



Original Research Article

Influence of composted mesquite on growth, yield, nutrients content of maize (*Zea mays L.*) and some soil properties in Sudan

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There is need to convert mesquite (*Prosopis spp.*) into a useful product instead of constituting a menace to agricultural lands. Thus, it was suggested using mesquite as compost. The purpose of this study is to evaluate the effect of composted mesquite on some soil properties, vegetative growth parameters and nutrient contents of maize. The compost was made from mesquite tress through aerobic methods and was applied at five rates: 0 (T1), 10 (T2), 20 (T3), 30 (T4) and 40 (T5) t ha⁻¹ equivalents. A pot experiment was carried out in a complete randomized design, with four replications. Results shows that T5 is positively affected both of plant and soil compared with other treatments. T5 is significantly ($p < 0.05$) increased plant height (107±0.147 cm), number of leaves (9.0±0.250), stem diameter (1.3±0.014 cm), dry matter (48±0.026 g plant⁻¹), total N (8.27±0.006 g kg⁻¹), P (5.35±0.009 g kg⁻¹) and K (38.5±0.008 g kg⁻¹), compared with control treatment were (81±0.326 cm), (6.0±0.250), (0.6±0.006 cm), (30±0.712 g plant⁻¹), (3.25±0.009 g kg⁻¹) (1.85±0.007 g kg⁻¹) and (25.5±0.013 g kg⁻¹), respectively. While, soil analysed for pH (8.21±0.009), EC (1.32±0.010 dS m⁻¹), N (2.15±0.006 g kg⁻¹), P (4.90±0.006 mg kg⁻¹), K (19.53±0.004 mg kg⁻¹) and SOM (6.72±0.004 g kg⁻¹), where in control treatments were (8.51±0.008), EC (0.77±0.008 dS m⁻¹), (0.84±0.004 g kg⁻¹), (1.64±0.007 mg kg⁻¹), (11.01±0.022 mg kg⁻¹) and (3.4±0.006 g kg⁻¹). This study showed that composted mesquite application offers the potential to enhance soil quality, improve maize growth and nutrients content. Moreover, T5 (40 ton ha⁻¹) showed a significant superiority compared with other treatments.

Key words: Composted mesquite, vegetative growth, maize, nutrients availability, soil properties.

INTRODUCTION

One of the greatest problems facing most African countries is the inability to grow enough food for her ever-increasing population. Maize (*Zea mays L.*) is one of the most important cereals crops that provide staple food to address the growing shortage of food for a large number of human populations in the worldwide (Hossain et al., 2012). In the global, maize occupies the third after wheat and rice. In

developing countries such as West and Central Africa, the maize firstly in ranking (Jones, 1997; Akbar et al., 2016). Maize culture can be in a traditional level and/or in commercial scale. Recently, the demand for maize increased significantly to meet numerous industrial foods materials that led to the need to use more fertilizers. Synthetic fertilizers have become the major nutrient

sources for agriculture. Exclusive uses of chemical or inorganic fertilizers is limited because of its negative effect of environment such as soil acidity, water pollution, and imbalance of nutrient content. Moreover, its high cost are not always available to farmers and smallholder (Adebayo et al., 2017; Mensah and Frimpong, 2018; Olowoake et al., 2018). Thus, there is a tendency to use another source of fertilizer such as organic fertilizer. Organic fertilizers such as compost, farmyard and animal manures may be used as a substitute for chemical fertilizer (Hossain et al., 2012; Mohamedelnour et al., 2018). The addition of compost made from plant residues enhanced crop production by improving nutrient availability for plant, as the result of improving soil properties (Liu et al., 2013; Olowoake et al., 2018; Khan et al., 2019).

Mesquite (*Prosopis spp.* Mimosaceae, Leguminosa) has been described as thorny shrubs or small trees (3 to 15 meter) and one of the rapid growth and spreading plants, especially in arid and semi-arid (Henciya et al., 2017). Mesquite trees have a long life cycle, fast-growing, high seed production, an ability to survive droughts (Mwangi and Swallow, 2008). They also have a deep-growing taproot, thereby lowering the water table at a depth of more than 30 m and causing other trees to wither away due to lack of water (Henciya et al., 2017). Mesquite in many cases become a major nuisance in ecosystems because invaded agricultural land, depletion of rangeland, adverse effect on biodiversity in many countries like South Africa, Sudan and Australia (Pasiiecznik, 1999). However, mesquite trees are one of the leguminosae family and have a symbiotic relationship with rhizobium bacteria like other legumes and this relationship allows them to fixation of nitrogen from the air in the form of ammonia. Because of this, mesquite trees can my use as organic fertilizer (Bailey 1976; Geesing et al., 2000).

According to the mentioned above, Mesquite has been ranking as one of 100 unwanted species (Lowe et al., 2000). The above facts have led to hypothesized that prepare compost from mesquite. In view of the above, the objective of this study was to evaluate the effect of composted mesquite on some soil properties, vegetative growth parameters and nutrient contents of maize.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out in greenhouse of the Department of Soil and Environment Sciences, Faculty of Agriculture, University of Khartoum, Sudan (latitude 15°:14' N and longitude 32°:32' E).

Compost preparation

The compost of mesquite was prepared by collecting mesquite trees sprouting abundantly along irrigation channels in Alsilate agricultural project in Khartoum city.

The leaves and twigs mesquite have been cut into small pieces manually, air-dried under a shadow, then have been made in heaped (aerobically composted). Watered when necessary, the heap periodically shifted to improve aeration and the decomposition process lasted for 120 days.

Experimental design and Treatments

A pot experiment was conducted in a completely randomized design (CRD) with four replicates and the treatments of composted mesquite was calculated as (ton ha⁻¹) include: Control 0 (T1); 10 (T2); 20 (T3); 30 (T4) and 40 (T5). Maize as testing crop was sown with five seeds per pot, each pot was filled with 5 kg (soil/pot) and after 7 days of germination only three healthy and uniform plants was retained in pots. The mineral fertilizers N, P₂O₅ and K₂O (mg kg⁻¹) were applied for maize crops as a recommended dose (100: 50: 62.5) by agronomists for all the treatments. Irrigation was done regularly to maintain soil moisture content about 80% of field capacity, and weeding was performed manually when needed during the growing period (12 weeks).

Soil analysis

The main soil characteristics (0-30 cm) are shown in Table (1). Soil pH was measured by a pH meter with glass electrode in a soil paste and Electrical conductivity of the saturation extract (EC) was measured by EC-meter (Page et al., 1982). Total nitrogen (N), Available Phosphorus (P), Exchangeable potassium (K) and Soil organic matter (OM) were determined according to methods described in AOAC (2005). Particle size distribution (soil texture) was obtained by the modified hydro-pipette method (Day, 1965).

Plant measurement

Agronomic parameters

The agronomic characteristics of the maize crop such as plant height (cm), stem diameter (cm) and number of leaves per plant were recorded, at harvesting time (12 weeks). The plant samples (leaves and stem) were first washed with tap water twice, then with distilled water and then oven-dried at 70±3°C for 3 days until a constant weight and dry weight was also recorded (g plant⁻¹).

Chemical analyses of plant

The ground material of plant samples was analyzed for N, P and K according to method described by Bremner and Mulvaney, (1982) and AOAC, (2005).

Statistical analysis

Analysis of variance (ANOVA) and least significant difference (LSD) tests were performed on the data using

Table 1. Some physical and chemical properties of soil used in this study

Soil	p	EC (dS m ⁻¹)	N (g kg ⁻¹)	P (mg kg ⁻¹)	K (mg kg ⁻¹)	OM (g kg ⁻¹)	Soil texture (%)		
							Clay	Silt	Sand
	7.73	0.8	0.5	2.65	7.01	1.03	52.3	14.6	33.1

Table 2: Effect of composted mesquite on some soil chemical properties

Treatments	pH	EC (dS m ⁻¹)	N (g kg ⁻¹)	P (mg kg ⁻¹)	K (mg kg ⁻¹)	OM (g kg ⁻¹)
T1	8.51a±0.008	0.77c±0.008	0.84c±0.004	1.64e±0.007	11.01e±0.022	3.4e±0.006
T2	8.42b±0.007	1.2b±0.006	1.11c±0.009	2.65d±0.007	14.02d±0.007	4.05d±0.010
T3	8.35c±0.010	1.17b±0.004	1.17b±0.004	3.14c±0.008	17.02c±0.010	5.95c±0.011
T4	8.27d±0.004	1.17b±0.007	1.26b±0.008	4.28b±0.004	18.53b±0.012	4.91b±0.004
T5	8.21e±0.009	1.32a±0.010	2.15a±0.006	4.89a±0.006	19.53a±0.004	6.72a±0.004

In each column values with a different letter are significantly different at a ($p < 0.05$)

MSTAT-C statistical analysis package (Russel and Eisensmith, 1983).

RESULTS

Soil properties

The data presented in Tables 1 showed some physical and chemical properties of soil used in this study. The soil texture was sandy clay, moderately alkaline (pH 7.73), non-saline (EC 0.8 dS m⁻¹) and poor in nutrients content included N (0.5 g kg⁻¹), P (0.52.65 mg kg⁻¹), K (7.01 mg kg⁻¹) and OM (1.03 g kg⁻¹).

Effects of Composted Mesquite Applications on some soil chemical properties

Soil pH

The results revealed a significant ($p < 0.05$) decrease in the soil pH following applications of composted mesquite (Table 2). The highest soil pH was recorded in the control (8.51±0.008), while the lowest value was recorded in T5 (8.21±0.009).

Electrical Conductivity (EC):

Analysis of variance (ANOVA) indicated significant difference ($p < 0.05$) of EC values between T5 (1.32±0.010) and control (0.77±0.0081). The results did not show any variation between T2, T3 and, T4 (Table 2).

Total nitrogen (N):

Application of composted mesquite significantly affect nitrogen uptake by maize (Table 2). The highest (2.15±0.006 g kg⁻¹) and the lowest (0.84±0.004g kg⁻¹)

uptake of N found in treatment T5 and T1, respectively.

Soil available phosphorus (P)

According to the statistical analysis the application of composted mesquite has significantly increased soil available P compared with untreated soil (Table 2). The available P values ranged from 1.64±0.007 (mg kg⁻¹) in T1 (control) to 4.90±0.006 (mg kg⁻¹) in T5.

Exchangeable potassium content (Exch. K)

The application of composted mesquite caused significant differences ($p < 0.05$) in potassium content between all of treated soil and control (Table 2). T5 had the highest value of exch. K (19.53±0.004mg kg⁻¹) while control had the least (11.01±0.022 mg kg⁻¹).

Soil organic matter (SOM)

Significant differences ($p < 0.05$) were recorded among treatments for soil organic matter (SOM). The values of SOM ranged between 3.41±0.006 (g kg⁻¹) from T1 and 6.72±0.004 (g kg⁻¹) from T5 (Table 2). Also, data demonstrated SOM content of T3 high than T4 were 5.95±0.011 and 4.91±0.004 (g kg⁻¹), respectively.

Effects of Composted Mesquite Applications on Agronomic Performance of Maize

The plant height (cm)

There were significant differences ($p < 0.05$) in the plant height between those treated with composted mesquite and the control (T1). The results showed that the plant height was increased in parallel with compost application (Table 3). Plant height values were ranged between 81±0.326 cm and 107± 0.147 cm, from T1 and T5,

Table 3. Effect of composted mesquite on agronomic performance of Maize

Treatments	Plant height (cm)	Number of leaves	Stem diameter (cm)	dry matter (g plant ⁻¹)
T1	81e±0.326	6d±0.250	0.6d±0.006	30e±0.712
T2	93d±0.091	7c±0.250	0.8c±0.004	35d±0.064
T3	96c±0.135	7c±0.000	0.9c±0.013	38c±0.075
T4	98b±0.091	8b±0.250	1.1b±0.025	42b±0.039
T5	107a±0.147	9a±0.250	1.3a±0.014	48a±0.026

In each column values with a different letter are significantly different at a ($p < 0.05$)

respectively.

A number of leaves

The application of composted mesquite resulted in significant ($p < 0.05$) increases in the number of leaves. It noted that T5 gave the highest number of leaves (9.0 ± 0.250) compared to (T1) control (6.0 ± 0.250) (Table 3). Also, the data demonstrated no difference between T2 and T3, the number of leaves in both of them were 7.

Stem diameter (cm)

Analysis of variance (ANOVA) indicated significant difference ($p < 0.05$) in stem diameter or thickness between those treated with composted mesquite and the T1 (control) (Table 3). The highest thickness of stem was recorded where the application of composted mesquite at T5 (1.3 ± 0.014). While, no significant difference was observed between T2 (0.8 ± 0.004 cm) and T3 (0.9 ± 0.013 cm) ($p > 0.05$).

Dry Matter (g plant⁻¹)

Application of composted mesquite was effective in increasing dry matter content in maize plant (Table 3). Significant differences were recorded in dry matter (leaves and stem) between control and other treatments ($p < 0.05$). The highest of dry matter was observed in T5 (48 ± 0.026 g plant⁻¹) and least in T1 (30 ± 0.712 g plant⁻¹).

Effects of Composted Mesquite Applications on Nutrient (N-P-K) uptake by Maize

Nitrogen uptake

The nitrogen (N) uptake by maize increased with increase of composted mesquite application (Table 4). There was significant difference ($p < 0.05$) in N content between all of treatments. At T5 had the highest N content (8.25 ± 0.006 g kg⁻¹) while the least (3.25 ± 0.009 g kg⁻¹) was obtained with T1 (control).

Phosphorus uptake

Table (4) summarized effects of composted mesquite application on phosphorus (P) content of maize. It is clear

that P concentration was increased linearly with compost applications. The maximum uptake of P occurred in the T5 and minimum in the T1(control). The P content ranged from 5.35 ± 0.009 to 1.85 ± 0.007 form T5 and T1, respectively.

Potassium uptake

A linear increase in potassium (K) content with increase of composted mesquite rates (Table 4). The minimum (25.5 ± 0.013 g kg⁻¹) and the maximum (38.5 ± 0.008 g kg⁻¹) values of potassium uptake were obtained in the control and T5, respectively.

DISCUSSION

Application of composted mesquite generally have positive effects on examined soil properties, growth parameters and nutrients content (N-P-K) of maize crop in the study.

Soil chemical properties

After the composted mesquite application, the soil pH was significantly decreased with increasing of application rate, that is due to release of H⁺ via nitrification process and /or organic acids during decomposition (Chang et al., 1991; Pocknee and Sumner, 1997; Rashad et al., 2011). The electrical conductivity (EC) values of all treatments were ranged between (0.77 to 1.32 dS m⁻¹) and it is a below the critical threshold ($EC > 4$ dS m⁻¹). It is known that the compost releases nutrients during the decomposition which leads to increase of EC (Eghball, 2002; Hossen et al., 2015). It also increases the amount of soil total nitrogen (N) during the mineralization of soil organic matter and stimulation to uptake by plant. This finding was also in line with results of (Eghball and Pwure, 1999a; Dambreville et al., 2006; Mylavarapu and Zinati, 2009). The amended pots showed increase of soil available P in parallel of application rate, that may due to decreasing of soil pH and reduced sorption capacity of the soil available P (Sharpley and Rekolainen, 1997; Eghball, 2002; Eghball et al., 2004; Agegnehua et al., 2015). They also found that, the addition of compost increased the availability of potassium content in soil, that because the potassium is mineralized during biodegradation of compost (Warman and Cooper, 2000;

Table 4. Effect of composted mesquite on nutrient (N-P-K) uptake by Maize

Treatments	N (g kg ⁻¹)	P (g kg ⁻¹)	K (g kg ⁻¹)
T1	3.25e±0.009	1.85e±0.007	25.49e±0.013
T2	4.22d±0.006	2.82d±0.007	28.5d±0.015
T3	6.72c±0.012	3.48c±0.012	33.3c±0.008
T4	7.48b±0.006	4.28b±0.004	35.5b±0.006
T5	8.27a±0.006	5.35a±0.009	38.5a±0.008

In each column values with a different letter are significantly different at a ($p < 0.05$)

Ojobor et al., 2017). The soil organic matter was increased with compost rate, that could be explained by the fact that compost is a source of organic carbon and was expected to released more carbon during decomposition. Additionally, organic amendments such as compost have advantages like to improving soil properties, enhancing nutrients availability, and gives a greater C/N ratio than untreated soil (Zebarth et al., 1999; Eghball, 2002; Leonor et al., 2007; Hargreaves et al., 2008).

Agronomic Performance of Maize

The results showed that the plant height was increased in parallel with compost application, that could be due to improving soil condition by adding compost and enhancing nutrients availability such as nitrogen and phosphorus, which plays an important role in cell division and their expansion which ultimately leads to an increase the plant height (Fujiwara, 1987; Zafar et al., 2012; Mensah and Frimpong, 2018). The increase of number of leaves as result of composted mesquite application can be explained by the fact that the nitrogen promoted the apical branching and hence the total number of leaves (Mensah and Frimpong, 2018). The increase of stem diameter could be attributed to the decreased of soil pH and effect on nutrients availability following application of compost (Minhas and Sood, 1994; Chamle and Jadhav, 2007; Mensah and Frimpong, 2018). It also increases the dry matter according to application rate of composted mesquite. That probably due to the application of compost directly affecting root growth and enhancement nutrients uptake from the soil (Ogbonna and Obi, 2005; Poll et al., 2008).

Nutrient (N-P-K) uptake by Maize

The results showed that the total N content, total P content and potassium (K) content were increased linearly with compost application. The increase of nitrogen content (N) may due to compost that can release nitrogen through the mineralization process and that lead to stimulation of N uptake by plant (Poll et al., 2008; Passoni and Bonn, 2009; Oworu et al., 2010). It also increases of total P content, this probably due to mineralization of organic phosphorus releases P into the soil solution and the results of soil available P confirmed this probability. Also, the application of composted mesquite can increase phosphorus solubility

due to the effect of soluble carbon compounds on sorption of P in soil (Mohammadi et al., 2009; Mantovani and Spadon, 2017). The high potassium content in maize can be explained by the raise in potassium concentrations in the soil, with the application of compost (Heymann et al., 2005; Mantovani and Spadon, 2017).

Conclusion

The findings of this research highlighted that the Mesquite '*Prosopis spp.*' can be converted to a useful product and applied as compost. It noted that the application of composted mesquite had a significant and positive ($P < 0.05$) effect on growth parameters (plant height, number of leaves, stem diameter and dry matter yield), nutrients uptake (N-P-K) for maize crop, and improve soil chemical properties such as soil pH, EC and availability of N, P and K. The 40 t ha⁻¹ had the highest effects on all measured parameters in this study, therefore, it could be recommended for farmers. Though, application level higher than 40 t ha⁻¹ can further be evaluated to achieve the optimum level.

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Conflict of interests

The authors declare that they have no conflicting interests

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