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Growth response of *Moringa oleifera* Lam. as affected by various amounts of compost under greenhouse conditions

Laba Christophe Haouvang[a,b,*], Ngakou Albert[a], Yemefack Martin[b], Mbailao Mbaiguinam[c]

[a] *Department of Biological Sciences, University of Ngaoundere, P.O. Box 454, Ngaoundere, Cameroon*
[b] *International Institute of Tropical Agriculture, P.O. Box 2008, Yaounde, Cameroon*
[c] *Research Laboratory of Natural Substances, Faculty of Applied and Exact Sciences, University of Ndjamena, P.O. Box 1027, Chad*

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ABSTRACT

The study was carried out to assess the effect of domestic animal composts on growth performance of potted moringa. The study was conducted in the greenhouse for 55 days. Various quantities of composts (100–300 g) added to 800 g of soil were applied. A Randomized Complete Block Design (RCBD) with 14 treatments (each of which was replicated 12 times) was used, giving a total of 168 experimental units. Plant height, stem diameter, leave length and number of leaves were assessed for each treatment. Results indicate that cow dung compost (100 g, 200 g and 300 g) significantly increased the stem diameter of moringa by respectively 33.09%, 33.09%, and 29.93 as compared to that of the control 55 days after in the greenhouse. An increase in the number of leaves by 48.54% due to application of 100 g cow manure compost was observed after 40 days compared to the control. There were significant differences between treatments effects ($p < .05$) on all the parameters. Organic amendments in general and cow dung compost in particular could constitute the best fertilizer to improve growth moringa in pots.

Introduction

Moringa oleifera Lam is a shrub native from India, Pakistan, Bangladesh and Afghanistan that has being populated everywhere (Fahey, 2005). This plant is cultivated in plantation and around habitations in tropical area of Africa. It's used in food, medicine and water treatment (Rebecca et al., 2006). Cited as one of the world's most useful plants, that moringa leaves are edible and are of high nutritive value. Studies have shown that different parts of this plant consider as a source of protein, vitamin and carotene, all essentials amino acids and phenolic components (Anwar and Rashid, 2007). Some of the plant parts could also be dried, turned into powder and used for several food diets. According to Azeez et al. (2013), moringa has more vitamin A than carrots, more vitamin C than oranges, more calcium than milk and more iron than spinach and therefore, is a complete food in itself. Moringa tree contains also antioxidants, anti-inflammatory, phytochemical elements, lipids such as omega-3 and omega-6 (Kasolo et al., 2010). It was reported that it has ability to reduce children nutritional deficiency in India (Srikanth et al., 2014), or use to feeding people having HIV (Aissi et al., 2013). It has taken high socio-economic interest in the tropic. It's important to valorize its production in this area where hunger is occurring constantly.

Organic manure is becoming an important component of environmentally sound sustainable agriculture. Residual nature of organic sources makes them more value based for the whole system compared to individual crops (Arora and Maini, 2011). Recently, the use of organic materials as fertilizers for crop production has received attention for sustainable crop productivity (Dong et al., 2012; Arif et al., 2014). This shrub does not need enough fertilizers but an average amount could improve its growth, particularly organic fertilizers for long term basis fertilization. It has been proven that addition of organic matter improved soil properties such as aggregation, water-holding capacity, hydraulic conductivity, bulk density, the degree of compaction, fertility and resistance to water and wind erosion (Carter and Stewart, 1996; Zebarth et al., 1999; Franzluebbers, 2002).

Generally, fertile soils have a relatively high structure stability index and percentage. Improvement in soil aggregation by organic matter may positively affect seed germination, roots, shoots plant growth and development (Van Noordwijk et al., 1993). The effect of long-term organic and inorganic fertilizer on soil physical properties such as aggregation, porosity and water-holding capacity has been reported (Celik et al., 2004).

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* Corresponding author at: International Institute of Tropical Agriculture, P.O. Box 2008, Yaounde, Cameroon.
E-mail address: labachristophe@gmail.com (L.C. Haouvang).

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Organic sources like farm yard manure, poultry manure, green manure and compost do not only supply the organic matters. but also increase the fertility status of soil (Mohammadi et al., 2011). They provide organic acids that help dissolve soil nutrients and make them available to the plants (Husson, 2013). Recently, attention has been directed towards organic manure because of the rising cost of inorganic fertilizers coupled with their inability to give the soil the desired sound health (Oyedeji et al., 2014). In a related literature, effects of compost applied on growth parameters were studied (Asante et al., 2012; Huda et al., 2016), but the application of different amounts has not yet been investigated. The use of organic manure to fertilize moringa in the field is increasing, but very few studies have been carried out to evaluate the effect of this fertilizer in the nursery. This inadequacy makes it difficult to make any recommendation to farmers on the quantity and type of organic manure to apply.

The main objective of this experiment was to test the efficiency of various amounts of composts on growth of moringa under controlled conditions in the greenhouse. The responses to plant growth parameters are discussed.

Materials and methods

Study area

The study was carried out in greenhouse at the International Institute of Tropical Agriculture (IITA) station at Nkolbisson-Yaounde in Cameroon. This greenhouse is transparent with average intensity of solar light, air and without insects or pests. Trials were conducted for 55 days.

Biological materials

Seeds for this experiment were collected from local variety of moringa, while soil and animals wastes were collected in southern region of Chad (10°16′50.002N 15°22′19.999″E). Compost was obtained after decomposition of domestic animals wastes using pile composting method (Ngakou et al., 2008) from the manures of goat, cow, poultry and the mixture of wastes. Mineral fertilizer (NPK: 20:10:10) was obtained from IITA Cameroon. Pots (130 mm) were used to contain the applied treatments (Fig. 1).

Experimental design and treatment

The experiment was carried in a randomized complete block design (RCRD) with 14 treatments, each of which was replicated 12 times, giving a total of 168 experimental units (Fig. 1). On each of the 25, 40 and 55 days after sowing, 4 plants were randomly chosen and destroyed per treatments to measure development. Table 1 describes details on treatments combinations, whereas Table 2 illustrates the chemical content of different organic manures.

Treatments and sowing

For this experiment, 168 pots were used. Each pot has a fixed amount of soil (800 g) and compost varying from 100 g, 200 g, to 300 g according to a given treatment. Each pot was placed into a bowl to avoid water loss. The bowl-pot complex was then placed on a shelf in a greenhouse. Seeds were soaked for 24 h in tap water before sowing. Two seeds were sowed at 2 cm maximum depth, and germination occurred between 7 and 10 days after sowing. After germination, one vigorous plant was allowed to grow in each pot. Plants were watered at the rate of 250 mL/pot after every 3 days.

Data collection

At each of 15 days from germination up to 40 days after planting, the following parameters were evaluated: plant growth was measured from the base of stem to the last leaf using a graduated ruler; stem diameter was measured at the soil level using a slide calliper; leave number was determined by counting the leaves on plant; leave length was estimated on the basal leave at 15 days after germination and on leave located in the middle of plant (as from 30 days after germination).

Data analysis

All data collected were analysed using the R 3.3.1. The Analysis of Variance (ANOVA) was used to compare different treatments and Turkey test for multiple comparison range of means.

Results

Effect of treatments on plant size

The influence of the treatments on moringa size is illustrated in Fig. 2. It shows that there was a significant difference between the treatments ($p < .01$). At 25 DAS, treatments 100 g MF, 200 g CMC and the mixture of fertilizers (MF100), 200 g cow manure compost (CMC 200), 100 g poultry manure compost (PMC 100) recorded heights of respectively 20.73 ± 0.66, 19.27 ± 2.15, 18.75 ± 1.49 cm that were significantly greater than 11.0 ± 0.94, 12.8 ± 1.86 for 300 g MF and 100 g GMC. At 40 DAS, it was instead treatments 100 CMC, 300 CMC, 100 GMC and 100 MF that contributed to an improvement of the plant

Fig. 1. Partial view of the experiment showing treatments.

Table 1
Description of treatments.

Types of composts	Treatments	Soil quantity (g)	Compost quantity (g)	Mineral fertilizer NPK (g)
Poultry manure compost (PMC)	PMC100	800	100	00
	PMC200	800	200	00
	PMC300	800	300	00
Goat waste compost (GWC)	GWC100	800	100	00
	GWC200	800	200	00
	GWC300	800	300	00
Cow manure compost (CMC)	CMC100	800	100	00
	CMC200	800	200	00
	CMC300	800	300	00
Mixture of fertilizers (MF)	MF100	800	32 gPMC + 32 gGWC + 32 gCMC	03
	MF200	800	65 gPMC + 65 gGWC + 65 gCMC	05
	MF300	800	97 gPMC + 97 gGWC + 97 gCMC	09
Mineral fertilizer (NPK)	NPK10	800	00	10
Control (ctrl)	C800	800	00	00

Table 2
Physical and chemical properties of different levels of soil mixtures and compost before and after experiment.

Treatments	pH water	Ca cmol$^{(+)}$/kg or meq/100 g	Mg	K	Na	CEC	O.C. %	N %	C/N %	Bray P µg/g	Moisture content %
PMC100	6.79	3.76	1.84	1.76	0.47	3.59	1.35	0.102	13.15	266.23	2.51
PMC200	6.76	5.13	3.33	3.11	0.74	5.5	1.74	0.132	13.15	408.62	4.59
PMC300	6.77	5.7	4.05	3.82	0.9	6.56	2.18	0.208	10.45	401.35	13.1
GWC100	7.52	5.25	1.79	2.86	0.4	4.23	1.43	0.095	15.09	116.66	3.34
GWC200	8.04	7.41	2.76	5.05	0.52	5.86	2.14	0.175	12.21	146.85	5.87
GWC300	8.21	8.67	2.97	5.73	0.57	6.31	2.5	0.206	12.16	170.56	8.65
CMC100	6.66	3.08	142	1.15	0.25	3.66	1.36	0.083	16.36	51.08	2.35
CMC200	6.54	4.68	2.49	2.18	0.35	6.01	2.17	0.149	14.56	61.29	5.09
CMC300	6.71	6.62	3.95	3.44	0.46	8.59	3.46	0.217	15.95	88.2	9.5
MF100	7.28	5.59	3.09	3.63	0.59	5.9	2.73	0.209	13.09	259.17	17.29
MF200	7.3	11.29	6.06	8.73	1.18	11.63	4.84	0.424	11.41	366.02	16.67
MF300	7.35	10.12	6.2	9.11	1.2	12.11	5.26	0.481	10.93	375.41	16.14
C800	6.34	1.71	0.59	0.35	0.07	1.88	0.75	0.042	17.73	20.65	0.86

C800 = Control (800 g of soil); PMC = Poultry Manure Compost, GWC = Goat Manure Compost, CMC = Cow Manure Compost (1 = 100 g, 2 = 200 g; 3 = 300 g); MF = Mixture of Fertilizers (1 = 32 g PMC + 32 g GWC + 32 g CMC + 3 g NPK; 2 = 65 g PMC + 65 g GWC + 65 g CMC + 5 g NPK; 3 = 97 g PMC + 97 g GWC + 97 g CMC + 9 g NPK), O.C. = Organic carbon, CEC = Cation-exchange capacity.

height. The lowest plant size was observed in MF treatment. At 55 DAS the plant size was improved by 29.33% when treatment 300 CMC was applied, as compared to that of the control. Throughout the experiment, some treatments such as GWC and chemical fertilizer caused plant death.

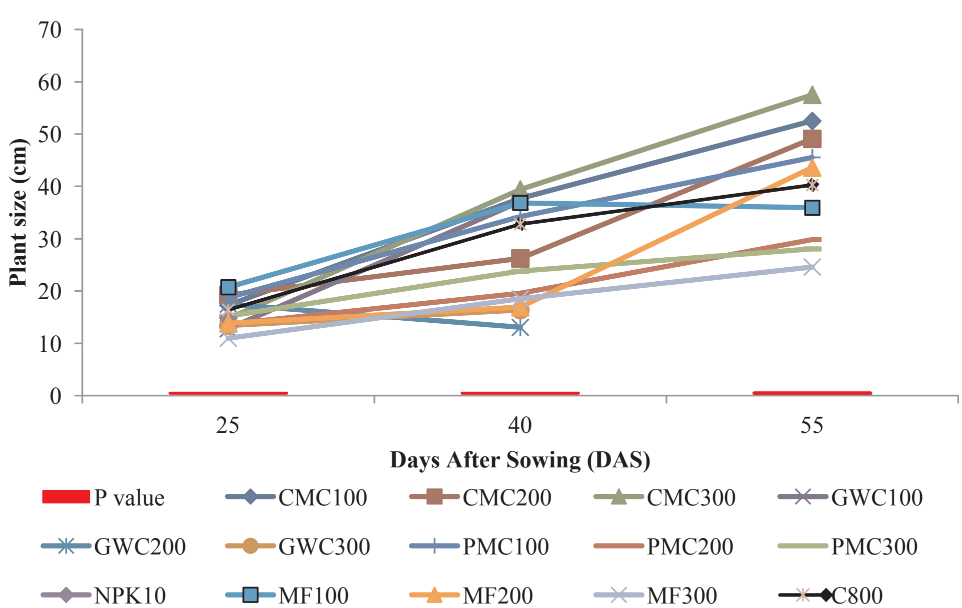

Fig. 2. Variation of moringa size (cm) between treatments. C800 = Control (800 g of soil); PMC = Poultry Manure Compost, GWC = Goat Manure Compost, CMC = Cow Manure Compost (100 = 100 g, 200 = 200 g; 300 = 300 g); MF = Mixture of Fertilizers (100 = 32 g PMC + 32 g GWC + 32 g CMC + 3 g NPK; 200 = 65 g PMC + 65 g GWC + 65 g CMC + 5 g NPK; 300 = 97 g PMC + 97 g GWC + 97 g CMC + 9 g NPK); NPK = Mineral Fertilizer (10 g).

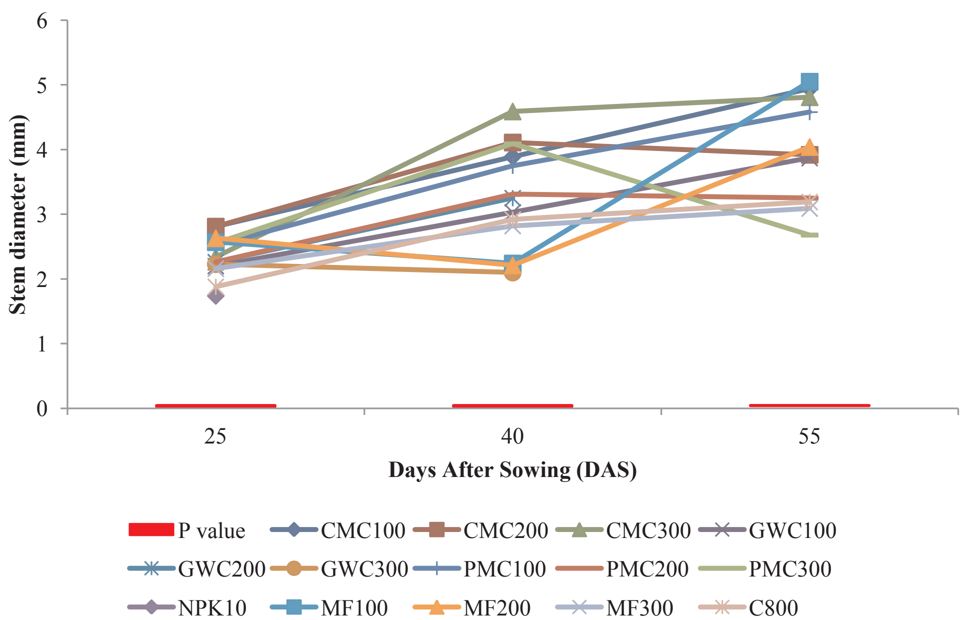

Fig. 3. Stem diameter of moringa as affected by treatments (mm). C800 = Control (800 g of soil); PMC = Poultry Manure Compost, GWC = Goat Manure Compost, CMC = Cow Manure Compost (100 = 100 g, 200 = 200 g; 300 = 300 g); MF = Mixture of Fertilizers (100 = 32 g PMC + 32 g GWC + 32 g CMC + 3 g NPK; 200 = 65 g PMC + 65 g GWC + 65 g CMC + 5 g NPK; 300 = 97 g PMC + 97 g GWC + 97 g CMC + 9 g NPK); NPK = Mineral Fertilizer (10 g).

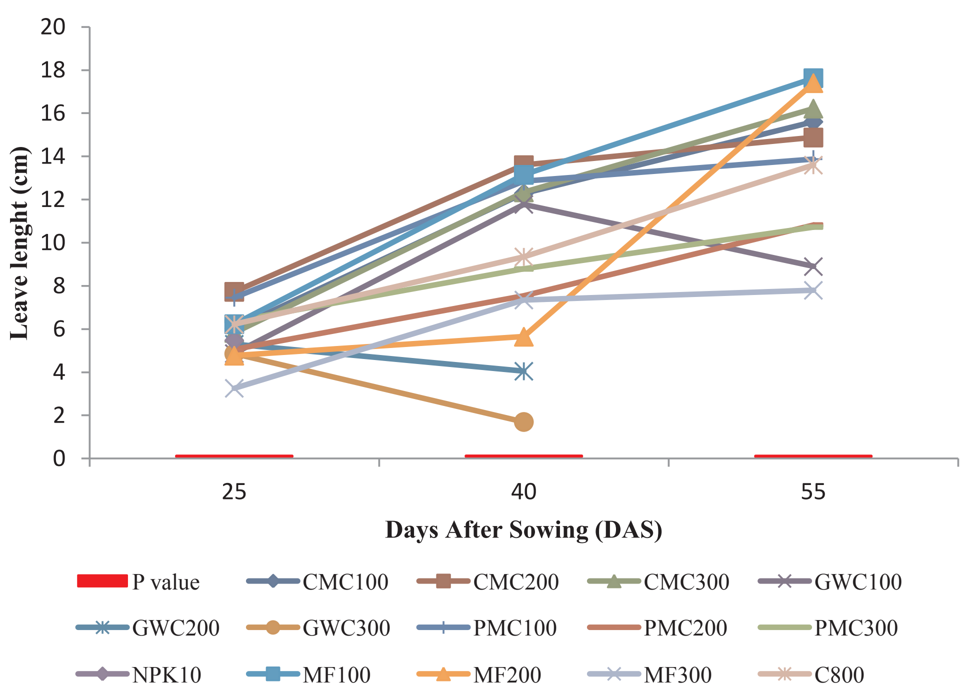

Fig. 4. Effect of treatments on leave length (cm) of moringa. C800 = Control (800 g of soil); PMC = Poultry Manure Compost, GWC = Goat Manure Compost, CMC = Cow Manure Compost (100 = 100 g, 200 = 200 g; 300 = 300 g); MF = Mixture of Fertilizers (100 = 32 g PMC + 32 g GWC + 32 g CMC + 3 g NPK; 200 = 65 g PMC + 65 g GWC + 65 g CMC + 5 g NPK; 300 = 97 g PMC + 97 g GWC + 97 g CMC + 9 g NPK); NPK = Mineral Fertilizer (10 g).

Effect of treatments on plant diameter (mm)

Data recorded in Fig. 3 indicate that the diameter of plants varied from one treatment to another ($p < .05$). At 25 days after sowing (DAS), the highest diameters were obtained from plants treated with 100 and 200 CMC, 100 and 200 MF, as well as with 100 and 300 PMC. The highest diameter was recorded in treatment 100 and 200 g CMC, with 38.9% as compared to the control (800 g soil), and 38.07% compared to the chemical fertilizer. The effects of CMC (100, 200 and 300 g), PMC (100, 200 and 300 g) and GMC (100 g) were more pronounced at 55 DAS. Similarly, mixture manure compost (MF) stimulated highest growth of plantlets from 2.24 ± 0.74 mm at 40 DAS to 5.05 ± 1.20 mm at 55 DAS for 100 MF, and from 2.21 ± 0.52 mm at 40 DAS to 4.04 ± 0.00 mm at 55 DAS for 200 MF.

Effects of treatments on improvement of leaves length

Leave length of plants was significantly influenced by treatments ($p < .05$). The average of leaf length varied from 3.26 cm (300 MF) to 7.73 cm (200 CMC) at 25 DAS, from 1.70 cm (300 GWC) to 13.60 cm (200 CMC) at 40 DAS, and from 17.63 cm (100 MF) to 7.8 cm (300 MF) at 55 DAS (Fig. 4).

Effects of treatments on improvement of leaves number

Fig. 5 shows that composts from cow manure (8 leaves), poultry manure at 100 g and 300 g (7 leaves) significantly increased the number of leaves compared to goat manure compost (4 leaves). The number of leaves was increased by 48.54% following application of 100 g of cow manure compost at 40 DAS compared to the control C800.

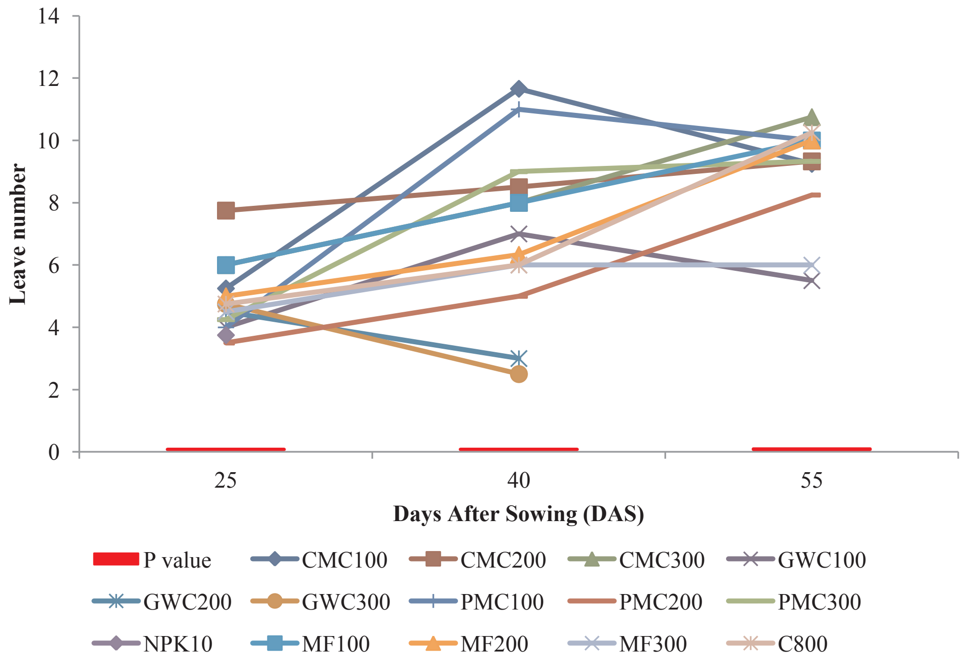

Fig. 5. Effect of treatments on leave number/moringa plant. C800 = Control (800 g of soil); PMC = Poultry Manure Compost, GWC = Goat Manure Compost, CMC = Cow Manure Compost (100 = 100 g, 200 = 200 g; 300 = 300 g); MF = Mixture of Fertilizers (100 = 32 g PMC + 32 g GWC + 32 g CMC + 3 g NPK; 200 = 65 g PMC + 65 g GWC + 65 g CMC + 5 g NPK; 300 = 97 g PMC + 97 g GWC + 97 g CMC + 9 g NPK); NPK = Mineral Fertilizer (10 g).

Discussion

Infertility in tropical soils is the main cause of declines agricultural productivity (Dania et al., 2014). Organic amendments contributed to important growth and yield of moringa in the greenhouse, indicating the effectiveness of animal composts in this study. Its application on maize (Ridine et al., 2014), and beans (Ngakou et al., 2008) was reported to considerably increased yield of these two plants. The objective was to evaluate the influence of composts of animal manure on the production in potted moringa plants at the greenhouse. The results of the vegetative parameters obtained were influenced by various treatments. The application of poultry manure, cow, goat's compost and their mixtures significantly improved the size of plant, number and the length of leaves compared to chemical fertilizer NPK and the negative control (800 g soil).

At the beginning of the experiment, all plants treated with organic manure did not show a significant variation compared to untreated plants. This was explained by the time required by soil micro-organisms to begin their activity, to mineralize an efficient amount of organic matter and to allow a high absorption and accumulation of dry matter by plants (Tedonkeng et al., 2005). It is only after 55 days that 300 CMC amended plants showed improved plant growth rate of 29.93% compared to the control. The composition of organic manure was reported to enrich the soil with humus, consisting mainly of cellulose, hemicelluloses and lignin which are a real source of energy for soil microorganisms (Splittoesser, 1984; Keeton et al., 1993). These results are agreement to those obtained by Dania et al. (2014), who pointed out that the poultry waste compost was better than the chemical fertilizer NPK (20:10:10) on the vegetative development of moringa, the composition of mineral elements such as nitrogen favoring the development of upper parts of plants. The above results are in agreement with those obtained by Adebayo et al. (2011), Ozobia (2014). Attia et al. (2014) noted increased yield components of moringa trees following application of fertilization types where mineral and organic fertilization recorded 85% increase in all yield parameters of moringa trees over control, while mineral, organic and bio-fertilization recorded 86% over control.

In a research by Adebayo et al. (2011), compost and other organic manures were sources of soil amendments that improved soil nutrient status. Compost has the ability to provide a continuous supply of nutrients for plant growth and increased the soil's ability to retain essential minerals. Compared with raw organic wastes, mature compost provides a stabilized form of organic matter and has the potential to enhance nutrient release in the soil. In most of the result obtained, the cow manure compost and poultry manure compost were the best of all the others. This efficacy comes from its physical and chemical composition. We found out that a sandy soil added to small amount of compost (100 g) improves the growth parameters. Recent research have suggested that the addition of compost in sandy soils can facilitate moisture dispersion by allowing water to move more readily laterally from its point of application (Alexander, 2001). However, a high application of compost may exhibit toxicity due to iron and manganese (Palm et al., 2001) and this can justify the low plant growth from treatments with significant amount of compost, such as mineral fertilizer and 300 g compost, which recorded plants death, less leave number, small height, small size of leave and stem diameter.

Conclusion

The experiment carried out to evaluate the growth of compost amended moringa proved that addition of compost from different animal manures increased leave and stem development of plants depending on compost application rate. Treatments CMC significantly increase up to 29.93% (CMC 300), 33.09% (CMC 100 and CMC 200) the stem diameter of moringa compared to the control 55 DAS under greenhouse conditions. An increase in the number of leaves by 48.54% following application of 100 g cow manure compost was observed after 40 DAS compared to the control C800. It's a desirable privilege of growing moringa in pot or any other suitable container, preferably with a mixture of soil and cow manure composts.

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References

Adebayo, A.G., Akintoye, H.A., Olufolaji, A.O., Aina, O.O., Olatunji, M.T., Shokalu, A.O., 2011. Assessment of organic amendments on vegetative development and nutrient uptake of *Moringa oleifera* Lam in the nursery. Asian J. Plant Sci. 10, 74–79.

Aissi, A.K., Kougblenou, S.D., Dougnon, V., Klotoe, J.R., Bankole, H., Deguenon, Y., Degbey, C., Montcho, S., Fanou, B., Fah, L., Edorh, P.A., Loko, F., 2013. Evaluation of health quality of *Moringa oleifera* Lam. leaves powder sold to HIV patients at Cotonou (Benin). Int. J. Biol. Chem. Sci. 7 (4), 1461–1473. http://dx.doi.org/10.4314/ijbcs.v7i4.4. (in French).

Alexander, R., 2001. Field Guide to Compost Use. The US Composting Council. <http://compostingcouncil.org>.

Anwar, F., Rashid, U., 2007. Physico-chemical characteristics of *Moringa oleifera* seeds and seed oil from a wild provenance of Pakistan. Pak. J. Bot. 39 (5), 1443–1453.

Arif, M., Jalal, F., Jan, M.T., Muhammad, D., 2014. Integration of biochar and legumes in summer gap for enhancing productivity of cereal based cropping system. Sarhad J. Agric. 30 (4), 393–403.

Arora, N., Maini, P., 2011. Anaerobic digested slurry, an input for sustainable agriculture. Asian J. Exp. Sci. 25 (1), 59–62.

Asante, W.J., Kwame, O., Baatuuwie, N.B., 2012. Initial growth response of *Moringa oleifera* seedlings to different soil amendments. Afr. J. Agric. Res. 7 (45), 6082–6086.

Attia, M.F., Shahin, M.F.M., Merwad, M.A., El-Hady, E.S., Haggag, L.F., 2014. Effect of mineral, organic and bio-fertilization on productivity of *Moringa* plant under saline conditions in North Sina. Middle-East J. Appl. Sci. 4 (4), 825–832.

Azeez, F.A., Nosiru, M.O., Clement, N.A., Awodele, D.A., Ojo, D., Arabomen, O., 2013. Importance of *Moringa oleifera* tree to human livelihood: a case study of Isokan local government area in Osun State. Elixir Int. J. 55, 12959–12963.

Carter, M.R., Stewart, B.A. (Eds.), 1996. Structure and Organic Matter Storage in Agricultural Soils. CRC Press, Boca Raton.

Celik, I., Ortas, I., Kilic, S., 2004. Effects of compost, mycorrhiza, manure and fertilizer on some physical properties of a Chromoxererert soil. Soil Till. Res. 78, 59–67.

Dania, S.O., Akpansubi, P., Eghagara, O.O., 2014. Comparative effects of different fertilizer sources on the growth and nutrient content of moringa (*Moringa oleifera*) seedling in a greenhouse trial. Adv. Agric. 2014 Article ID 726313.

Dong, W., Zhang, X., Wang, H., Dai, X., Sun, X., Qiu, W., 2012. Effect of different fertilizer application on the soil fertility of paddy soils in red soil region of Southern China. PLoS ONE 7 (9) Article ID e44504.

Fahey, J.W., 2005. *Moringa oleifera*: a review of the medical evidence for its nutritional, therapeutic, and prophylactic properties. Part 1. Trees Life J. 1, 5. <http://www.tfljournal.org/article.php/20051201124931586>.

Franzluebbers, A.J., 2002. Water infiltration and soil structure related to organic matter and its stratification with depth. Soil Till. Res. 66, 197–205.

Huda, N., Abul Hashem, M., Haque, K.S., Roy, B.K., 2016. Study on effects of fertilizer on production performance of *Moringa oleifera* (*Moringa oleifera* Lam.) in autumn season. Int. J. Agric. Inno. Res. 5 (1), 36–40.

Husson, O., 2013. Redox potential (Eh) and pH as drivers of soil/plant/microorganism systems: a transdisciplinary overview pointing to integrative opportunities for agronomy. Plant Soil 362, 389–417.

Kasolo, J.N., Bimenya, S.G., Ojok, L., Ochieng, J., Ogwal-Okeng, J.W., 2010. Phytochemicals and uses of *Moringa oleifera* leaves in Ugandan rural communities. J. Med. Plants Res. 4 (9), 753–757.

Keeton, W.T., Gould, J.L., Gould, C.G., 1993. Biological Science. Norton and Company Inc., New York/London, pp. 742–839.

Mohammadi, K., Heidari, G., Khalesro, S., Sohrabi, Y., 2011. Soil management, microorganisms and organic matter interactions: a review. Afr. J. Biotech. 10 (86), 19840–19849.

Ngakou, A., Megueni, C., Noubissie, E., Tchuenteu, T.L., 2008. Evaluation of the physico-chemical properties of cattle and kitchen manures derived composts and their effects on field grown *Phaseolus vulgaris* L. Int. J. Sustain. Crop Prod. 3 (5), 13–22.

Oyedeji, S., Animasaun, D.A., Bello, A.A., Agboola, O.O., 2014. Effect of NPK and poultry manure on growth, yield, and proximate composition of three *Amaranths*. J. Bot. 2014 Article ID 828750.

Ozobia, A.P., 2014. Comparative assessment of effect of *Moringa* extracts, NPK fertilizer and poultry manure on soil properties and growth performance of *Solanium menlongina* in Abuja, North Central Region of Nigeria. J. Agric. Crop Res. 2 (5), 88–93.

Palm, C.A., Gachengo, C.N., Delve, R.J., Cadisch, G., Giller, K.E., 2001. Organic inputs for soil fertility management in tropical agroecosystems: application of an organic resource database. Agric. Ecosyst. Environ. 83, 27–42.

Rebecca, H.S.U., Sharon, M., Arbainsyah, A., Lucienne, D., 2006. *Moringa oleifera*: Medicinal and Socio-Economic Uses. International Course on Economic Botany. National Herbarium Leiden, Netherlands, pp. 2–6.

Ridine, W., Ngakou, A., Mbaiguinam, M., Namba, F., Anna, P., 2014. Changes in growth and yield attributes of two selected maize varieties as influenced by application of chemical (NPK) and organic (bat's manure) fertilizers in Pala (Chad) grown field. Pak. J. Bot. 46 (5), 1763–1770.

Splittoesser, W.E., 1984. Vegetable Growing Handbook, second ed. Avi. Pub. Co., West. Port. USA.

Srikanth, V.S., Mangala, S., Subrahmanyam, G., 2014. Improvement of protein energy malnutrition by nutritional intervention with *Moringa oleifera* among Anganwadi children in rural area in Bangalore, India. Int. J. Sci. Study 2 (1), 32–35.

Tedonkeng, P.E., Boukila, B., Tendonkeng, F., Kana, J.R., Tonfack, L.B., Momo, M.C.S., 2005. Influence of organic manure, NPK and the mixture of the two fertilizers on growth of *Moringa oleifera* Lam. in the Western highland of Cameroon. Livestock Res. Rural Dev. 17(3). <http://lrrd.cipav.org.co/lrrd17/3/tedo17031.htm>.

Van Noordwijk, M., Schhonderbeek, D., Kooistra, M.J., 1993. Root-soil contact of field-grown winter wheat. Geoderma 56, 277–286.

Zebarth, B.J., Neilsen, G.H., Hogue, E., Neilsen, D., 1999. Influence of organic waste amendments on selected soil physical and chemical properties. Can. J. Soil Sci. 79, 501–504.