrogen content the results shows that there were no significant difference ($p>0.05$) between all treatments for the two seasons, these results may be due to loss of nitrogen, as nitrate by the process of leaching due to continues addition of water, as well as plant uptake. Agbenin and Goladi (1997) reported that when soils with low organic matter, cation exchange and buffer capacity, are under continuous cultivation, organic matter declines quite rapidly followed by extensive leaching of basic cations and rapid development of acidity, and concluded that growing of crops with chemical fertilizer alone cannot mitigate the loss of carbon, nitrogen and phosphorus while combined application of organic manure and chemical fertilizer was effective in this respect. The concentration of available phosphorus shows significant difference ($p<0.05$) between compost, vermicompost and chemical fertilizer treatments for the two seasons. Moreover, increase in available phosphorus was observed in most treatments of the second season as compared to the first one. The highest value of available phosphorus in both season were obtained by CR+V+F treatments and the lowest values were obtained by Control and chemical fertilizer treatments. Gil et al. (2007) accomplished a comparison of the effect of compost plus mineral with conventional mineral fertilization, the available P concentration in soil significantly increased to the same extent with both treatments after one year. In contrast Warman and Termeer (2005) compared organic and conventional fertilizers in two years of field experiment. They found that nutrient availability from the organic amendments (especially N and P) was considerably lower than 50% at the end compared to beginning of the experiment. The results of available potassium concentration in both season indicated that potassium behaved similarly as available phosphorus. Although there were no significant differences ($p>0.05$) between the different treatments in the first season, available potassium content in the first season statistically differed from the second season. For the second season the highest values of the available potassium were measured in the soil treated by CR+FYM+E eq 2N. Gil et al. (2007) reported that available potassium significantly increased in soil fertilized with compost plus mineral fertilizers, whereas its concentration did not change with mineral fertilization compared to the initial soil.

BIOGRAPHY

Dr. Ibrahim Saeed Ibrahim is currently a Senior Lecturer at the Department of Soil and Environment Sciences, Faculty of Agriculture University of Khartoum, Khartoum, Sudan, where he teaches the graduate and postgraduate courses in soil Sciences. Born in Atbara, Sudan, he is a graduate and postgraduate (B.SC & M.Sc) of the University of Khartoum. He also holds a PhD degree from the University of Oxford, England. Has served as Head of Department of Soil and Environment Sciences, Director of Desertification and Desert Cultivation Institute, Secretary of Faculty Research Board and Deputy Dean of Faculty of Agriculture, University of Khartoum, he also worked as Assistant Director of the Society of Arab Colleges of Agriculture, Associate Professor at the University of Omer, Libya and External Examiner of the University of Dresden, Germany. His current research interests include: soil genesis and classification, soil survey and land evaluation, land degradation monitoring and land Management

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Table 2:
Plant Height, Number of Leaves, Number of Tillers and Fresh Weight of Teff Plant in Different Treatments for Two Seasons.

	Season one				season two			
Treatments	Height (cm)	leaves No.	tillers No.	Fresh weight (gm/plant)	Height (cm)	No. leaves	No. tillers	Fresh weight (gm/plant)
CR eq 1N	69.69^{a}	5.88^{a}	4.25^{a}	1.39^{a}	42.88^{bc}	6.31^{bc}	4.25^{a}	1.24^{cd}
CR eq 2N	80.34^{a}	6.31^{a}	6.00^{a}	1.60^{a}	45.00^{a}	6.25^{bc}	6.00^{a}	1.36^{bc}
CR+FYM eq 1N	74.45^{a}	6.33^{a}	5.00^{a}	1.26^{a}	40.56^{c}	6.19^{bc}	5.00^{a}	1.32^{bc}
CR+FYM eq 2N	73.67^{a}	5.81^{a}	6.00^{a}	1.31^{a}	31.31^{f}	6.13^{bc}	4.75^{a}	1.41^{bc}
CR+E eq 1N	66.98^{a}	6.13^{a}	5.75^{a}	1.71^{a}	33.19^{ef}	5.44^{c}	5.75^{a}	1.53^{ab}
CR+E eq 2N	75.22^{a}	6.25^{a}	5.50^{a}	2.58^{a}	45.13^{ab}	6.25^{bc}	5.50^{a}	1.73^{a}
CR+FYM+E eq 1N	73.53^{a}	5.25^{a}	4.5^{a}	1.48^{a}	37.25^{d}	6.75^{b}	4.50^{a}	1.43^{b}
CR+FYM+E eq 2N	84.02^{a}	6.44^{a}	4.75^{a}	2.13^{a}	45.94^{a}	8.44^{a}	4.75^{a}	1.75^{a}
Urea eq 1N	75.54^{a}	5.63^{a}	4.00^{a}	1.38^{a}	31.38^{f}	6.06^{bc}	4.00^{a}	1.24^{bc}
Urea eq 2N	70.11^{a}	4.94^{a}	1.41^{a}	4.00^{a}	35.69^{de}	5.94^{bc}	4.00^{a}	1.42^{bc}
Control	64.71^{a}	6.63^{a}	4.00^{a}	1.37^{a}	25.94^{g}	3.88^{g}	4.00^{a}	1.42^{bc}
SE ±	4.572	0.3806	0.8627	0.3034	1.1789	0.3847	0.1338	0.15061

Means in the same column with different letter (s) are significantly different ($P \leq 0.05$) according to Least Significant Test (LSD)

Table 3:

Concentration of Nitrogen, Phosphorus and Potassium in Teff Plant Tissue in Different Treatments for the Two Seasons

Treatments	Season one TN (%)	Season one P (%)	Season one K^{+} (%)	Season two TN (%)	Season two P (%)	Season two K^{+} (%)
CR eq 1N	0.51^{d}	0.50^{bc}	0.45^{ab}	0.90^{ef}	0.65^{b}	0.34^{ab}
CR eq 2N	0.78^{ab}	0.54^{bc}	0.34^{abc}	1.26^{cd}	0.66^{b}	0.33^{ab}
CR+FYM eq 1N	0.58^{cd}	0.59^{b}	0.38^{abc}	0.98^{def}	0.65^{b}	0.35^{ab}
CR+FYM eq 2N	0.64^{c}	0.58^{b}	0.45^{ab}	1.36^{bc}	0.71^{b}	0.35^{ab}
CR+E eq 1N	0.72^{b}	1.14^{a}	0.45^{ab}	1.14^{cde}	0.73^{b}	0.37^{ab}
CR+E eq 2N	0.76^{ab}	0.54^{bc}	0.44^{ab}	0.98^{def}	0.62^{b}	0.34^{ab}
CR+FYM+E eq 1N	0.79^{ab}	0.60^{b}	0.66^{a}	1.62^{ab}	1.02^{a}	0.38^{ab}
CR+FYM+E eq 2N	0.79^{ab}	0.60^{b}	0.43^{ab}	1.92^{a}	1.02^{a}	0.35^{ab}
Urea eq 1N	0.61^{cd}	0.42^{bc}	0.43^{ab}	0.74^{e}	0.50^{c}	0.29^{bcd}
Urea eq 2N	0.84^{a}	0.42^{bc}	0.13^{bc}	1.06^{cde}	0.50^{c}	0.27^{cd}
Control	0.45^{cd}	0.38^{c}	0.07^{c}	0.73^{f}	0.51^{c}	0.26^{d}
SE±	0.054	0.0532	0.0213	0.1399	0.0293	0.093

Means in the same colum with different letter (s) are significantly different (*$P \leq 0.05$*) according to Least Significant Test (LSD)

Table 4:
Effect of Compost, Vermicompost and Urea on Soil pH, Electrical Conductivity, Total Nitrogen, Available Potassium and Available Phosphorus for the Two Seasons

	Season one					season two				
Treatments	pH 1:5	EC 1:5	Nt%	P (mg/kg)	K^+ (mg/kg)	pH 1:5	EC 1:5	N%	P (mg/kg)	K^+ (mg/kg)
CR eq 1N	7.63^{a}	0.33^{a}	0.15^{a}	1.37^{ab}	1.14^{a}	7.22^{bc}	0.30^{a}	0.14^{a}	1.65^{bc}	1.42^{de}
CR eq 2N	7.60^{a}	0.32^{a}	0.18^{a}	0.86^{cde}	1.37^{a}	7.42^{ab}	0.28^{ab}	0.16^{a}	1.49^{c}	1.38^{de}
CR+FYM eq 1N	7.62^{a}	0.24^{a}	0.17^{a}	1.20^{abc}	1.16^{a}	7.35^{ab}	0.25^{bc}	0.14^{a}	1.86^{ab}	1.66^{cd}
CR+FYM eq 1N	7.70^{a}	0.20^{a}	0.16^{a}	1.06^{bc}	1.37^{a}	7.41^{ab}	0.30^{a}	0.14^{a}	1.79^{ab}	1.83^{bc}
CR+E eq 1N	7.69^{a}	0.24^{a}	0.39^{a}	1.02^{bc}	1.14^{a}	7.34^{ab}	0.25^{bc}	0.10^{a}	1.83^{ab}	1.51^{de}
CR+E eq 2N	7.76^{a}	0.20^{a}	0.16^{a}	0.87^{cde}	1.32^{a}	7.26^{bc}	0.23^{bcd}	0.17^{a}	1.02^{d}	1.42^{bc}
CR+FYM+E eq 1N	7.69^{a}	0.24^{a}	0.36^{a}	1.52^{a}	1.4^{a}	7.24^{bc}	0.34^{a}	0.49^{a}	1.53^{c}	2.06^{ab}
CR+FYM+E eq 2N	7.75^{a}	0.19^{a}	0.19^{a}	0.89^{cd}	1.37^{a}	7.47^{a}	0.33^{a}	0.37^{a}	1.98^{a}	2.20^{a}
Urea eq 1N	7.70^{a}	0.26^{a}	0.14^{a}	0.55^{e}	1.15^{a}	7.32^{bc}	0.20^{cd}	0.12^{a}	150^{c}	1.33^{de}
Urea eq 2N	7.61^{a}	0.17^{a}	0.15^{a}	0.59^{e}	1.23^{a}	7.16^{c}	0.26^{bc}	0.13^{a}	145^{c}	1.28^{e}
Control	7.73^{a}	0.19^{a}	0.12^{a}	0.70^{de}	0.96^{a}	7.12^{c}	0.18^{b}	0.11^{a}	1.70^{ab}	1.23^{e}
SE ±	0.045	0.0803	0.084	0.1576	0.1576	0.0745	0.0298	0.1082	0.1132	0.15051

Means in the same colum with different letter (s) are significantly different (*$P \leq 0.05$*) according to Least Significant Test (LSD)