Available online at www.worldnewsnaturalsciences.com

World News of Natural Sciences

An International Scientific Journal

WNOFNS 46 (2023) 53-67 EISSN 2543-5426

Performance of Fodder Sorghum (*Sorghum bicolor* L.) in a Sandy Soil as Influenced by Application of Manure and Canal Sediment

Mubarak Abdelrahman Abdalla[1], **Ali Abdalla Mohammed**[2,*], **Imran Ali Ahmed**[2], **Ammar Wedaa Hammad**[2], **Elsadig Agbna Elhadi**[3] and **Fatoma Ali Mohamed Rezig**[4]

[1]Desertification and Desert Cultivation Studies Institute, University of Khartoum, Sudan

[2]National Institute of Desert Studies, University of Gezira, Wad Medani, Sudan

[3]Institute of Environmental Studies, University of Khartoum, Sudam

[4]National Research Center, Khartoum, Sudan

*E-mail address: aliabdala97611976@gmail.com

ABSTRACT

This the study was conducted for two successive seasons(winter and summer seasons of 2017/2018) on a desert soil with the aim to investigate the effects of canal sediment (CS) and chicken manure (CM) on some properties of a desert soil and performance of fodder sorghum. The treatments (CS, CM, and their combinations and a control) were arranged in a randomized complete block design (RCBD) with three replications. Some selected soil properties and dry matter yield were determined. Canal sediment and CM were effective in improving soil moisture content and had minor increase in organic carbon, total nitrogen, available phosphorus and potassium. Canal sediment and CM can be ranked according to their effectiveness in improving the soil properties and increasing dry matter yield of fodder sorghum as follows: the chicken manure (4 t ha^{-1}) + N 86 kg, canal sediment (30 t ha^{-1}) + chicken manure (4 t ha^{-1}) + N 86 kg, canal sediment (10 t ha^{-1}) + chicken manure (4 t ha^{-1}) + N 86 kg, N 86 kg, canal sediment (30 t ha^{-1}) and lastly canal sediment (10 t ha^{-1}).

***Keywords*:** Light texture, soil quality parameters, chicken manure, Canal sediment

(Received 10 December 2022; Accepted 28 December 2022; Date of Publication 29 December 2022)

1. INTRODUCTION

Major changes in climate has increased global areas of dry land to about 50 million km^2 which indicates that 35 to 40% of the total global area is under arid and semi-arid (Schimel, 2010; Ziadat et al., 2012). Such phenomenon has resulted in successive droughts with persistence of resource miss-management has expanded marginal agricultural production systems of the world and thereby threatening food security (DLRC, 2005).Dry land degradation was estimated to induce an annual global terrestrial net loss of land productivity of around 2% (Zika and Erb, 2009). Generally, most soils under arid conditions have extremely low quality due to poor physical conditions (Al-Darby, 1996), low organic matter and water retention capacity, soil fertility and consequently both low water and fertilizer use efficiencies (Sivapalan, 2006). Accordingly, programs aimed at planning and sustainable agricultural management in dry lands are facing extremely large challenges.

Turning marginal agriculture production systems such as desert soil productive relies mainly on many factors including water availability and improving soil physicochemical properties(Scotti et al., 2015; White et al., 2012) by reducing loss of organic matter and water infiltration rate (Eldridge et al., 2000; Lal, 2004), increasing water and nutrients retention capacity (Mor-Mussery et al., 2013a; Mazen et al., 2015; Kianian et al., 2018; Sun, 2018), introduction of stress-tolerant, climate resilient nutritious food crops (Choukr-Allah et al., 2016) and development of site-specific fertilizer recommendation of inherently infertile soils (Soropa et al., 2019).

Practice of application of organic amendments is old (Montgomery, 2007) and remains the optimal alternative for sustainable soil management (Larney and Angers, 2012) since it increases levels of organic matter and considered a single most important property affecting soil quality and functioning (Gregorich et al., 1994).Organic amendments will expect to be more available especially with the world forecast showing increased growth (Larney and Angers, 2012). Previous studies on magnitude of change that recycling of organic materials may induce in buildup of soil carbon varies according to many factors including initial carbon content and quality (Chantigny et al., 1999; Lashermes et al., 2009) and intrinsic cation exchange capacity, texture of degraded soil (Kasonogo et al., 2011) and soil-quality parameters (Yang et al., 2007; Idowu et al., 2017; Iqbal et al., 2018). Under desert conditions, successive three years of incorporation of manures reduced bulk density by 17%, increased porosity and soil moisture by 29, 80%, respectively and grain yield of wheat by 3-5 times the control (Ahmed et al., 2018). Similarly, under extreme desert conditions, application of composted manure had positive effects on soil quality and crop performance (Yu et al., 2011; Ibrahim and Fadni, 2013; Mubarak et al., 2015; Dawi et al., 2017).

Ahmed (2017) evaluated the effect of green and chicken manures on properties of desert plain soil in Northern Sudan. His study showed that each of the tested manures was effective in improving the soil chemical properties. A minor increase in organic carbon, nitrogen, available phosphorus and potassium were observed with application of the manures, but the pH was not affected by the source of organic manure.

The long-term annual sediment carried by the Blue Nile River was quantified between 130-170 ton $year^{-1}$ (Ali et al., 2014) with suspended sediment load distribution of clay, silt and fine sand to be 25, 16 and 59%, respectively (Mubarak and Ali, 2012).Recent work (Iqbal et al., 2018) showed addition of 10 t poultry manure compost ha^{-1} to sandy soils increased soil inorganic-N (512%), organic-carbon (78%), water-holding capacity (65.36%) and maize grain

(43.85%), stover yield (94%) and nitrogen use efficiency (30.6 kg kg^{-1}). Sudan grass or fodder sorghum (*Sorghum bicolor* L.), is an extensively used crop in making hay and silage for animal feed as it is adapted for low fertile and degraded soils (Skerman and Rivers, 1999; Pholsen and Suksri, 2007).

In Sudan, fodder sorghum was harvested in 70 days and locally known as "Abusabien", is the main annual fodder crop produced at 971000 ton of dry matter $year^{-1}$ and constituted about 43% of the total annual yield (Khair and Salih, 2007) used to feed 140 million heads of livestock (Ministry of Animals Resources 2004). The present study investigated the effects of incorporation of sediment from irrigation canals and chicken manure on properties of a desert soil and performance of fodder sorghum.

2. MATERIALS AND METHODS

Study site:

This study was carried out for two consecutive seasons (summer and winter seasons of 2017/2018) in the Experimental Research Farm (latitude 17º 55' N, longitude 31º 10' E) of the National Institute of Desert Studies(ERFNIDS), New Hamdab Scheme, Northern State, Sudan. Soil is non-saline and non-sodic and classified as haplocambids, coarse loamy, mixed, hyperthermic. The physical and chemical properties of the soil are shown in Table 1 (LWRC, 1999).

Table 1. Some soil properties of the experimental site.

Soil properties	Soil depth (cm)				
	0 - 23	23 - 65	65 - 80	80 - 105	105 - 125
FS (%)	40	23	22	21	24
CS (%)	37	33	43	42	40
Silt (%)	15	25	11	19	8
Clay (%)	8	19	24	18	28
Texture	**LS**	**SL**	**SL**	**SL**	**SCL**
pH_{paste}	7.5	7.3	8.1	7.8	7.5
ECe	0.35	0.37	0.42	1.1	3.2
ESP	3.0	3.0	4.0	5.0	8.0
$CaCO_3$ (%)	0.8	2.6	10.4	0.2	27.5
OC (%)	0.052	0.066	0.078	0.061	0.052
C/N ratio	4	4	5	5	5

FS = Fine sand, CS = Corase sand, LS = loamy sand, SL = sandy loam, SCL = sandy clay loam, OC = Organic carbon, ESP = Exchangeable sodium percent, ECe = Electrical conductivity of the saturation extract

Experimental:

The treatments are as follows:

Control (C)

Inorganic N: 86 kg N ha^{-1}

Canal sediment at 10 t ha^{-1} (CS10)

Canal sediment at 30 t ha^{-1} (CS30)

Chicken manure at 4 t ha^{-1} (CM)

Inorganic N: 86 kg N ha^{-1} with CS10 t ha^{-1} (NCS10)

Inorganic N: 86 kg N ha^{-1} with CM 4 t ha^{-1} (NCM)

CM with CS10 with N (CMCS10)

CM with CS10 with N (NCMCS10)

Plots (4 m × 4 m) were prepared using tractors mounted with disc harrow; manure and sediment (Table 2) were manually incorporated into the top 0-30 cm soil depth before two weeks from sowing. Treatments were arranged in a Randomized Complete Block Design (RCBD) with three replications. Fodder sorghum was manually sown on 20/11/2017 (for the winter season) and 15/03/2018 (for the summer season). River Nile water (EC of 0.25 dSm^{-1}) was used for irrigation (0.1 m^{3} m^{-2}) at 7 days interval until harvest (after 70 and 80 days from sowing for the winter and summer season, respectively). Gravimetric soil moisture content for the top 0-30 cm was weekly monitored using auger (5 cm ∅) whereas, plant height (from the soil surface to the growing point) was monitored at 15, 30, 45 and 60 days from sowing.

At harvest, 10 plants from the two inner rows were randomly selected, removed from the 5 cm above the soil surface, cut into parts (5-10 cm), inserted into labeled bags and immediately weighed in the field, air-dried, oven dried (75 °C) for 48 hrs, weighed (used to calculated total dry matter weight; ton ha^{-1}), crushed (0.5 mm) and analyzed for TN, P and K content. Then after, soil samples (0-30 cm) were collected from the inner 2 m × 2 m area, air-dried, sieved (2.0 mm ∅) and analyzed for pH_{paste} (McLean 1982), electrical conductivity (Richard 1954), TN (Bremner and Mulvaney 1982), organic carbon (Nelson and Sommers, 1982), available P (Olsen and Sommers 1982), soluble K^{+} (Chapman and Pratt 1961). Differences between treatments were determined by SAS (1995).

3. RESULTS ANDDISCUSSION

Chemical analysis of the amendments

Total N(4.5%), organic carbon (15%), total phosphorus (1.06%), total potassium (1.2%) are higher in CM as compared to that of CS (0.08, 0.73, 0.05, and 0.20 % respectively).

Table 2. Chemical analysis of the amendments

Amendments	N (%)	O.C (%)	Total P (%)	Total K (%)
Chicken Manure (CM)	4.5	15.0	01.06	1.2
Canal Sediment (CS)	0.08	0.73	0.05	0.20

Soil moisture percentage

The soil moisture percentage at W1, W2, W3, W4, W5, W6, W7, and W8 for the 0 - 30 cm soil depth during winter and summer seasons were shown in Figures 1 and 2, respectively. Chicken manure and CS generally increased soil moisture content as well. Soil moisture in the CS10 and N treatments were almost closed to the control in all weeks during the winter and summer seasons. However, during all weeks of both seasons, the soil moisture content has been clearly increased in the CM, CS30, and the interaction of CM and CS as compared with that of the control. The improvement of soil moisture content in response to application of soil amendments has widely been reported elsewhere (Ahmed*et al.*, 2018; Mor-Mussery et al., 2013a; Mazen et al., 2015; Kianian et al., 2018; Sun, 2018).

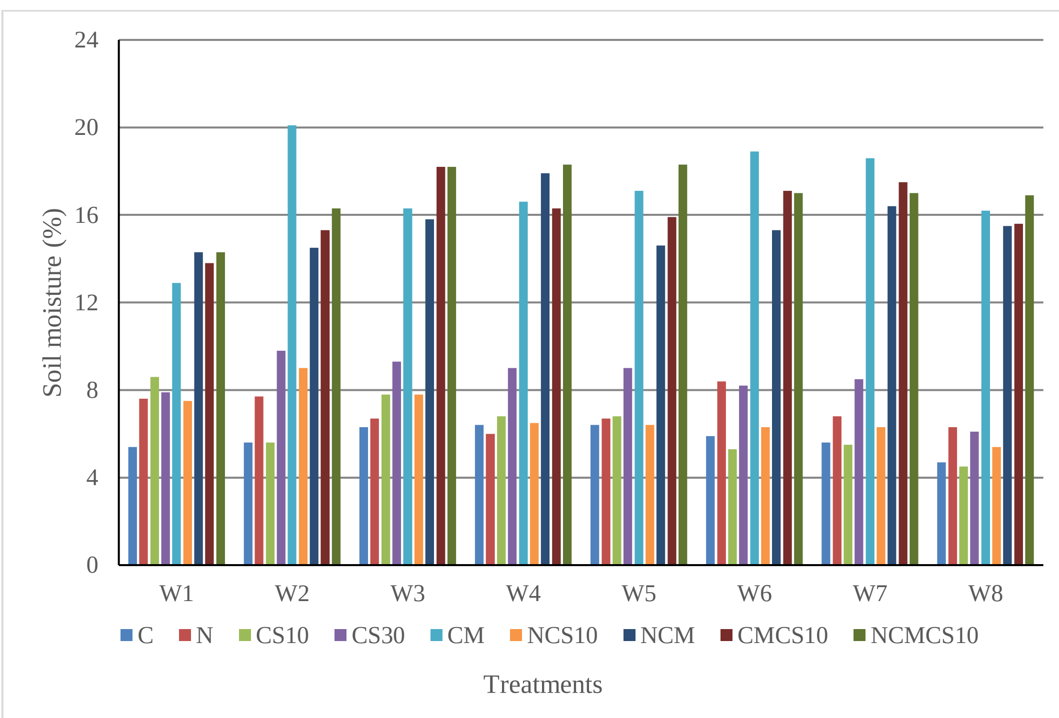

Figure 1. Monitoring of soil moisture content (%) in the top 0-30 cm during of winter season C: Control, N: 86 kg N ha^{-1}, CS10: Canal sediment at 10 t ha^{-1}, CS30: Canal sediment at 30 t ha^{-1}, CM: Chicken manure 4 t ha^{-1}, NCS10: 86 kg N ha^{-1} with Canal sediment at 10 t ha^{-1}, NCM: 86 kg N ha^{-1} with Chicken manure 4 t ha^{-1}, CMCS10: Chicken manure 4 t ha^{-1} with Canal

sediment at 10 t ha^{-1}, NCMCS10: 86 kg N ha^{-1} with Chicken manure 4 t ha^{-1} with Canal sediment at 10 t ha^{-1}

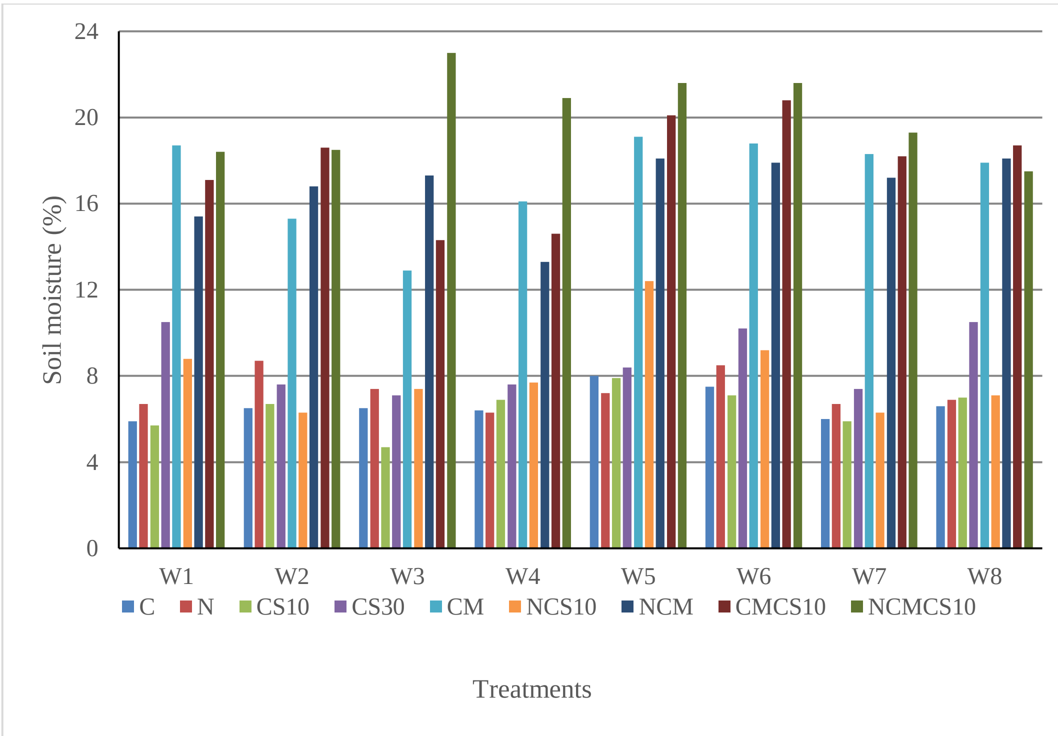

Figure 2. Monitoring of soil moisture content (%) in the top 0-30 cm during of summer season C: Control, N: 86 kg N ha^{-1}, CS10: Canal sediment at 10 t ha^{-1}, CS30: Canal sediment at 30 t ha^{-1}, CM: Chicken manure 4 t ha^{-1}, NCS10: 86 kg N ha^{-1} with Canal sediment at 10 t ha^{-1}, NCM: 86 kg N ha^{-1} with Chicken manure 4 t ha^{-1}, CMCS10: Chicken manure 4 t ha^{-1} with Canal sediment at 10 t ha^{-1}, NCMCS10: 86 kg N ha^{-1} with Chicken manure 4 t ha^{-1} with Canal sediment at 10 t ha^{-1}

Nutrients status in the soil:

In the top 0-30 cm soil depth and almost also in the 30-60 cm depth of both seasons, compared to the control treatment, there was slight increase in O.C%, TN, available phosphorus and potassium as a result of application of amendments (Table 3 and 4).However, in both depths and seasons, the pH was not affected by treatments which might be due to the possible leaching of soluble cations such as Ca^{2+}, Mg^{2+} and Na^{+} (though not determined in this study) that may have direct effects on pH changebelow the rooting zone. The retention of TN, P and K found in this study is inline withTahir and Mrschner (2017) who reported increased in nutrients retention in sandy soil treated with clay additions of 10 and 20%.However, the same author's authors have also reported no change in pH. In similar climatic conditions, Ahmed (2017) found that the organic manures had slight increase in O.C%, TN, available phosphorus, potassium and CEC and showed no change in pH.

Table 3. Effects of treatments on soil (0-30 and 30-60 cm) properties after harvest of the winter season (average ± standard deviation, n=3)

Treatments	$pH_{(paste)}$	EC dSm^{-1}	OC	TN	K meq L^{-1}	P μg^{-1}
			gkg^{-1}			
0-30 cm						
C	8.3±0.1a	0.56±0.1	0.400±0.01ab	0.1±0.00a	0.15±0.03a	2.13±0.84
N	8.2±0.1ab	0.46±0.2	0.480±0.01ab	0.1±0.00a	0.15±0.08a	1.50±0.72
CS10	8.1±0.2b	0.49±0.0	0.507±0.02ab	0.1±0.00a	0.18±0.02a	1.37±0.24
CS30	8.1±0.1bc	0.54±0.1	0.373±0.00b	0.1±0.00a	0.14±0.04a	5.57±0.30
CM	8.0±0.1bcd	0.60±0.0	0.613±0.02a	0.1±0.00a	0.24±0.01a	3.07±0.63
NCS10	8.1±0.0bcd	0.44±0.2	0.480±0.01ab	0.1±0.00a	0.36±0.02a	2.40±0.62
NCM	7.9±0.0cd	0.60±0.1	0.453±0.03ab	0.1±0.00a	0.19±0.00a	2.37±0.15
CMCS10	7.9±0.2d	0.56±0.1	0.560±0.02ab	0.1±0.00a	0.17±0.06a	5.27±0.14
NCMCS10	8.0±0.0bcd	0.59±0.1	0.453±0.01ab	0.1±0.00a	0.12±0.01a	3.60±0.59
P≤	*0.009*		*0.05*	*NS*	*NS*	
30-60 cm						
C	8.4±0.1a	0.46±0.2a	0.187±0.00d	0.1±0.00a	0.13±0.10a	
N	8.4±0.3a	0.23±0.1a	0.240±0.00c	0.1±0.00a	0.09±0.03a	1.53±0.04a
CS10	8.2±0.1a	0.33±0.1a	0.240±0.01c	0.1±0.00a	0.14±0.08a	2.37±0.50a
CS30	8.3±0.2a	0.42±0.2a	0.240±0.02c	0.1±0.00a	0.26±0.05a	0.63±0.21a
CM	8.3±0.1a	0.44±0.2a	0.240±0.01c	0.1±0.00a	0.09±0.03a	0.63±0.21a

NCS10	8.4±0.2a	0.34±0.1 a	0.187±0.01 d	0.1±0.00 a	0.12±0.06 a	5.87±0.6 7a
NCM	8.1±0.2a	0.25±0.0 a	0.240±0.01c	0.1±0.00 a	0.09±0.03 a	2.30±0.1 9a
CMCS10	8.2±0.2a	0.41±0.2 a	0.267±0.02 b	0.1±0.00 a	0.10±0.04 a	1.70±0.6 2a
NCMCS10	8.3±0.1a	0.39±0.2 a	0.293±0.02a	0.1±0.00 a	0.09±0.02 a	1.87±0.9 5a
P≤	*NS*	*NS*	0.03	*NS*	*NS*	*NS*

C: Control, N: 86 kg N ha^{-1}, CS10: Canal sediment at 10 t ha^{-1}, CS30: Canal sediment at 30 t ha^{-1}, CM: Chicken manure 4 t ha^{-1}, NCS10: 86 kg N ha^{-1} with Canal sediment at 10 t ha^{-1}, NCM: 86 kg N ha^{-1} with Chicken manure 4 t ha^{-1}, CMCS10: Chicken manure 4 t ha^{-1} with Canal sediment at 10 t ha^{-1}, NCMCS10: 86 kg N ha^{-1} with Chicken manure 4 t ha^{-1} with Canal sediment at 10 t ha^{-1}

Table 4. Effects of treatments on soil (0-30 and 30-60 cm) properties after harvest of the summer season (average ± standard deviation, n=3)

Treatments	$pH_{(paste)}$	EC dSm^{-1}	OC	TN	K meq L^{-1}	P μg^{-1}
			gkg^{-1}			
0-30 cm						
C	8.1±0.2	0.34±0.18	0.1±0.00	0.1±0.00	0.16±0.06	1.37±0.22
N	8.1±0.2	0.33±0.17	0.1±0.00	0.1±0.00	0.15±0.07	2.53±0.69
CS10	8.0±0.0	0.32±0.13	0.2±0.01	0.1±0.00	0.17±0.05	1.07±0.50
CS30	8.0±0.0	0.42±0.13	0.2±0.01	0.1±0.00	0.19±0.02	1.60±0.08
CM	7.9±0.1	0.44±0.02	0.1±0.00	0.1±0.00	0.16±0.03	4.83±0.07
NCS10	8.0±0.2	0.41±0.14	0.2±0.00	0.1±0.00	0.15±0.07	1.50±0.79
NCM	7.8±0.0	0.46±0.22	0.2±0.01	0.1±0.00	0.20±0.06	0.83±0.32
CMCS10	7.8±0.1	0.60±0.07	0.3±0.04	0.1±0.00	0.25±0.06	1.13±0.47
NCMCS10	7.8±0.1	0.56±0.10	0.2±0.02	0.1±0.00	0.16±0.11	1.60±0.08

30-60 cm						
C	8.1±0.3	0.40±0.15	0.1±0.00	0.1±0.00	0.10±0.01	1.97±0.18
N	7.9±0.1	0.32±0.14	0.1±0.00	0.1±0.00	0.10±0.02	3.53±0.37
CS10	8.1±0.1	0.43±0.17	0.1±0.00	0.1±0.00	0.12±0.03	0.97±0.38
CS30	8.0±0.1	0.41±0.15	0.1±0.00	0.1±0.00	0.09±0.02	0.50±0.26
CM	7.9±0.1	0.23±0.03	0.1±0.00	0.1±0.00	0.09±0.04	7.30±0.44
NCS10	7.9±0.1	0.32±0.13	0.2±0.00	0.1±0.00	0.10±0.05	3.67±0.12
NCM	8.0±0.1	0.33±0.15	0.1±0.00	0.1±0.00	0.13±0.06	4.53±0.72
CMCS10	7.9±0.2	0.29±0.13	0.2±0.01	0.1±0.00	0.11±0.04	0.83±0.49
NCMCS10	8.0±0.1	0.28±0.17	0.1±0.00	0.1±0.00	0.09±0.01	2.00±0.62

C: Control, N: 86 kg N ha^{-1}, CS10: Canal sediment at 10 t ha^{-1}, CS30: Canal sediment at 30 t ha^{-1}, CM: Chicken manure 4 t ha^{-1}, NCS10: 86 kg N ha^{-1} with Canal sediment at 10 t ha^{-1}, NCM: 86 kg N ha^{-1} with Chicken manure 4 t ha^{-1}, CMCS10: Chicken manure 4 t ha^{-1} with Canal sediment at 10 t ha^{-1}, NCMCS10: 86 kg N ha^{-1} with Chicken manure 4 t ha^{-1} with Canal sediment at 10 t ha^{-1}

Plant Performance:

Figures 3 and 4 illustrate the plant height (cm) after 15, 30, 45 and 60 days after sowing (DAS) of the fodder sorghum crop during winter and summer seasons. The chicken manure and CS treatments clearly increased the plant height at 15, 30, 45, and 60 days from sowing of the fodder sorghum crop as a compared to the control.. The longest plants (155.9 and 130.7) cm was recorded for NCM and NCMCS10 treatments for winter and summer seasons, respectively at 60 DAS. The shorter plants (78.8 and 96.3) cm were recorded for the control for the winter and summer seasons at 60 DAS. This result is in conformity with that of Agbede et al. (2020) and Larneyand Angers (2012) who reported that organic manure improved quality of sandy soils and their productivity.

Dry matter yield (t ha^{-1}) of fodder sorghum:

The average dry matter yield of fodder sorghum for winter and summer seasons as influenced by the soil amendments is shown in Figure 5.The results showed that there were significant differences in dry matter yield of fodder sorghum between the control and soil amendments treatments and their combination.

In the winter season the lowest dry matter yield was recorded by the control 2.69 t ha^{-1}. followed by CS which recorded 3.43 t ha^{-1} for CS 10 t ha^{-1} and 3.92 t ha^{-1} for CS 30 t ha^{-1}, which is not far from that of control. While the highest dry matter yield of (11.59 t ha^{-1}) was obtained in NCM treatment. For the summer season

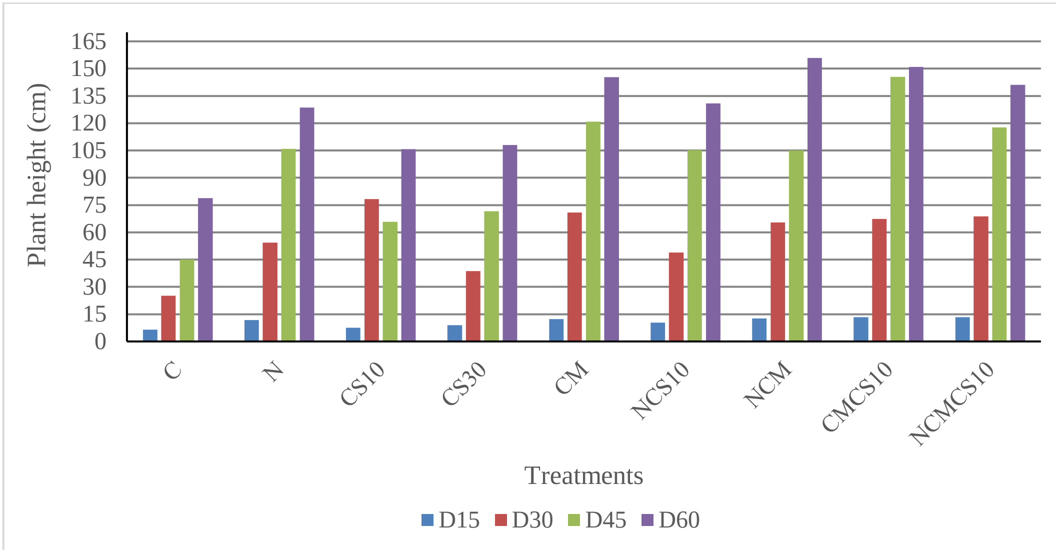

Figure 3. Plant height (cm) after 15, 30, 45 and 60 days from sowing of the winter season C: Control, N: 86 kg N ha^{-1}, CS10: Canal sediment at 10 t ha^{-1}, CS30: Canal sediment at 30 t ha^{-1}, CM: Chicken manure 4 t ha^{-1}, NCS10: 86 kg N ha^{-1} with Canal sediment at 10 t ha^{-1}, NCM: 86 kg N ha^{-1} with Chicken manure 4 t ha^{-1}, CMCS10: Chicken manure 4 t ha^{-1} with Canal sediment at 10 t ha^{-1}, NCMCS10: 86 kg N ha^{-1} with Chicken manure 4 t ha^{-1} with Canal sediment at 10 t ha^{-1}

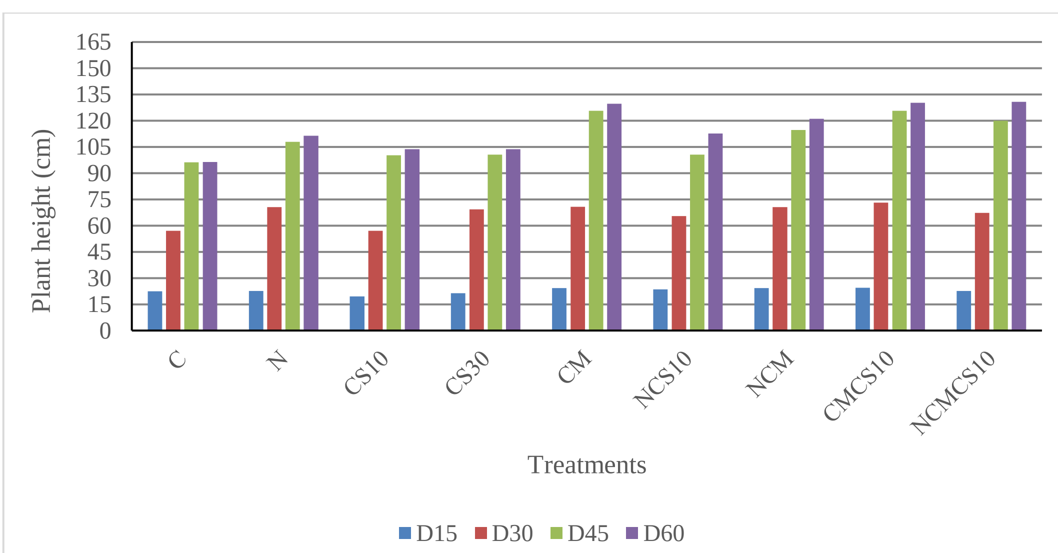

Figure 4. Plant height (cm) after 15, 30, 45 and 60 days from sowing of the summer season C: Control, N: 86 kg N ha^{-1}, CS10: Canal sediment at 10 t ha^{-1}, CS30: Canal sediment at 30 t ha^{-1}, CM: Chicken manure 4 t ha^{-1}, NCS10: 86 kg N ha^{-1} with Canal sediment at 10 t ha^{-1}, NCM: 86 kg N ha^{-1} with Chicken manure 4 t ha^{-1}, CMCS10: Chicken manure 4 t ha^{-1} with Canal sediment at 10 t ha^{-1}, NCMCS10: 86 kg N ha^{-1} with Chicken manure 4 t ha^{-1} with Canal sediment at 10 t ha^{-1}

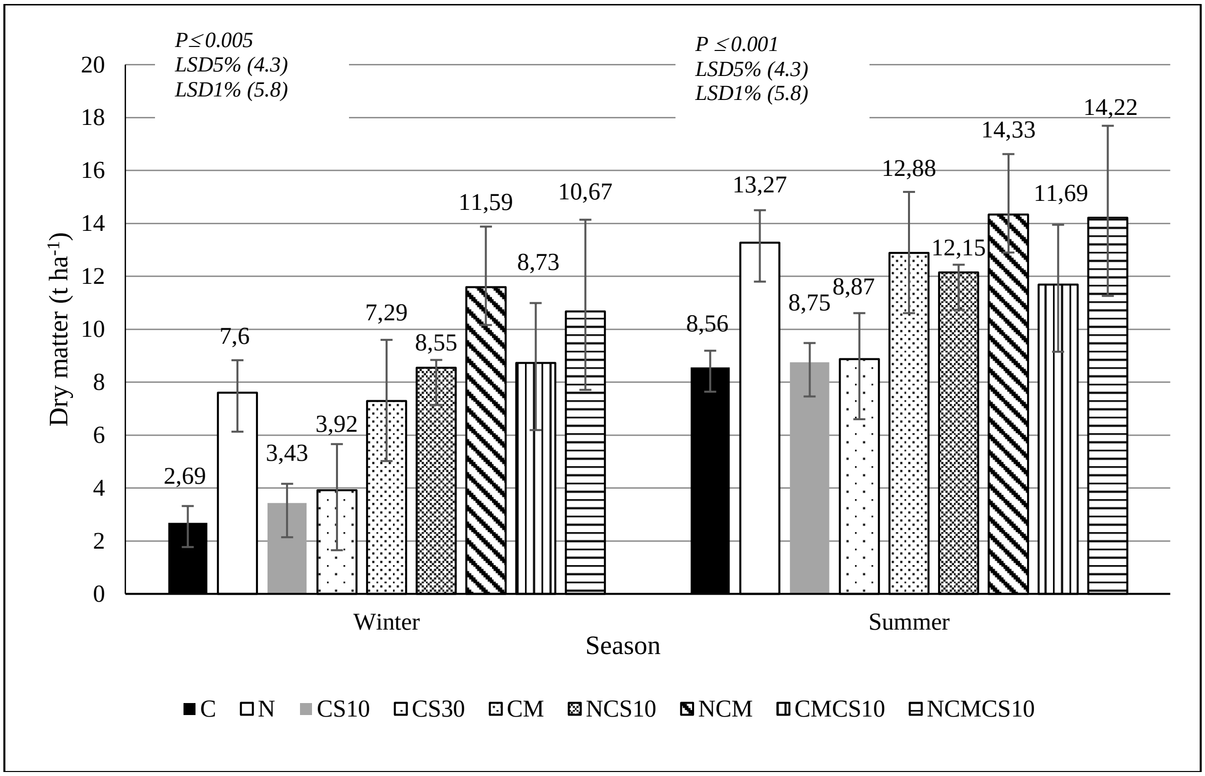

Figure 6. Dry matter yield (t ha-1) of fodder sorghum in winter and summer seasons as affected by treatments (average ± standard deviation n=3. C: Control, N: 86 kg N ha^{-1}, CS10: Canal sediment at 10 t ha^{-1}, CS30: Canal sediment at 30 t ha^{-1}, CM: Chicken manure 4 t ha^{-1}, NCS10: 86 kg N ha^{-1} with Canal sediment at 10 t ha^{-1}, NCM: 86 kg N ha^{-1} with Chicken manure 4 t ha^{-1}, CMCS10: Chicken manure 4 t ha^{-1} with Canal sediment at 10 t ha^{-1}, NCMCS10: 86 kg N ha^{-1} with Chicken manure 4 t ha^{-1} with Canal sediment at 10 t ha^{-1}recorded by the control 8.56 t ha^{-1}. Then CS alone recorded 8.75 t ha^{-1} for CS 10 t ha^{-1} and 8.87 t ha^{-1} for CS 30 t ha^{-1}, which is not far from that of control, while the highest dry matter yield (14.33 t ha^{-1}) was obtained for the NCM treatment, it is almost similar to that of in the winter season. Generally, the summer season recorded higher dry matter yield than that of the winter season. This result might be due to the climate.

This observed increase in dry matter yield of fodder sorghum can be attributed to addition of soil amendments which might be essential for plant nutrients, improving their availability and substantially improved of the physical conditions of the soil.

4. CONCLUSIONS

From the above mentioned results, it can be concluded that the application of canal sediment and chicken manure have resulted in improvement of the some properties of sandy soils. Specifically, increased the soil moisture content, organic carbon, total nitrogen, available phosphorus, potassium and consequently increased dry matter yield offodder sorghum.

Incorporation of manure and canal sediment in sandy soils as amendments is an alternative option for amelioration of poor sandy soils.

References

[1] Ahmed, I.A. 2017. Direct and Residual Effects of Green and Chicken Manures on Properties of Desert Plain Soils and Wheat (Triticum aestivum L.) Yield in the Northern State, Sudan. PhD thesis, Department of Soil and Water Sciences, Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan.

[2] Ahmed, I.A., Ahmed M.M., Hamad M.E. 2018. Direct and residual effects of chicken manure on soil air dry bulk density and moisture content of a desert plain soil and wheat (*Triticum aestivum* L.) yield, Northern State, Sudan. *Gezira Journal of Agricultural Science* 16(1),

[3] Agbede, T. M., A. S. Odoja, L. N. Bayode, P. O. Omotehinse & I. Adepehin (2020) Effects of biochar and poultry manure on soil properties, growth, yield and quality of cocoyam (Xanthosoma sagittifolium Schott) grown in sandy soil, *Communications in Soil Science and Plant Analysis,* 51: 7, 932-947, DOI: 10.1080/00103624.2020.1744621

[4] Al-Darby, A. M. 1996. The hydraulic properties of a sandy soil treated with gel forming soil conditioner. *Soil Technology* 9: 15–28

[5] Ali, Y.S.A., Crosato A., Mohamed Y.A., Abdalla S.H., Wright N.G. 2014. Sediment balances in the Blue Nile River Basin. *International Journal of Sediment Research* 29: 316-328

[6] AmnaJubara Ali and Mubarak AbdelrahmanAbdalla. 2012. Performance of sorghum (*Sorghum bicolor* L.) in amended sandy soil. *Journal of Disaster Management* Vol 1: 53-72

[7] Bremner J M, Mulvaney C S (1982) Nitrogen-total. In: Page AL (eds) Method of soil analysis; Part 2-chemical and microbiological properties,American. Society of Agronomy.Madison, Wisconsin. pp 595-663.

[8] Chantigny, M. H., Angers, D. A. and Beauchamp, C. J. 1999. Aggregation and organic matter decomposition in soils amended with de-inking paper sludge. Soil Sci. Soc. Am. J. 63: 1214- Lashermes, G., Nicolardot, B., Parnaudeau, V., Thurie` s, L., Chaussod, R., Guillotin, M. L., Line` res, M., Mary, B., Metzger, L., Morvan, T., Tricaud, A., Villette, C. and Houot, S. 2009. Indicator of potential residual carbon in soils after exogenous organic matter application. *Eur. J. Soil Sci.* 60(2) 297-310

[9] Chapman HD, Pratt PF (1961). Methods of analysis for soil, plant and water. University of California Riverside.

[10] Choukr-Allah, R., Rao N.K., Hirich A., Shahid M., Alshankiti A., Toderich K., Gill S., Butt K.U. Quinoa for marginal environments: Towards future food and nutritional security in MENA and Central Asia Regions. *Frontiers in Plant Science*, 2016 March 29; 7: 346. doi: 10.3389/fpls.2016.00346

[11] Dawi, B.S.I., Mubarak A.R., Yamanaka N., ElTilib A.M.A., Elhadi E. A., Rezig F.A.M. 2017. Use of organic amendments for improvement of desert soil properties and cultivation of grain sorghum (*Sorghum bicolor* L.). *Sudan Journal of Desertification Research* 9: 108-141

[12] DLRC (2005). Agricultural research and technology cooperation (ARTC),Dryland Research Centre (DLRC), Ministry of Science and Technology, Wad Medani, Sudan.

[13] Eldridge, D. J., E. Zaady, and M. Shachak. 2000. Infiltration through three contrasting biological soil crusts in patterned landscapes in the Negev, *Israel. Catena* 40: 323–336

[14] Franklin, J., T. Keeler-Wolf, K. Thomas, D. Shaari, P. Stine, J. Michaelsen, and J. Miller. 2001. Stratified sampling for field survey of environmental gradients in the Mojave Desert ecoregion. In GIS and Remote Sensing Applications in Biogeography and Ecology, Eds. A. Millington, S. Walsh, and P. Osborne 229–53. New York, NY: Springer.

[15] Gregorich, E. G., Carter, M. R., Angers, D. A., Monreal, C. M. and Ellert, B. H. 1994.Towards a minimum data set to assess degraded soils and intensification of world agriculture and forestry. *Land Degrad. Devel.* 14: 309322

[16] Huenneke, L. 2001. Deserts. In Global Biodiversity in a Changing Environment, Eds. F. S. Chapin, III., O. Sala and E. Huber-Sannwald 201–22. New York: Springer.

[17] Iqbal, S., HaroonZaman Khan, Tang Li & Muhammad Arif (2018) Organic Nitrogen Source Addition for Improving the Physicochemical Properties of Sandy Loam Soil and Maize Performance. *Communications in Soil Science and Plant Analysis*, 49: 1, 13-29, DOI: 10.1080/00103624.2017.1420798

[18] Kasongo, R. K., Verdoodt, A., Kanyankagote, P., Baert, G. and Van Ranst, E. 2011.Coffee waste as an alternative fertilizer with soil improving properties for sandy soils in humid tropical environments. *Soil Use Manage.* 27: 94-102

[19] Khair, M.A.M, and Salih, S.A.(2007). Dry matter yield and quality of some winter sown forage crops in the Sudan Gezira, *University of Khartoum Journal of Agricultural Sciences* 15(1), 204-219

[20] Kianian, M.K., Asgari H.R., Bahadori F. 2018. Impact of some amendments on some soil properties and plant growth in desert area of Iran. *Open Journal of Ecology* 8: 339-355

[21] Lal, R. 2004. Soil carbon sequestration impacts on global climate change and food security. *Science* 304: 1623

[22] Land and Water Research Centre (LWRC). 1999. Detailed Soil Survey and Land Suitability Classification of Multaga Scheme. Agricultural Research Corporation, Land and Water Research Centre, Wad Medani, Sudan.

[23] Larney, F.J, Angers D.A. 2012. The role of organic amendments in soil reclamation: A review. *Canadian Journal of Soil Science* 92: 19-38

[24] Mazen, A.M., DeyaEldeen Mohammed Radwan&AtefFathy Ahmed (2015) Growth responses of maize plants cultivated in sandy soil amended by different

superabsorbenthydrogels. *Journal of Plant Nutrition*, 38:3, 325-337, DOI: 10.1080/01904167.2014.957393

[25] Mclean EO (1982) Soil pH and lime requirement In: Page AL, Miller RH, Keeney DR (eds), Methods of soil analysis: Part 2. Chemical and microbiological properties, 2nd ed. American Society of Agronomy and Soil Science Society of America, Madison, WI. pp 199-223.

[26] Ministry of Animals Resources.(2004).Annual reports.

[27] Montgomery, D. R. 2007. Dirtthe erosion of civilizations. University of California Press, Berkeley, CA.

[28] Mor-Mussery, A., Stefan Leu, Arie Budovsky, and Itamar Lensky. 2015. Plant-Soil Interactions and Desertification: A Case Study in the Northern Negev, Israel. *Arid Land Research and Management*, 29:85–97

[29] Mor-Mussery, A., S. Leu, and A. Budovsky.2013a.Modeling the optimal grazing regime of Acacia victoria silvopasture in the Northern Negev, Israel. *Journal of Arid Environments* 94: 27–36

[30] Mubarak AbdelrahmanAbdalla, Abdelmonim Hassan, Imran Ali Ahmed and Abdelmoniem Mohamed Ahmed Eltilib. 2015. A Note Note on the Impact of Dry Sewage Sludge and Hamdab Irrigation Canal Sediment on Some Quality Attributes of an Aridisols, Northern State. *Sudan Journal of Desertification Research* 7: 126-135

[31] Nasef, M. A. 2012. Using GIS and statistical methods to detect the multi-decadal variability for temperature trends on Egypt: 1960–2000. *Geographia Technica* 15(1): 46–60

[32] Nelson DW, Sommers LE (1982). Total carbon, organic carbon and organic matter In: Page AL, Miller RH, Keeney DR (eds), Methods of Soil Analysis: Part 2. Chemical and microbiological properties, 2nd ed. American Society of Agronomy and Soil Science Society of America, Madison, WI. pp. 539-579

[33] Olsen SR, Sommers LE (1982) Phosphorous. In: Page AL (ed) Methods of Soil Analysis. Part 2.Chemical and microbiological properties.American Society of Agronomy, Madison, WI, pp. 403-430.

[34] Omololu John Idowu, SoumailaSanogo& Catherine Elizabeth Brewer (2017) Short-Term Impacts of Pecan Waste By-Products on Soil Quality in Texturally Different Arid Soils, *Communications in Soil Science and Plant Analysis*, 48:15, 1781-1791, DOI: 10.1080/00103624.2017.1395448

[35] Pholsen, S. and Suksri.A.(2007) Effects of Phosphorus and Potassium on Growth, Yield and Fodder Quality of IS 23585 Forage Sorghum Cultivar (Sorghum bicolor L.). *Pakistan Journal of Biological Sciences,* 10, 1604-1610. http://dx.doi.org/10.3923/pjbs.2007.1604.1610

[36] Richard LA (1954) Diagnosis and improvement of saline and alkali soils. *Soil Science Society of America Journal* Volume 18, Issue 3, July 1954, Pages 348-348

[37] D. Schulze, et al., 415–40. New York: Springer. SAS Institute Inc. 1995.SAS Guide to the REPORT Procedure, Reference, Release 6.11. Cary, NC: SAS Institute Inc.

[38] Sivapalan, S. 2006. Benefits of treating a sandy soil with a crosslinked-type polyacrylamide. *Australian Journal of Experimental Agriculture* 46: 579–584

[39] Skerman, P.J. and Rivers, F. (1999) Tropical Grasses. FAO. Plant Production and Protection, Series No. 23, FAO, Rome.

[40] Soropa, G., Nyamangara J., Nyakatawa E.Z. 2019. Nutrient status of sandy soils in smallholder areas of Zimbabwe and the need to develop site-specific fertiliser recommendations for sustainable crop intensification. *South African Journal of Plant and Soil* 36 (2): 149-151

[41] Sun, Z. 2018. Effect of soft rock amendment on soil moisture and water storage in Mu Us Sandy Land. *IOP Conf. Series: Materials Science and Engineering 381* (2018) 012044 doi:10.1088/1757-899X/381/1/012044

[42] Tahir,S., Marschner, P. 2017. Clay Addition to Sandy Soil Reduces Nutrient Leaching-Effect of Clay Concentration and Ped Size. *Communications in Soil Science and Plant Analysis* 48: 1813-1821

[43] Yang, Sheng-Mao, Malhi S.S., Li Feng-Min, Suo Dong-Rang, Xu Ming-Gang, Wang P., Xiao Guo-Ju, Jia Y., GuoTian-Wen, Wang Jian-Guo. 2007. Long-term effects of manure and fertilization on soil organic matter and quality parameters of a calcareous soil in NW China. *Journal of Plant Nutrition and Soil Science* 17: 234-243

[44] Yu, H., Ding, W., Luo, J. *et al.* Effects of long-term compost and fertilizer application on stability of aggregate-associated organic carbon in an intensively cultivated sandy loam soil. *Biol Fertil Soils* 48, 325–336 (2012). https://doi.org/10.1007/s00374-011-0629-2

[45] Ziadat, F., A. Bruggeman, T. Oweis, N. Haddad, S. Mazahreh, W. Sartawi, and M. Syuof. 2012. A participatory GIS approach for assessing land suitability for rainwater harvesting in an arid rangeland environment. *Arid Land Research and Management* 26: 297–311

[46] Zika, M. and Erb, K. H. 2009. The global loss of net primary production resulting from human-induced soil degradation in drylands. *Ecol. Econ.* 69: 310318