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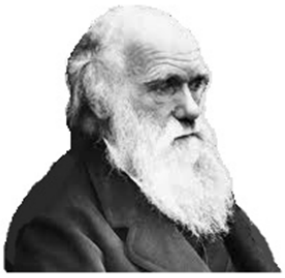

World News of Natural Sciences

An International Scientific Journal

WNOFNS 67 (2026) 84-95 EISSN 2543-5426

Effect of Compost on Some Soil Physical Properties and Forage Yield of Sudan grass and Sorghum in Desert Soil of Northern State, Sudan

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ABSTRACT

In Sudan forage production is very important because the forage is basic source of energy for growth and maintenance and product increment of livestock. Compost has positive effect on plant growth and yield due to its high organic matter content which improved soil physical and biological properties. This study was conducted for two consecutive summer seasons; 2017/18 and 2018/19, at the Research Farm of the National Institute of Desert Studies, New, Hamdab Scheme, Northern State of Sudan. The objective was to study the effect of compost manure on some soil physical properties and forage yield of Sudan grass and Marage in the desert soil. The experimental materials include Sudan grass (S) and Marage (M). Seed rate of (50 and 60) kg ha^{-1} were used for Sudan grass and Marage, respectively. Crops were grown under three levels of compost 0, 5 and 10 tons per hectare. Soil physical properties measured were, soil bulk density, soil total porosity and soil moisture content, whereas plant growth parameters measured were; plant population, plant height, number of tillers per plant, leaves fresh weight, stem fresh weight, plant fresh weight, leaf area per plant, leaf area index and fresh forage yield. The experimental design was randomized complete block design (RCBD) with three replicates. Data were subjected to standard procedure of analysis of variance. Means were separated using Duncan's Multiple Range Test (DMRT) at 5% significance level. The result showed that, compost application obtained very highly significant effect ($P \leq 0.001$) decreased soil dry bulk density on the average across the two seasons varied from 1.77 g cm^{-3} for the control to 1.41 g cm^{-3} in the compost treatments and increased soil moisture content on the average across both seasons varied from 9.1% in the control to

(Received 28 April 2026; Accepted 27 May 2026; Date of Publication 29 May 2026)

18.2 % in the compost treatments and also, and increased soil porosity on the average across both seasons varied from 32.2% in the control to 46.6 % in the compost treatments. The results also showed that compost significantly improved forage yield and its components. Highest fresh forage yield of (61.4 and 60.5) tons/hectare during first and seconds seasons, respectively were achieved by Sudan grass, using 10 tons per hectare compost, which indicated clear advantages of compost. It is recommended to use 10 Tons/ha compost with Sudan grass.

***Keywords*:** Sorghum (*Sorghum bicolor*), Sudan grass (*Sorghum sudanense*), compost, fresh forage yield, soil physical properties

1. INTRODUCTION

Sudan is the largest country in Africa, with an area of 1.88 million Km^2, with more than million head of Animals AOAD (2003). So, production of forage crops is very important for this huge number of livestock. and because the forage is basic source of energy for growth and maintenance and product increment of livestock the demand for fodder has greatly increased in recent years. In order to that, rangelands of the Sudan are diminishing due to overgrazing, tremendous expansion of rain fed agriculture and climate change. This has a negative impact on animal's production. To maintain high level of forage production, choice of suitable cultivars and fertilization programs are of great importance. The main forage grasses in Sudan are Sudan grass (*Sorghum sudanense* (Piper) Stapf.), Sorghum (*Sorghum bicolor* L. Moench) and Maize (*Zea mays* L.).

Tropical grasses are known to have a high rate of growth under favorable conditions, resulting in a high dry matter production (Eskandari et al., 2009). Sudan grass has a high fresh forage yield, due to its an excellent growing habit, quick growing, re-growth after cutting, better palatability and digestibility (Dahiya et al., 1997). Forage Sorghum is one of the most widely adapted forage crops and has a significant role in livestock production (Amandeep, 2012). In most cereal growing regions of the world, soils are deficient in essential elements, particularly nitrogen and phosphorus. Soil moisture without soil fertility is less effective for crop production which constitute addition challenge in arid and semi-arid areas (Gebreyesus, 2012).

Compost fertilizer is made from plant and animals remains with the objectives of recycling such organic products. The decomposition process converts potentially toxic or putrescible organic matter into a stabilized state that can improve soil fertility. Composted organics has other beneficial effects, including diverting landfills wastes to alternative uses, removal of pathogen inoculum or weed seeds and decomposition of petroleum, herbicide or pesticide residues, erosion control and as a nutrient source for sustainable re-vegetation of degraded soils. Using compost can improve the capacity to produce safe agricultural products and increase the potential for large-scale organic food (Paulin and O'Malley, 2008).

Organic matter plays such a key role in soil productivity by affecting almost all physical, chemical and biological properties. (Larney and Angers, 2012). Compost has positive effect on plant growth and yield due to its high organic matter content which improves soil physical and biological properties (Gupta and Pradhan 1995). In Sudan research dealing with forage production is of special importance due to the large number of animals and limited natural pasture, in addition to the nomadic system of grazing that doesn't allow proper management of natural pasture.

This realism necessitates more efforts and research to solve the problem of forage shortage hence, the objective of this study is to evaluate the effect of compost fertilizer on forage yield of Sudan grass and Sorghum under irrigation in northern Sudan.

2. MATERIALS AND METHODS

2. 1. Experimental site and sowing date

Figure 1. The region of area studied, Sudan.
(Google Map).

Figure 2. The region of area studied, Sudan.
(Google Map).

Figure 3. The region of area studied, Sudan.
(Google Map).

The experiment was carried out at the National Institute of Desert Studies Research Farm, New Hamdab Scheme, Northern State of Sudan. The study area lies at the intersection of latitude 17º 55' N, and longitude 31º 10' E in the desert climate. Experiment was carried out during two consecutive summer of 2017/18 and 2018/19 (Figures 1-3).

2. 2. Characteristics of the experimental site

Table 1. Some soil properties of the experimental site.

Soil properties	**Soil depth (cm)**				
FS (%)	0 - 23	23 – 65	65 - 80	80 - 105	105 - 125
CS (%)	40	23	22	21	24
Silt (%)	37	33	43	42	40
Clay (%)	15	25	11	19	8
Texture	8	19	24	18	28
pH (paste)	LS	SL	SL	SL	SCL

ECe	7.5	7.3	8.1	7.8	7.5
ESP	0.35	0.37	0.42	1.1	3.2
$CaCO_3$ (%)	3.0	3.0	4.0	5.0	8.0
O.C (%)	0.8	2.6	10.4	0.2	27.5
C/N ratio	0.052	0.066	0.078	0.061	0.052
	4	4	5	5	5

LS = loamy sand, SL = sandy loam, SCL= sandy clay

The soil of the study area belongs to El Multaga soil series which classified as Vertic Haplocambids, fine loamy, mixed, supper active, hyperthermic. The soil structure is moderate sub angular blocky. It is non-saline ECe ≥ 4 d Sm^{-1} (soil ECe 0.35, 0.37 and 0.42 d Sm^{-1} at 0 – 23, 23 – 65 and 65 - 80 cm soil depth, respectively) and non-sodic ESP ≥ 15 (ESP = 3, 3 and 4 for 0 – 23, 23 - 65 and 65 - 80 cm soil depth, respectively). Generally, the soil chemical fertility is low and mostly these soil deficient in nitrogen, phosphorus and organic carbon for optimum yield production of different cultivated crops. The physical and chemical properties of the soil are shown in Table 1.

2. 3. Experimental materials and land preparation

The experimental materials include two forage crops i.e. Sudan grass (S) and the local variety of Sorghum in northern Sudan, which called Marage (M) seed rate of 50 and 60) kg/ha were used for Sudan grass and Marage, respectively. Crops were grown under three levels of compost 0, 5 and 10 tons/ hectare, which made six treatments as shown below

S × C1 (Sudan grass grown under 0 Tons/ha compost (control)
M × C1 (Marage grown under 0 Tons/ha compost (control)
S × C2 (Sudan grass grown under 5 Tons/ha compost.
M × C2 (Marage grown under 5 Tons/ha compost.
S × C3 (Sudan grass grown under 10 Tons/ ha compost.
M × C3 (Marage grown under 10 Tons/ha compost.

Seeds of Sudan grass (S) and the local variety of Sorghum were obtained from the local market. The experimental site was disc ploughed, harrowed, leveled and ridged in to 70 cm apart after broadcasting the seeds on flat land. The experiments were sown on 12th of July 2017/18 and 2018/19 summer seasons. The experiments were irrigated immediately after sowing, then every 7-10 days' intervals according to the crop water requirements.

Compost manure was manually broadcasted at the rates of 0, 5, and 10 tons/ha. Nitrogen and phosphorus fertilizer were added as recommended by ARC (102 kg N/ha plus 102 kg P/ha).

2. 4. Experimental design

Treatments were arranged in a randomized complete block design (RCBD) with three replications. The plot area was 42 m^2.

2. 5. Growth parameters measured

Growth parameters measured were; plant population, plant height, number of tillers per plant, leaves fresh weight, stem fresh weight, plant fresh weight, leaf area/ plant, leaf area index and fresh forage yield. All growth parameters were taken at full flowering stage by taking five plants per plot selected randomly from the mid- ridges of plots, except plant population and fresh forage yield, which were estimated by taking one square meter twice from each experimental unit, then the average was calculated.

2. 6. Soil physical properties measured

Soil physical properties measured were, soil bulk density, soil total porosity and soil moisture content

2. 7. Statistical Analysis of forage yield and yield components

Data of yield and yield components were subjected to the standard procedure of analysis of variance. Means were separated using Duncan's Multiple Range Test (DMRT) at 5% significance level.

2. 8. Methods of soil physical analysis

The core sample method as described by Black, (1965) and Landon, (1984) was used to determine the soil dry bulk density (ρd). Soil core was obtained from 0-15 cm soil depth for each of experimental units at 60 days after sowing (DAS). The soil was oven dried at 105 ºC for 24 hours, and weighed. The soil dry bulk density (ρd) for all soil samples were calculated in the laboratory using the equation (1) below:

$$\rho d = \frac{Ms}{Vt} \tag{1}$$

where Ms is a dry soil mass and Vt is the total soil volume or the core volume.

Measurements of the soil moisture were done at 0 - 30 cm soil depths. Soil samples were taken by an auger. Readings were taken at the field, two days after irrigation at 60 DAS. Gravimetric method was used to determine the soil moisture percentage (Θ) as described by equation (2) below:

$$\theta = \frac{Mm - Md}{Md} \tag{2}$$

where: Mm is the moist soil mass and Md is the oven dry soil mass.

The soil total porosity (T.P) was calculated using equation (3) below:

$$T.P = 1 - \frac{\rho d}{\rho s} \tag{3}$$

where: T.P = Soil total porosity, ρd = Soil air dry bulk density,
ρs = Soil particle density (taken as 2.65 g cm^{-3}).

3. RESULTS AND DISCUSSION

3. 1. Soil physical properties

As shown in Tables 2 and 3 the results indicated that addition of 5 and 10 ton/ha of compost fertilizer showed very highly significant ($P \leq 0.001$) differences in reducing soil dry bulk density from 1.41 gcm^{-3} (on the average) compared to control 1.77 gcm^{-3} (on the average) and increasing porosity up to46.6 %compared to 32.2 % (control)in both seasons. This result agrees with Brown and Cotton, (2011); Fageria, (2002); and Moran and Schupp, (2003), who stated that compost application generally influences a beneficial way by reducing soil dry bulk density, this passively effect has been detected in most cases and it is typically associated with an increase in porosity.

Tables 2 and 3 showed highly significant ($P \leq 0.01$) increase in soil moisture content due to adding compost fertilizer from 18.2 % (on the average) compare to 9.1 % (control)during both seasons. This result is inconformity with that of Yüksek et al., (2009) who stated that compost manure increase significantly moisture content.

Table 2. Effect of compost manure on some soil physical properties for season 1.

Treatments	Bulk density (g/cm^{-3})	Porosity (%)	Moisture content (%)
M × C1	1.75	34.3	8.8
S × C1	1.76	33.3	8.8
M × C2	1.47	44.3	16.5
S × C2	1.46	44.6	16.6
M × C3	1.39	47.5	18.8
S × C3	1.41	47.1	19.0
Grand mean	1.54	41.9	14.76
C.V (%)	1.8	2.55	4.92
SE±	0.018	0.617	0.419
Prob.	$P \leq 0.001$	$P \leq 0.001$	$P \leq 0.001$

Means followed by different letters in the same column are significantly different at $P \leq 0.05$.

Table 3. Effect of compost manure on some soil physical properties for season 2.

Treatments	Bulk density ($g\ cm^{-3}$)	Porosity (%)	Moisture content (%)
M × C1	1.78	32.8	9.4
S × C1	1.79	32.5	9.2

M × C2	1.44	45.5	17.4
S × C2	1.45	45.3	17.5
M × C3	1.34	49.2	20.0
S × C3	1.34	49.5	19.9
Grand mean	1.52	42.4	15.57
C.V (%)	2.66	3.67	4.32
SE±	0.25	0.899	0.388
Prob.	P ≤ 0.001	P ≤ 0.001	P ≤ 0.001

Means followed by different letters in the same column are significantly different at P ≤ 0.05.

3. 2. Plant growth parameters and forage yield

The results of plant height and number of tiller per plant of Sudan grass and sorghum local variety (Marage) treated with three levels of compost tested for yield components in two seasons are presented in Table 4.

Table 4. Effect of compost manure on some plant growth parameters for two seasons.

Parameters	**Plant height (cm)**		**Number of tiller per plant**	
treatments	First season	Second season	First season	Second season
M × C1	138.0	141.0	1.4	1.3
S × C1	141.0	144.0	1.0	1.3
M × C2	142.0	145.0	2.0	2.3
S × C2	150	153.0	1.3	1.7
M × C3	151.0	155.0	2.7	2.7
S × C3	159.0	160.0	2.3	2.3
Grand mean	146.8	149.67	1.778	1.944
C.V (%)	4.06	6.74	31.93	39.47
SE±	3.445	5.828	0.3281	0.4431
Prob.	P ≤ 0.01	P ≤ 0.240	P ≤ 0.02	P ≤ 0.326

Means followed by different letters in the same column are significantly different at P ≤ 0.05.

The results showed that there were significant differences among treatments in most parameters during the growing period for growth attributes under study. Using 10 tons per

hectare compost gave highest plant height and number of tillers per plant for Sudan grass and sorghum local variety (Marage), respectively. Highest values of 159 and 160 (cm) plant height during both seasons, were recorded for Sudan grass × 10 tons per hectare compos, whereas M × 10 Tons/hectare compost gave highest number of tillers per plant. Highest plant height and number of tiller per plant recorded as a result of adding compost could be attributed to the availability of nitrogen to the plant roots, low carbon to nitrogen ratio and the effect of decomposition which lead to early release of plant nutrient in the soil., this is in agreement with the finding of (Hassan, 2002) who reported that chicken manure fertilizer significantly increased plant height of Sudan grass.

Ayub et al., (2005). reported that compost significantly increased number of tiller per plant of sorghum. Similar results were reported by Fagam et al., (2009).

Plant fresh weight (g.) and leaf area (LA)/plant (Cm^2), are presented in Tables 5. LA per plant is mainly associated with the leafiness of the crop and hence acceptability and quality of the forage. Significant differences among treatments during both seasons were observed.

The highest values for both parameters were achieved by Marage (M) × 10 Tons/hectare compost (C). These results confirming the finding of (Somashekar et al, 2015) who reported that, the increase in nitrogen led to an increase in LA per plant. moreover, Zheng et al., (2018); Cai et al., (2021), reported that compost increased all growth parameters of sorghum similar results were observed by Hassan, (2002). who reported that chicken manure fertilizer significantly increased plant fresh weight and leave area per plant, compare to control.

Table 5. Effect of compost manure on some plant growth parameters for two seasons.

Parameters	**Plant fresh weight**		**Leaf area per plant (cm^2)**	
treatments	First season	Second season	First season	Second season
M × C1	19.4	20.2	382.5	390.5
S × C1	18.0	18.4	287.8	300.0
M × C2	21.4	22.5	465.1	476.0
S × C2	19.5	20.4	368.1	350.0
M × C3	24.5	25.5	490.7	500.0
S × C3	21.8	22.0	410.9	430.0
Grand mean	20.76	21.50	400.97	407.75
C.V (%)	0.9471	9,92	3.85	2.39
SE±	0.9471	1.2316	1.002	0.9471
Prob.	$P \leq 0.01$	$P \leq 0.01$	$P \leq 0.001$	$P \leq 0.001$

Means followed by different letters in the same column are significantly different at $P \leq 0.05$.

Effect of compost on leaf area index (LAI) and fresh forage yield (F.F.Y) are presented in Table 6. LAI is a criterion of the amount and weight of leaves per square meter, which indicated the leafiness percentage of the crop per unit of the cultivated area. The analysis of variance procedure depicted clearly that LAI and fresh forage yield were significantly affected by compost fertilizer during both seasons. Highest values of LAI (9) and (9.5) and fresh forage yield of (61.4) and (60.5) tons per hectare during both seasons, were achieved by Sudan grass × 10 Tons / hectare compost. The increase in LAI with compost during both seasons can be attributed mainly to increasing LA per plant and plant population per square meter. These results were in agreement with finding of Abuswar, (2019) who reported that Manure increased leaf area of Sudan grass.

Table 6. Effect of compost on leaf area index and fresh forage yield for two seasons.

Parameters	**Leaf area index**		**Fresh forage yield**	
Treatments	First season	Second season	First season	Second season
M × C1	4.5	4.6	29.5	30.5
S × C1	7.1	6.9	46.3	47.0
M × C2	5.3	5.5	38.7	39.5
S × C2	7.5	8.0	48.5	49.5
M × C3	7.6	7.9	46.2	45.8
S × C3	9.0	9.5	61.4	60.5
Grand mean	6.82	7.07	45.1	45.5
C.V (%)	8.77	11.95	5.95	3.86
SE±	0.3454	0.4874	11.77	5.64
Prob.	$P \leq 0.001$	$P \leq 0.001$	$P \leq 0.001$	$P \leq 0.001$

Means followed by different letters in the same column are significantly different at $P \leq 0.05$

The increase in fresh forage yield as a result of adding compost fertilizer during both seasons can be attributed to the positive effect of Organic fertilizers that have a significant role in enhancing the physical, chemical, and biological characteristics of the soil, in addition to the increase of plant population, plant height, leaves and stem fresh weights per plant and plant fresh weight and thus fresh forage yield.

These results were in agreement with the finding of Feisal et al, (2024) work with Sudan grass, who found that adding compost resulted in increasing fresh and dry forage yield of Sudan grass. Furthermore, results were observed by Joorabi et al (2015), Kaplan et al (2019), who found that fertilization increased forage yield of Sudan grass.

Indicating the desirable role of compost fertilizers on the soil characteristics which increases the availability of the other nutrient elements to the plant ending up with increasing the yield of the crop.

4. CONCLUSION

It can be concluded that in the desert plain soil of the Northern State of Sudan, the application of 10 ton ha^{-1} compost manure increased forage yield and improved the physical soil condition by decreasing soil bulk density and increasing both total porosity and moisture content.

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