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ORIGINAL RESEARCH

Effect of organic fertilizers rate on plant survival and mineral properties of *Moringa oleifera* under greenhouse conditions

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Abstract

Purpose The nursery is the production of vigorous seedlings for field transplantation. Fertilization improves the quality of *Moringa oleifera* in the greenhouse. Thus, the effect of composts amendments on the survival rate and mineral composition of *M. oleifera* was studied.

Methods A randomized complete block (RCB) design comprising fourteen treatments and twelve repetitions (pots referring to as repetitions), was led out in greenhouse. Varying compost receipts (0.1 kg, 0.2 kg, and 0.3 kg) were used and an increasing amount of a chemical fertilizer (NPK: 20:10:10) was added in some treatment at 25 days after sowing. Parameters such as germination rate, survival rate, biomass, and mineral composition of *M. oleifera* plants were assessed.

Results The germination rate was maximal (100%) in the combined treatment PM_1 (0.8 kg of soil + 0.1 kg). A considerable reduction of germination rate and high plantlet mortality were observed in treatments that received chemical fertilizer, although the mineral components' uptake in young *M. oleifera* plants was considerably improved. The highest dry root biomass was obtained from the treatments MF_1 (0.8 kg of soil + 0.032 kg each of cow dung, goat, chicken manures + 0.003 kg NPK) and CM_1 (0.8 kg of soil + 0.1 kg of cow dung compost), with, respectively, 0.62 g and 0.59 g per plant.

Conclusions All composts types used in this study have appeared as appropriate amendments to improve the *M. oleifera* production in nursery, through an increase of the vigour and mineral composition of this valuable plant.

Keywords Compost · *Moringa oleifera* · Mineral components · Plant survival rate · Greenhouse

Introduction

Moringa oleifera Lam. (Moringaceae: Capparales) is a plant of great importance because of its industrial, medicinal and food uses. *Moringa oleifera* leaves and fruits are widely consumed by rural populations of tropical regions of the world (Ramachandran et al. 1980; Lockett et al. 2000). As far as the nutritional value of *M. oleifera* leaves is concerned, it has four times more calcium than a cup of milk, more iron than in 100 g of spinach, seven times more vitamin C than in 100 g of oranges, 100 g contain four times more vitamin A than the same amount of carrots and three times more potassium than in 100 g of bananas (Fahey 2005). Therefore, *M. oleifera* could be used in food security programmes to solve malnutrition. The plant is not very demanding in terms of fertilizer, but a minimal intake improves its yield. Factors required for better crop yield are adequate soil fertilization and proper field management with organic amendments of plant or animal origin. According to Stoffella et al. (1997), compost and other organic fertilizers have been reported to improve soil nutrient levels, as fertilizers provide a ready source of carbon and nitrogen for soil microorganisms, improve soil structure, reduce erosion, lower soil temperatures, facilitate seed germination and increase soil water retention capacity. Fertilizers stabilize soil pH, increase soil organic matter, and ultimately improve the growth and yields of plants (Roe et al. 1997).

Moringa oleifera as a fast-growing, deciduous and drought-resistant plant can be grown in fields either by direct seeding

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or through nursery. However, during nursery time, the nutrient amount of soil should be high enough to sustain the plant life cycle (Wilson et al. 2001), and can be periodically increased with doses of organic fertilizers and chemical fertilizers-NPK (Beaulah et al. 2001). In related research, a positive response of *M. oleifera* plants was obtained after fertilizers application (Haouvang et al. 2017). Similarly, a trial to determine the influence of biofertilizers on the growth and nutritional quality of *M. oleifera* in Egypt has revealed the beneficial effect of amendments to the plant (Mona 2012). The effect of various amounts of composts on *M. oleifera* has not been evaluated. The objective of this study was to find the appropriate amount of organic wastes for the production of vigorous *M. oleifera* plants. We investigate the potential of different compost formulations from various animal wastes on the survival rate and chemical composition of *M. oleifera* plants under greenhouse conditions.

Materials and methods

Soils and seeds used

The soil was collected at 0–5 cm of depth within each sampling location of the study site in Chad. This soil was analysed in the soil and water laboratory at the International Institute of Tropical Agriculture (IITA) of Yaounde (Cameroon). *Moringa oleifera* seeds were collected from plants of farmers inhabiting the Mayo-kebbi East division, which is located in the South-western Chad.

Fertilizers used

The mineral fertilizer NPK (20:10:10) applied in this study was provided by IITA. It was used as a source of nitrogen, phosphorus, and potassium. Organic fertilizers were made up of composts produced from various organic animal wastes such as poultry, goats and cow dung manures. The composting procedure as described by Ngakou et al. (2008) consisted of superposing wastes in layers to build piles comprising dry straws, manures, and inoculum (waste degrading microorganisms). All piles not lower than 1.5 m in height were monitored by aerating or turning after every 2 weeks until all substrates within the pile were completely degraded to yield mature compost (not more than 4 months). The chemical components of organic fertilizers are presented in Table 1.

Table 1 Chemical properties of organic fertilizers

Type of composts	K (%)	C (%)	N (%)	C/N	P (ug/g)
Poultry manure compost	13.09	8.42	0.641	13.14	920.7
Goat manure compost	25.37	10.87	1.064	10.21	328.6
Cow dung compost	5.40	5.47	0.442	12.38	276.5

K potassium, *C* carbon, *N* nitrogen, *C/N* carbon-to-nitrogen ration, *P* phosphorous

Experimental design and treatments

Experimental design

Trials were performed following a randomized complete block (RCB) design; comprising fourteen treatments and twelve replicates formulated as follow:

1. $T = 0.8$ kg soil control.
2. $PM_1 = 0.8$ kg soil + 0.1 kg poultry manure compost.
3. $PM_2 = 0.8$ kg soil + 0.2 kg poultry manure compost.
4. $PM_3 = 0.8$ kg soil + 0.3 kg poultry manure compost.
5. $GW_1 = 0.8$ kg soil + 0.1 kg goat manure compost.
6. $GW_2 = 0.8$ kg soil + 0.2 kg goat manure compost.
7. $GW_3 = 0.8$ kg soil + 0.3 kg goat manure compost.
8. $CM_1 = 0.8$ kg soil + 0.1 kg cow dung manure compost.
9. $CM_2 = 0.8$ kg soil + 0.2 kg cow dung manure compost.
10. $CM_3 = 0.8$ kg soil + 0.3 kg cow dung manure compost.
11. $MF_1 = 0.8$ kg soil + 0.032 kg PM + 0.032 kg GW + 0.032 kg CM + 0.003 kg NPK.
12. $MF_2 = 0.8$ kg soil + 0.065 kg PM + 0.065 kg GW + 0.065 kg CM + 0.005 kg NPK.
13. $MF_3 = 0.8$ kg soil + 0.095 kg PM + 0.095 kg GW + 0.095 kg CM + 0.09 kg NPK.
14. NPK = 0.8 kg soil + 0.01 kg NPK.

Experimental layout

The experimental units were represented by pots. A pot contained 0.8 kg of soils each, as well as compost ranging from between 0.1 kg, 0.2 kg, or 0.3 kg depending on the treatment considered. A variable amount (0.003 kg, 0.005 kg, and 0.09 kg) of chemical fertilizer (NPK: 20:10:10) was added to some treatments 25 days after sowing. The pot-tray was installed in a greenhouse. Seeds were soaked in water for 24 h before sowing (two per pot) at a maximum depth of 2 cm. After germination (7 and 10 days after sowing), only one vigorous plant was left in each pot. Pots were watered at a rate of 250 ml/pot every 3 days.

Assessed parameters

Germination and survival plants rate

The germination rate was evaluated from the 7th–10th day after sowing. This operation consisted of counting the total number of germinated seeds and expressed it as a percentage using the following formula:

$$\text{Germination rate}(\%) = (\text{Number of emerged plants}) \times 100/\text{Number of seeds sown}.$$

The survival rate of plants was assessed by recording dead and alive plants after every 15 days and the percentage of survived plants was calculated using the formula:

$$\text{Survival plants rate} = (\text{Number of survived plants}) \times 100/\text{Number of seeds sown.}$$

The plant biomass was measured at 55 days after sowing after drying of plants in an oven at 105° for 24 h.

Biomass

Plant biomass was measured by quantifying the weight of the different parts of plants. Thus, the dry biomass of the roots and the aerial part of plants was determined by drying in an oven at 105 °C for 24 h, and then weighing with a Jewelry Scale GEM 50 electronic scale with an accuracy of 1/1000. Fresh biomass was evaluated by simple weighing.

Soil analysis

Soil samples were air-dried and crushed to pass through a 2-mm sieve. For the analysis of carbon (C) and nitrogen (N), samples were sieved to fine soil through 0.5 mm pores. The soil pH was determined in a mixture of 1:2.5 (w/v) soil/water suspension using a pH-meter. Organic C was determined by chromic acid digestion and spectrophotometric analysis (Heanes 1984). Total N was determined from the wet acid method (Buondonno et al. 1995), and analysed by colorimetric method as recommended by Anderson and Ingram (1993). The available phosphorus (P) was extracted using bray extraction procedure, while the resulting extracts were analysed through the blue molybdate method described by Murphy and Riley (1962). The exchangeable cations: calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na) were extracted using ammonium acetate and assessed using the atomic absorption spectrophotometer (García and Báez 2012). The CEC (cation exchange capacity) was determined colorimetrically. The particle size (three fractions) was determined by the hydrometer method (Day 1953). Total C and total N were expressed in percentage (%), whereas Ca, Mg, K, Na, and CEC were expressed in cmol (+)/kg, which corresponds to me/100 g.

Plant analysis

Total Ca, Mg, K, and Na were extracted by dry incineration in a furnace muffle, after a dilution using a mixture of diluted hydrochloric acid (HCl)/nitric acid (HNO_3), then analysed using the atomic absorption spectrophotometer, and expressed in percentage or ug/g or ppm, respectively. P was extracted as previously described (Murphy and Riley 1962). Total N was determined from a wet acid method (Buondonno et al. 1995) and analysed by colorimetric method as recommended by Anderson and Ingram (1993).

Statistical analysis

All data, except those of germination and survival rates, soil mixtures and compost were subjected to analysis of variance (ANOVA) for comparison of mean values and Turkey test for multiple comparison range of mean values using the XLStat 2014 program.

Results and discussion

Physico-chemical properties of substrates mixtures before and after experiment

The physical and chemical characteristics of different composts (Table 2) show a variation in elemental components of soil before and after the experiment. These elements were unequally distributed in different treatments. The soil pH was generally acid or neutral, except for few basic treatments, such as goat manure compost-based treatments. For macro-elements, calcium Ca, Mg, K, Na, C and N were more concentrated in chemical fertilizer treatments, with, respectively, 18.27 me/100 g, 9.88 me/100 g, 14.35 me/100 g, 1.55 me/100 g, 5.77 me/100 g and 0.7%. Conversely, phosphorus was very weakly represented in the control. MF_3 treatment after the experiment was the wettest with 38.4%. The amount of most elements in treatments was reduced at 55 days after sowing (DAS). This decrease could be attributed to the assimilation of some nutrients by the plant for food diet. Treatment with chemical fertilizer resulted in pH values around 6.17. An improved supply of nutrients was reported in NPK fertilizers and organic manure treatments that resulted in better fruit quality, growth and yield of tomato plants as pointed out by Zhang et al. (1988). Similarly, the application of NPK fertilizer (150, 50 and 50 kg/ha, respectively) markedly enhanced the concentration of magnesium in selected green leafy vegetables, whereas the concentration of copper was not affected significantly (Reddy and Geeta 2001). Potassium content in green leafy vegetables was not affected by the addition of chemical fertilizers to soil. The availability of N, P and K was improved in the soil during different application rates of compost could be attributed to an increased microbial activity, as the result of enhanced decomposition of the organic forms of N, P and K. Thus, treatments with a given dose of fertilizers were more concentrated in mineral elements than the control. Previous studies have shown an improved N, P, K, Ca, Mg and CEC status of soil, as well as reduced exchangeable acidity (EA) of soil, following organic

Table 2 Variation of physico-chemical properties of different levels of soil mixtures and compost before and after experiment

Treatments	PH water	Ca (me/100 g)	Mg (me/100 g)	K (me/100 g)	Na (me/100 g)	CEC (me/100 g)	C (%)	N (%)	C/N	Bray P (ug/g)	MC (%)
CM_1											
Before	6.66	3.08	142	1.15	0.25	3.66	1.36	0.083	16.36	51.08	2.35
After	6.57	3.44	1.54	1.04	0.12	3.86	1.44	0.098	14.66	41.97	8.06
CM_2											
Before	6.54	4.68	2.49	2.18	0.35	6.01	2.17	0.149	14.56	61.29	5.09
After	6.88	4.15	2.08	1.57	0.16	4.95	2.23	0.146	15.24	61.33	9.06
CM_3											
Before	6.71	6.62	3.95	3.44	0.46	8.59	3.46	0.217	15.95	88.20	9.50
After	6.98	6.11	3.39	2.82	0.26	7.45	3.10	0.230	13.50	81.93	14.72
GW_1											
Before	7.52	5.25	1.79	2.86	0.40	4.23	1.43	0.095	15.09	116.66	3.34
After	8.10	4.42	1.48	2.56	0.21	3.33	1.49	0.118	12.58	110.14	17.70
GW_2											
Before	8.04	7.41	2.76	5.05	0.52	5.86	2.14	0.175	12.21	146.85	5.87
GW_3											
Before	8.21	8.67	2.97	5.73	0.57	6.31	2.50	0.206	12.16	170.56	8.65
MF_1											
Before	7.28	5.59	3.09	3.63	0.59	5.90	2.73	0.209	13.09	259.17	17.29
After	7.57	9.22	5.07	6.72	0.92	9.27	3.86	0.340	11.36	335.88	17.00
MF_2											
Before	7.30	11.29	6.06	8.73	1.18	11.63	4.84	0.424	11.41	366.02	16.67
After	6.17	14.10	8.12	10.21	1.29	12.83	5.64	0.510	11.06	654.77	36.63
MF_3											
Before	7.35	10.12	6.20	9.11	1.20	12.11	5.26	0.481	10.93	375.41	16.14
After	6.61	18.27	9.88	14.35	1.55	16.13	5.77	0.700	8.24	639.52	38.24
PM_1											
Before	6.79	3.76	1.84	1.76	0.47	3.59	1.35	0.102	13.15	266.23	2.51
After	6.78	4.60	2.26	2.04	0.44	4.11	1.59	0.140	11.32	264.05	1.95
PM_2											
Before	6.76	5.13	3.33	3.11	0.74	5.50	1.74	0.132	13.15	408.62	4.59
After	7.57	5.49	3.26	2.89	0.57	5.49	2.06	0.163	12.61	368.64	23.71
PM_3											
Before	6.77	5.70	4.05	3.82	0.90	6.56	2.18	0.208	10.45	401.35	13.10
After	7.16	7.27	4.85	5.11	0.95	6.79	2.89	0.258	11.19	485.84	24.77
T											
Before	6.34	1.71	0.59	0.35	0.07	1.88	0.75	0.042	17.73	20.65	0.86
After	6.24	1.92	0.64	0.28	0.04	2.03	0.89	0.045	19.80	35.78	3.25

T control, *PM* poultry manure compost, *GW* goat manure compost, *CM* cow manure compost, *MF* mixture of fertilizers, *NPK* mineral fertilizer, *MC* moisture content, *1* 0.1 kg, *2* 0.2 kg, and *3* 0.3 kg fertilizer application (Smith and Ayenigbara 2001). Positive changes in soil K, Ca and Mg contents, reduction in EA values, and increases in CEC upon application of animal manures have been documented (Uwah et al. 2012).

Effect of fertilizer treatments on germination rate of seeds

The seed germination rate was higher in treatments receiving small amount of fertilizers (Fig. 1). It was increased by 100% for treatment PM_1, and 72.22% for treatments CM. In contrast, treatment PM_2 on one hand, and treatments GW_2, MF_2 and MF_3 on the other, contributed in reducing the seed germination rate with, respectively, 41.67% and 50%.

The effect of fertilizer treatment on germination rate of seeds allowed us to deduce that the compost produced was well mature (Guedira et al. 2011). *Moringa oleifera* is a plant with a high germination rate under normal conditions (Lamia et al. 2014). With a germination rate of up to 99%, compost for cow dung and poultry manure composts have a slight advantage over other treatments. This high germination rate could also be attributed to the 24-h pre-treatment of seeds before sowing. *Moringa oleifera* seeds subjected to pre-treatment such as soaking in water, dehiscence of seed, or destruction of seed shells before sowing were reported to greatly increase germination rate. A seed germination rate of 69.66% in soils without fertilizer input was obtained (Baye-Niwah and Mapongmetsem 2014), which is less than the 99% revealed in the present study.

Effect of fertilizer treatments on survival rate of *M. oleifera* plants

The survival rate of *M. oleifera* plants varied with treatments (Fig. 2). Composts from goat manures and mineral fertilizers contributed to an increase of mortality rates of plants (up to 67% dead plants after 55 days after sowing), thus corresponding to only 37% of survival rate of plants. On the other hand, cow dung and poultry compost (100 g) did not in any way affect the survival rate of plants, expressing 100% of healthy plants. This high mortality could be attributed to the uncontrolled fertilization that changed the soil colour from whitish to blackish with reduced root development as a consequence. These results line with those of Grzyb et al. (2013), who obtained significantly high mortality of plants following a high NPK mineral fertilization application on apples.

Impact of different amendments formulation on biomass of *M. oleifera*

The biomass of the plants obtained at 55 days after sowing presented in Table 3 indicates that there was a significant difference between treatments ($p < 0.05$). The aerial part of the plants had a dry weight clearly above the amount produced by the roots. The greatest dry root biomass was obtained from treatments MF_1 and $CM_{1,}$ with 0.62 g and 0.59 g, respectively, per plant. Treatments with elevated proportions of fertilizers recorded low dry aerial plant weight, due to low root production, with, respectively, 0.17 g, 0.11 g 0.11 g/plant for treatments CM_3, PM_3 and MF_3. Conversely, treatments with small proportions of CM_1, PM_1 and MF_1 composts greatly stimulated the aerial biomass of *M. oleifera* plants, although this was not true for treatment GW_1 that recorded a biomass (0.33 g) lower than that of the control.

The application of small amount of compost with or without inorganic fertilizer had a significant effect on plant biomass. The same results were obtained by Priyadarshani et al. (2013) who revealed optimal production of vetiver biomass following application of a mixture of compost with inorganic fertilizer in a 3:1 ratio. Rotkittikhun et al. (2007) demonstrated the suitability of compost application with lower doses of inorganic fertilizer for higher biomass production in field crops such as lemongrass and sunflower. Increased plant yields may also be due to an improvement in soil aggregate stability that may have favoured the multiplication of beneficial microorganisms that helped in improving biomass production (Basso and Ritchie 2005).

Variation in the mineral composition *of M. oleifera* at 55 days after sowing as influenced by treatments

Table 4 illustrates the mineral contents of *M. oleifera* leaves at 55 DAS, and was in general more elevated in all treatments than in the control. For the total N content in leaves, the most significant increase was recorded when plants were treated with the mixture of fertilizers such as MF_3 (4.34%) and MF_2 (3.19%). Ca was weakly represented in *M. oleifera* leaves compared to other minerals, except in cow dung compost (CM) where it was more concentrated (0.69%). The *M. oleifera* leaves in Mg were, respectively, 0.38, 0.38 and 0.37% in PM_1, CM_1 and CM_3 treatments. The most elevated P content was recorded in MF_3 and PM_1 treatments with 0.52% and 0.51%, respectively, compared to 0.17% in the control. Potassium was more concentrated in treatments with up to 3.87% when chemical fertilizer was applied. The organic carbon content in leaves ranged from 32.29% in the control leaves to 39.58% in PM1-treated leaves. These results are similar to those of Mbailao et al. (2014), who found values of 1.73, 1.23, 0.39 and 0.32 g/100 g of dry

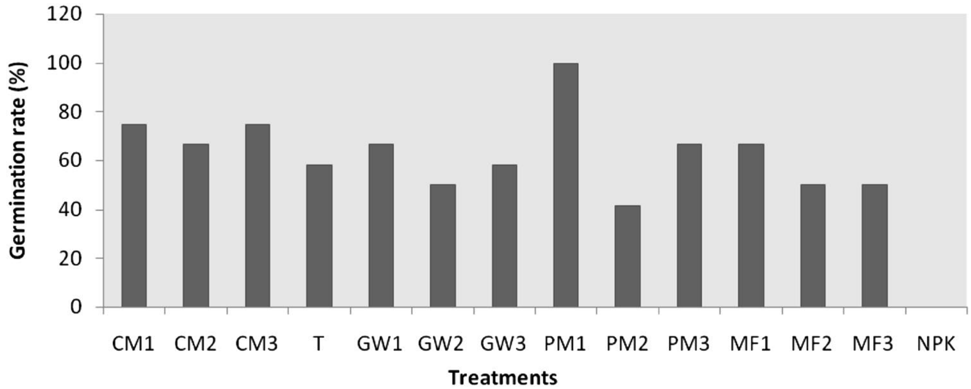

Fig. 1 Influence of treatments on germination rate of *M. oleifera* (*T* control, *PM* poultry manure compost, *GW* goat manure compost, *CM* cow manure compost, *MF* mixture of fertilizers, *NPK* mineral fertilizer, *MC* moisture content, 1. 0.1 kg, 2. 0.2 kg, 3. 0.3 kg)

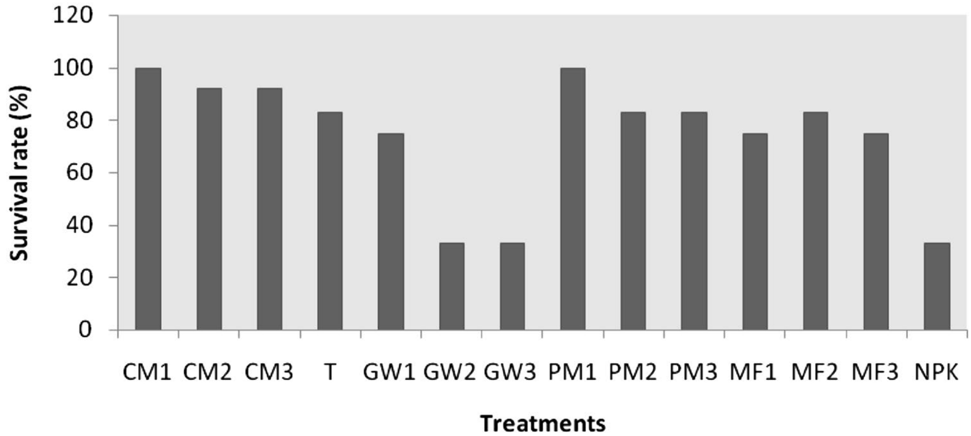

Fig. 2 Influence of treatments on survival rate of *M. oleifera* (*T* control, *PM* poultry manure compost, *GW* goat manure compost, *CM* cow manure compost, *MF* mixture of fertilizers, *NPK* mineral fertilizer, *MC* moisture content, *1* 0.1 kg, *2* 0.2 kg, *3* 0.3 kg)

matter, respectively, for K, Ca, Mg and P in mature *M. oleifera* leaves in Chad.

These results line with those of other reported findings researchers that have revealed accumulation of N, P and K in young *M. oleifera* plants following application of various organic amendments (Adebayo et al. 2011). According to Adebayo et al. (2011), the application of organic amendments tends to improve the chemical properties of the soil and plant organs. Compost types and mineral fertilizer were more effective, as they provided more mineral elements such as N, P, K, Ca, N, Mg and C for plant growth and development. Dania et al. (2014) obtained similar results, the nitrogen of *M. oleifera* leaves being significantly improved by Poultry manure with 4.13% compared to the organomineral fertilizer (2.01%).

The present results contrast those of Asante et al. (2014), who established that high application of nitrogen did not influence the accumulation of nutrients (N, P, K, Ca and Mg) in *M. oleifera* leaves. Indeed, the mineral content in leaves of *M. oleifera* was reported to be linked to the environmental conditions (soil and climate), production areas, leaf maturity (dark and mature leaves being generally more rich in nutrients than young and clear leaves), cropping methods (irrigation, fertilizers), harvest season

Table 3 Variation in *M. oleifera* dry root biomasses between treatments at 55 days after planting

Treatments	Dry root biomass (g)	Dry aerial biomass
CM_1	0.59 ± 0.42b	1.57 ± 0.35d
CM_2	0.32 ± 0.14ab	0.86 ± 0.51a
CM_3	0.17 ± 0.07a	1.54 ± 0.63d
GW_1	0.26 ± 0.00ab	0.33 ± 0.29a
PM_1	0.37 ± 0.09ab	1.24 ± 0.39bcd
PM_2	0.2 ± 0.16a	0.59 ± 0.28ab
PM_3	0.11 ± 0,08a	0.43 ± 0.15a
MF_1	0.62 ± 0.20b	1.44 ± 0.58 cd
MF_2	0.21 ± 0.00ab	1.25 ± 0.00abcd
MF_3	0.11 ± 0.06a	0.355 ± 0.34a
T	0.31 ± 0.08ab	1.165 ± 0.26bcd
P value	0.0422	0.0035
F-ratio	2.42	3.95

T control, *PM* poultry manure compost, *GW* goat manure compost, *CM* cow manure compost, *MF* mixture of fertilizers, *NPK* mineral fertilizer, *MC* moisture content, *1* 0.1 kg, *2* 0.2 kg, *3* 0.3 kg

and the genetic makeup of trees (De Saint Sauveur and Broin 2010). Thus, in the present study, plants with good growth were also more enriched in macro-elements than

Table 4 Changes in mineral composition *M. oleifera* leaves as affected by different compost receipts

Treatments	Total N (%)	Ca (%)	Mg (%)	K (%)	P (%)	Organic C (%)
CM_1	2.52 ± 0.08cd	0.69 ± 0.04d	0.38 ± 0.04d	3.40 ± 0.40b	0.27 ± 0.05abc	39.20 ± 0.30c
CM_2	2.245 ± 0.09bc	0.45 ± 0.08bcd	0.31 ± 0.07bcd	2.68 ± 0.02a	0.34 ± 0.01abc	38.79 ± 0.14c
CM_3	2.83 ± 0.13de	0.55 ± 0.06e	0.37 ± 0.04d	3.79 ± 0.31b	0.36 ± 0.08bcde	37.89 ± 0.33bc
GW_1	2.15 ± 0.04bc	0.27 ± 0.02a	0.19 ± 0.03a	3.36 ± 0.06b	0.25 ± 0.03ab	38.46 ± 0.43c
MF_1	2.27 ± 0.05bc	0.35 ± 0.03ab	0.24 ± 0.01ab	3.87 ± 0.12b	0.34 ± 0.08bcd	39 ± 0.72c
MF_2	3.19 ± 0.09e	0.4 ± 0.03abc	0.32 ± 0.09bcd	3.75 ± 0.52b	0.37 ± 0.01bcde	39.54 ± 0.66c
MF_3	4.34 ± 0.35f	0.57 ± 0.08de	0.36 ± 0.04cd	3.81 ± 0.08b	0.52 ± 0.16e	35.92 ± 1.27b
T	1.21 ± 0.04a	0.32 ± 0.02a	0.27 ± 0.04abcd	2.39 ± 0.11a	0.17 ± 0.02a	32.29 ± 2.88a
PM_1	2.85 ± 0.38de	0.51 ± 0.08cd	0.38 ± 0.04d	3.6 ± 0.14b	0.51 ± 0.14de	39.58 ± 0.60c
PM_2	2.42 ± 0.04bc	0.37 ± 0.05ab	0.36 ± 0.04cd	3.62 ± 0.37b	0.42 ± 0.04cde	35.95 ± 0.78b
PM_3	2.12 ± 0.16b	0.35 ± 0.08ab	0.25 ± 0.07abc	2.28 ± 0.04a	0.29 ± 0.04abc	37.93 ± 0.39bc
P-value	< 0.0001	0.0005	0.033	0.0003	0.019	0.0007
F-ratio	39.93	9.40	3.24	10.43	3.78	8.54

T control, *PM* poultry manure compost, *GW* goat manure compost, *CM* cow manure compost, *MF* mixture of fertilizers, *NPK* mineral fertilizer, *MC* moisture content, *1* 0.1 kg, *2* 0.2 kg, *3* 0.3 kg

other stunted plants. This might be due to their increased availability through manures, as well as effective translocation of nutrients to the sink. Hanchimani (1994) have claimed a good response of *M. oleifera* to application of fertilizers, and enhanced nutrient availability in the pods, and hence, increased yield. Out of elements estimated in different plants by atomic absorption, K and Ca were found to be present in higher level, with Ca helping in transporting long chain fatty acid, which helps in preventing of heart diseases and high blood pressure (Rajurkar and Damame 1998).

Conclusion

Organic fertilization has improved the germination, biomass and minerals nutrition of *M. oleifera* plantlets. Cow dung (100 g) and of poultry manure (100 g) composts have positively impacted plantlets, providing a 100% survival rate. The efficiency of composts is attributed to their average mineral composition, because high amount of nutrients has a negative influence on the survival rate of plants. To increase the nursery production of *M. oleifera*, the use of small quantities of compost can be recommended.

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