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ORIGINAL RESEARCH

Effects of organic amendments on sand dune fixation

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Abstract
Background Poor physical and chemical properties of sand dune soil are the main constrains in afforestation of sand dune in desertified area. The aim of this study is to improve the physical and chemical properties of dune soil in Elrawakeeb Dry Land Station using organic wastes as a fertilizer source and amendments, for sustainable sand dune stabilization program. *Salvadora persica* L. seedlings were transplanted in a 2 m × 2 m plots and treated with: sawdust (SW), chicken manure (CH), chicken manure with sawdust (CH + SW), sawdust with inorganic fertilizer (SW + IF), sewage sludge (SS), sewage sludge with sawdust (SS + SW), and control (C). The treatments were arranged in a randomized complete block design with four replicates. The soil chemical properties were determined from soil samples collected from the fixed sand dune (0–20 cm depth) in the second year after application.
Results Application of organic amendments significantly ($P = 0.001$) increased soil organic carbon by 224 %, available P by 139.9 %, total nitrogen by 142.9 %, and mineral nitrogen by 83.5 % and decreased soil pH by 5.6 %.
Conclusions Incorporation of organic waste in desertified sandy dune soils increased its nutrient content and hence sustained biological fixation of sand dunes.

Keywords Soil attributes · Organic amendments · Sand dune stabilization · *Salvadora persica* · Land degradation

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Introduction

Low rainfall and high-potential evaporation result in sparse or nonexistence vegetation and as a consequence active sand dunes (Thornthwaite 1931). Abdi et al. (2013) suggested deep ploughing and leveling as the causes of sand dune accumulation in rain-fed agricultural land in Sudan. Sand accumulation is one of the indicators of desertification in Sudan, which affected agricultural production (Ibrahim 1978). Sand dunes are known as inert soil freed from any positive characteristics for flora. This is due to: (a) relatively coarse particles and the big pore spaces which result in a low amount of available water to plants; (b) high rate of permeability and leaching which wash away the nutrients necessary for plant growth (Tsoar 1990); and (c) lack of cohesion between the grain particles which increased the erodibility of the sand. Sandy soils have the lowest threshold velocity for erosion of all known soils (Pye and Tsoar 1990).

Mesquite (*Prosopis juliflora*) has been used for stabilization of sand dune in Sudan (ElFadl and Luukkanen 2003). However, during the 1990, the government of the Sudan has considered the mesquite as problematic tree, and in 1995, eradication program was issued by the government. In sand dune in the Namib Desert, Salvadora bushes survive and continue to grow when the Acacia trees have been buried and died (Mizuno and Yamagata 2005). Therefore, Salvadora (Arak) tree is selected in this study as substitute for the mesquite tree.

Incorporation of organic amendments such as animal manures, crop residues, and compost, to the sandy soil, improved its properties (Mubarak et al. 2009; Bationo et al. 2006). This practice is important in sand dune soils where poor properties are a serious constraint for agriculture and food production. The organic fraction in organic amendments can enhance significantly soil aggregation, water infiltration, microbial activity, structure, and water-holding capacity particularly in soils of arid and semiarid regions, and it can reduce soil compaction and erosion (Rezig et al. 2013; Angin and Yaganoglu 2011; Gilley and Risse 2000; Haynes and Naidu 1998). Chemical properties such as cation exchange capacity, organic carbon, and soil pH may also be improved by organic amendments application (Rezig et al. 2013; Ogunwole et al. 2010; Kumar and Goh 2000; Tisdale et al. 1993).

In Khartoum State, large quantities of organic wastes are just dumped after cleaning into big heaps. This type of disposal will create in the long-term disposal problems. Tremendous amounts of sewage sludge are produced annually in the vicinity of Khartoum State, and it has been estimated as 26,752.25 ton year^{-1}. This amount could help in amelioration of sand dunes soils. There is also large quantity of sawdust and chicken manure, taking all these into consideration together, since Khartoum State is surrounded by displaced people and refugees occupying fragile soils around the state. Therefore, it is necessary to improve the marginal land around the capital by application of organic amendments. The aim of this study is to improve sand dune properties by application of organic amendments for sustainable sand dune fixation.

Methods

Study site

This experiment was conducted in 2009 on sand dune in Elrawakeeb Dry Land Station located west of Omdurman between latitudes 15°.2′–15°.36′ North longitudes 32°.0′–32°.10′ East. The climate of the study is part the arid and semiarid zones, and it has low relative humidity (<20 %). The summer is hot and dry, and the winter is moderately cold and dry. The temperature ranges between 40 °C (maximum) in summer and 21 °C (minimum) in winter (Oliver 1965). The rainy season starts in July and ends in September. The average rainfall is 157 mm.

Treatments

The experiment included seven treatments as follows:

1. Control (no fertilizer and no organic amendments)
2. Sawdust at rate of 10 t ha^{-1} (SW)
3. Sawdust combined with inorganic fertilizer (92 kg N ha^{-1} as urea and 100 kg P_2O_5 ha^{-1} as triple super phosphate) (SW + IF).
4. Chicken manure 10 t ha^{-1} (CH)
5. Chicken manure 5 t ha^{-1} combined with sawdust 5 t ha^{-1} (CH + SW)
6. Sewage sludge applied at rate of 10 t ha^{-1} (SS)
7. Sewage sludge 5 t ha^{-1} combined with sawdust 5 t ha^{-1} (SS + SW)

The treatments were arranged in a randomized complete block design with four replications (i.e., 28 plots, 2 m length and 2 m width). Seedlings of Arak (*Salvadora persica* L.) were obtained from the Forest Research Nursery Soba Khartoum, Sudan.

Experimental protocol

Before establishment of the plots, the dune was fenced and leveled. Experimental plots were prepared manually; treatments were assigned randomly to plots and blocks. The organic amendments were manually incorporated in the topsoil. The chemical composition of organic amendments incorporated into the soil is shown in Table 1. The concentration of heavy metals in sewage sludge was described previously by Rezig et al. (2013). Four seedlings of Arak were planted per plot in December 2009. The whole dune was irrigated twice a week in the first month, weekly in the second month, and then twice a month throughout the study period to obtain 70 % field capacity.

Soil sampling and analysis

Soil samples (0–20 cm) were collected and analyzed before the start of the experiment. In the second year after application, three samplings were done after 4 months, after 9 months and after 11 months using 5 cm Ø auger. About 10 g of moist soil was frozen (4° C) and used for the determination of mineral N (NH_4^+–N + NO_3^-–N),

Table 1 Chemical composition (g kg^{-1}) of organic amendments used in the study

Amendments	N g kg^{-1}	P	K	Ca	Mg	% O.C	C/N
SW	1.3	2.0	11.0	29.3	3.3	52.1	400.8
SS	28.0	28	34.0	4.8	3.9	24.0	8.57
CH	39.8	25.3	23.2	2.1	10.6	16.69	4.19

whereas the other portion was air-dried and kept for analysis. Mineral N was determined by extraction with 40 ml 2 M KCl after shaking for 1 h on a reciprocating shaker. An aliquot of 10 ml extract was used for the determination of NH_4^+–N by steam distillation with 0.2 g MgO, and subsequently NO_3^-–N was determined using Devarda's alloy (Keeny and Nelson 1982). The distillate was collected in 2 % boric acid mixed with methyl red and bromocresol green indicators. The amount of NH_4^+ and NO_3^-–N in the distillate was quantified by titration with 0.01 N HCl. Part of the air-dried portion was crushed and sieved (2 mm) and analyzed for saturated soil paste pH determined by a glass electrode pH meter (Mclean 1982), total soil N by digestion, with sulfuric acid and using Se, Cu_SO_4, and K_2SO_4 as catalyst, and the digested material was analyzed for N following the procedure developed by Bremner and Mulvaney (1982), available P (Olsen and Sommers 1982), water-soluble Ca and Mg, by titration against ethylene diamine tetra acetic acid (0.1 N EDTA), whereas water-soluble K was determined by flame photometer. Soil organic carbon was estimated by oxidizing organic matter in samples with $K_2Cr_2O_7$ after addition of concentrate sulfuric acid, left for 30 min, and the excess of $K_2Cr_2O_7$ was titrated against ferrous ammonium sulfate (Nelson and Sommers 1982).

Statistical analysis

The data collected from each sampling date were subjected to analysis of variance using SAS software version 5 (SAS 1985) to determine the significant differences among treatments.

Results

After 4 months (the first sampling), soil pH decreased significantly ($P \leq 0.0001$) in all treated plots, except in plots treated with SW (Table 2), and analysis of soil pH showed that application of sawdust at 10 t ha^{-1} increased soil pH significantly ($P \leq 0.0001$) relative to other treatments. Similar results were observed in the last sampling when the sandy soil was treated with 5 t ha^{-1} sawdust and mineral fertilizer. The lowest reduction in soil pH in all sampling periods was recorded in plots received 10 t ha^{-1} chicken manure.

Soil organic carbon (O.C) decreased after application of organic amendments in all treatments except in plot treated with sewage sludge and chicken manure (Table 3). However, soil O.C increased significantly ($P \leq 0.0001$) at all sampling periods in all treated plots relative to nontreated plots. The highest soil organic carbon was observed in plots treated with chicken manure alone, while the lowest amounts of organic carbon were recorded in control. Application of sawdust with chicken manure or sewage sludge increased soil organic carbon significantly relative to sawdust alone or sawdust with inorganic fertilizers. The increase in soil organic carbon relative to the control ranged from 207.4 % in plots treated with chicken manure to 18.5 % in plots treated sawdust.

Soil-available P, after 4 months, increased significantly in all treated plots except plots treated with sawdust alone (Table 4). However, in the second and third sampling, soil-available P increased by 0.23 and 0.6 mg kg^{-1}, respectively. At all sampling, the highest soil-available P was in plots received 5 t ha^{-1} sawdust and inorganic fertilizer, followed by plot treated with chicken manure. Combined application of 5 t ha^{-1} sawdust and 5 t ha^{-1} chicken manure or sewage sludge increased soil P availability in the soil. The addition of sawdust with sewage sludge increased soil-available P from 0.48 mg kg^{-1} t^{-1} sawdust alone to 0.54 mg kg^{-1} t^{-1}, while combined application of sawdust with chicken manure increased available P to 0.57 mg kg^{-1} t^{-1}.

In all sampling, soil water-soluble K tend to increase significantly ($P \leq 0.0001$) after addition of organic amendments (Table 5). The highest amount of water-soluble K was recorded in the first sampling in plot treated with chicken manure. Application of inorganic fertilizer

Table 2 Soil pH as influenced by organic amendments application (average ± SD)

Treatments	Before application	After 4 months	After 9 months	After 11 months
C	7.29	7.44a ± 0.01	7.44c ± 0.02	7.41b ± 0.01
SW	7.29	7.43a ± 0.03	7.53a ± 0.03	7.39c ± 0.02
SW + IF	7.29	7.41b ± 0.02	7.47b ± 0.01	7.45a ± 0.01
SS + SW	7.29	7.27c ± 0.01	7.29d ± 0.02	7.29d ± 0.03
CH + SW	7.29	7.17d ± 0.04	7.21e ± 0.01	7.20e ± 0.02
SS	7.29	7.09e ± 0.02	7.10f ± 0.03	7.09f ± 0.04
CH	7.29	6.99f ± 0.01	7.01g ± 0.02	7.03g ± 0.01
LSD		0.013	0.0155	0.014
$P \leq$		0.0001	0.0001	0.0001

Means in columns, within each treatment, followed by different letter (s) are significantly different at $P \leq 0.05$ using least significant difference (LSD)

Table 3 Soil organic carbon (%) as influenced by organic wastes application (average ± SD)

Treatments	Before application	After 4 months	After 9 months	After 11 months
C	0.48	0.28g ± 0.02	0.27f ± 0.05	0.25g ± 0.06
SW	0.48	0.30f ± 0.01	0.33e ± 0.04	0.32e ± 0.02
SW + IF	0.48	0.32e ± 0.05	0.34e ± 0.08	0.31f ± 0.08
SS + SW	0.48	0.38d ± 0.03	0.40d ± 0.06	0.37d ± 0.05
CH + SW	0.48	0.44c ± 0.02	0.46c ± 0.01	0.46c ± 0.07
SS	0.48	0.69b ± 0.04	0.70b ± 0.01	0.64b ± 0.08
CH	0.48	0.86a ± 0.01	0.84a ± 0.08	0.81a ± 0.07
LSD		0.013	0.012	0.010
$P \leq$		0.0001	0.0001	0.0001

Means in columns, within each treatment, followed by different letter (s) are significantly different at $P \leq 0.05$ using least significant difference (LSD)

Table 4 Soil-available phosphorus (mg kg^{-1}) as influenced by organic wastes application (average ± SD)

Treatments	Before application	After 4 months	After 9 months	After 11 months
C	7.65	4.93f ± 0.13	4.52g ± 0.23	4.19g ± 0.08
SW	7.65	4.93f ± 0.07	4.75f ± 0.11	4.79f ± 0.11
SW + IF	7.65	11.67a ± 0.13	11.35a ± 0.11	10.90a ± 0.11
SS + SW	7.65	7.14e ± 0.11	6.99e ± 0.12	7.05e ± 0.11
CH + SW	7.65	7.84d ± 0.13	7.59d ± 0.13	7.91d ± 0.08
SS	7.65	8.93c ± 0.08	8.61c ± 0.08	8.48c ± 0.13
CH	7.65	10.12b ± 0.08	9.76b ± 0.13	10.04b ± 0.08
LSD		0.1639	0.1961	0.229
$P \leq$		0.0001	0.0001	0.0001

Means in columns, within each treatment, followed by different letter (s) are significantly different at $P \leq 0.05$ using least significant difference (LSD)

Table 5 Soil water-soluble K (mEq L^{-1}) as influenced by organic wastes application (average ± SD)

Treatments	Before application	After 4 months	After 9 months	After 11 months
C	0.59	0.28g ± 0.08	0.26f ± 0.01	0.22g ± 0.02
SW	0.59	0.31f ± 0.05	0.45e ± 0.03	0.39f ± 0.03
SW + IF	0.59	0.54e ± 0.08	0.59d ± 0.01	0.57e ± 0.08
SS + SW	0.59	0.58d ± 0.07	0.66c ± 0.08	0.63c ± 0.04
CH + SW	0.59	0.62c ± 0.04	0.70b ± 0.06	0.66b ± 0.02
SS	0.59	0.68b ± 0.06	0.65c ± 0.01	0.61d ± 0.01
CH	0.59	0.85a ± 0.10	0.81a ± 0.08	0.78a ± 0.08
LSD		0.0119	0.0134	0.0147
$P \leq$		0.0001	0.0001	0.0001

Means in columns, within each treatment, followed by different letter (s) are significantly different at $P \leq 0.05$ using least significant difference (LSD)

and organic fertilizer enhanced significantly the release of K from sawdust at all sampling.

Application of organic amendments significantly ($P \leq 0.0001$) affect soil mineral nitrogen (NH_4–N+ and NO_3–N) compared to the control treatment (Tables 6, 7). Application of sawdust at the 10 t ha^{-1} decreased significantly soil mineral nitrogen (NH_4–N), after 4 months from application. However, in the second and third sampling, NH_4–N increased significantly in SW treatments. Soil mineral nitrogen (NO_3–N) in SW treatment increased significantly in all sampling; however, in the first sampling, the increase was not significant. The highest amount of

Table 6 Soil mineral nitrogen (NH_4–N) mg kg^{-1} as influenced by organic wastes application (average ± SD)

Treatments	Before application	After 4 months	After 9 months	After 11 months
C	34.99	26.48f ± 0.17	25.30g ± 0.08	24.60g ± 0.02
SW	34.99	24.13g ± 0.09	29.78f ± 0.10	27.08f ± 0.06
SW + IF	34.99	26.88e ± 0.08	32.53e ± 0.10	30.80e ± 0.03
SS + SW	34.99	28.90d ± 0.09	34.50d ± 0.08	33.70d ± 0.04
CH + SW	34.99	36.75b ± 0.08	37.60c ± 0.08	35.50c ± 0.03
SS	34.99	31.88c ± 0.08	39.95b ± 0.06	38.95b ± 0.05
CH	34.99	44.33a ± 0.09	45.30a ± 0.08	44.30a ± 0.04
LSD		0.1467	0.1273	0.1185
$P\leq$		0.0001	0.0001	0.0001

Means in columns, within each treatment, followed by different letter (s) are significantly different at $P \leq 0.05$ using least significant difference (LSD)

Table 7 Soil mineral nitrogen (NO_3–N mg kg^{-1}) as influenced by organic wastes application. (average ± SD)

Treatments	Before application	After 4 months	After 9 months	After 11 months
C	33.10	24.35e ± 0.13	23.48g ± 0.09	22.60g ± 0.14
SW	33.10	25.70de ± 0.09	25.70f ± 0.08	22.80f ± 0.08
SW + IF	33.10	27.33 cd ± 0.10	27.30e ± 0.08	25.30e ± 0.08
SS + SW	33.10	29.53c ± 0.08	29.53d ± 0.10	27.30d ± 0.06
CH + SW	33.10	42.40b ± 0.06	42.40b ± 0.08	37.60b ± 0.07
SS	33.10	41.35b ± 0.10	34.60c ± 0.07	32.45c ± 0.06
CH	33.10	48.70a ± 0.09	48.70a ± 0.08	42.70a ± 0.08
LSD		2.4982	2.5176	0.1213
$P\leq$		0.0001	0.0001	0.0001

Means in columns, within each treatment, followed by different letter (s) are significantly different at $P \leq 0.05$ using least significant difference (LSD)

Table 8 Soil total nitrogen (g kg^{-1}) as influenced by organic wastes application (average ± SD)

Treatments	Before application	After 4 months	After 9 months	After 11 months
C	0.28	0.22ef ± 0.01	0.17f ± 0.02	0.15g ± 0.02
SW	0.28	0.21f ± 0.03	0.23e ± 0.03	0.20f ± 0.01
SW + IF	0.28	0.23e ± 0.02	0.25d ± 0.01	0.22e ± 0.03
SS + SW	0.28	0.25d ± 0.01	0.29c ± 0.04	0.26d ± 0.04
CH + SW	0.28	0.27c ± 0.02	0.30c ± 0.01	0.29c ± 0.03
SS	0.28	0.30b ± 0.03	0.33b ± 0.02	0.31b ± 0.01
CH	0.28	0.32a ± 0.01	0.37a ± 0.03	0.34a ± 0.04
LSD		0.016	0.013	0.013
$P\leq$		0.0001	0.0001	0.0001

Means in columns, within each treatment, followed by different letter (s) are significantly different at $P \leq 0.05$ using least significant difference (LSD)

mineral N was recorded in CH treatment followed by CH + SW treatment.

After 6 months, addition of organic amendments significantly affected soil TN (Table 8). After the first sampling, CH treatment compared to all other treatments had significantly ($P \leq 0.0001$) increased TN from 6.7 to 45.5 %. After the second sampling, incorporation of chicken manure had increased TN by 48.0 % as compared to the sawdust with inorganic fertilizer (SW + IF). After the third sampling, plots with CH had consistently maintained the significantly highest (126.7 %) TN values as compared to other treatments. The increase in TN due to application of CH, relevant to SW + IF treatment, was 54.5 %. Also, incorporation of SS has significantly increased soil TN as compared to the SW + IF treatments, and maximum increased value after the third sampling was

Table 9 Soil water-soluble Ca (mEq L^{-1}) as influenced by organic wastes application (average ± SD)

Treatments	Before application	After 4 months	After 9 months	After 11 months
C		3.40ef ± 0.08	3.38f ± 0.10	2.80g ± 0.08
SW	4.03	3.30f ± 0.08	3.58e ± 0.10	3.30e ± 0.08
SW + IF	4.03	3.48e ± 0.10	3.75d ± 0.06	3.20f ± 0.06
SS + SW	4.03	3.75d ± 0.06	3.78c ± 0.26	3.50d ± 0.07
CH + SW	4.03	4.23c ± 0.10	4.45b ± 0.06	4.25c ± 0.05
SS	4.03	4.53b ± 0.05	4.43b ± 0.10	4.43b ± 0.05
CH	4.03	4.95a ± 0.06	4.88a ± 0.10	4.60a ± 0.08
LSD		0.129	0.11	0.132
$P\leq$		0.0001	0.0001	0.0001

Means in columns, within each treatment, followed by different letter (s) are significantly different at $P \leq 0.05$ using least significant difference (LSD)

Table 10 Soil water-soluble Mg (mEq L^{-1}) as influenced by organic wastes application. (average ± SD)

Treatments	Before application	After 4 months	After 9 months	After 11 months
C	0.39	0.25f ± 0.01	0.25g ± 0.02	0.21g ± 0.05
SW	0.39	0.27e ± 0.03	0.34e ± 0.01	0.31e ± 0.08
SW + IF	0.39	0.28e ± 0.01	0.31f ± 0.03	0.30f ± 0.06
SS + SW	0.39	0.33d ± 0.05	0.38d ± 0.06	0.35d ± 0.08
CH + SW	0.39	0.38c ± 0.03	0.40c ± 0.01	0.37c ± 0.04
SS	0.39	0.46b ± 0.06	0.44b ± 0.01	0.42b ± 0.02
CH	0.39	0.62a ± 0.07	0.60a ± 0.02	0.57a ± 0.01
LSD		0.014	0.0159	0.011
$P\leq$		0.0001	0.0001	0.0001

Means in columns, within each treatment, followed by different letter (s) are significantly different at $P \leq 0.05$ using least significant difference (LSD)

40.9 %. Also in this sampling date, the increased TN due to the application of CH + SW and SS + SW was significantly observed, and this increase compared to the control treatment was 93.3 and 73.3 %. In this sampling, incorporation of sawdust with and without inorganic fertilizers had also resulted in significantly increased TN, but less increase (46.7 and 33.3 %).

The effect of application of organic amendments on water-soluble Ca and Mg is presented in Tables 9 and 10, respectively. After the first sampling, CH treatment increased Ca and Mg by 42.2 and 121.4 %, respectively, compared to the SW + IF treatment. After the third sampling, the increase in Ca and Mg was 43.8 and 90.0 %, 38.4 and 40.0 %, 32.8 and 23.3 %, and 9.4 and 16.7 % in CH, SS, CH + SW, and SS + SW, respectively, relative to the SW + IF.

Discussion

The decrease in soil pH after application of chicken manure and sewage sludge is in agreement with the results reported by Rezig et al. (2013), Mubarak et al. (2008), Usman et al. (2004), and Speir et al. (2003). However, Melero et al. (2007) reported that addition of organic amendments has a little effect on soil pH. The decrease in soil pH is either due to nitrification of NH_4^+ or the release of H^+ ions during mineralization of the organic amendments (Antolin et al. 2005). Organic amendments can affect on soil pH via accumulation of CO_2 and organic acid during their decomposition in the soils (Yunsheng et al. 2007; Hulugalle and Weaver 2005; Huang et al. 2004; Millar and Baggs 2004). Our results showed that application of chicken manure and sewage sludge with and without sawdust had acidifying effect on the soil of the study site. The increase in soil OC has previously attributed to the continuous addition of C (Blanco-Canqui and Lal 2007; Bhattacharyya et al. 2008). There are many studies documenting an increase in O.C with organic amendments application (Dhiman et al. 2000; Kushwaha et al. 2000; Karanja et al. 2006; Ogbodo 2009; Rezig et al. 2013). Although application of organic amendments increased soil-available P except in sawdust alone, P content of sawdust was below the critical value (13 mg P kg^{-1}) suggested by Adetunji (1996). This result indicates that sawdust alone is not good sources for P in sandy soil, and therefore, supplementation with inorganic P is needed. The application of organic amendments may increase P availability, either directly by from decomposition of organic matter and release of P or indirectly by increasing the amount of soluble organic acids that increase the rate of desorption of phosphate (Nziguheba et al. 1998). The increase in available P concentration in sawdust with inorganic fertilizer treatment might be due to high microbial activity induced by the addition of sawdust, and soluble inorganic P, which increased P cycling (Melero et al. 2007). The addition of organic amendments in this study supplied the soil with significant amounts of K, chicken manure and sewage sludge have high K content, (23.2 and 34 g kg^{-1}), and their application may increase K availability in the soil (Chatterjee and Mondal 1996; Mubarak et al. 2002, 2003; Mubarak and Dawi 2009). The decrease in mineral nitrogen after sawdust (high C/N ratio) incorporation is likely due to N immobilization and possibly ammonia volatilization (Reiter et al. 2002). The study showed that proportionately more N is available from low C/N ratio organic amendments (CH, SS) than high C/N ratio organic amendments (SW), which is in agreement with results found by Rezig et al. (2013) and Mubarak et al. (2003). The results showed an increased total N content in plots treated with chicken manure, sewage sludge, and combined application of sawdust and inorganic fertilizer. Organic waste with high C/N ratio such as, sawdust, wheat, rice, barley, and maize may require addition of inorganic N for decomposition to proceed (Rezig et al. 2014; Debnath and Sinha 1993). Improved decomposition rates of organic amendments due to addition of inorganic N and low C/N ratio organic amendments have been reported by several workers (Rezig et al. 2014, 2013; Debnath and Sinha 1993). The increase in Ca and Mg in plots treated with organic amendments may be due to the release of organic forms of these elements in the organic residue (Ogbodo 2009). The contents of Ca and Mg in decomposing organic amendments have been reported to released (Rezig et al. 2014; Mubarak et al. 2008) or completely immobilized (Lupwayi and Haque 1999).

Conclusions

There are many studies indicated the positive and useful effect from addition of organic matter to the sandy soils, and also investigating chicken manure addition to the soil. Addition of sewage sludge is useful but also with high consideration and carefulness about the heavy metals. The availability of different sources for organic matter not used given space to the more specifications in the applications: as amounts, timing, and effect on the crops and trees. In brief, application of organic amendment to sandy soil improved its chemical properties and sustained sand dune fixation.

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