Agricultural and Biological Sciences Journal
Vol. 5, No. 4, 2019, pp. 132-137
http://www.aiscience.org/journal/absj
ISSN: 2381-7178 (Print); ISSN: 2381-7186 (Online)

Effect of Different Composts on Soil Chemical Conditions and Green Bean Yield in Bugesera District, Eastern Province of Rwanda

Liliane Uwamahoro*, Guillaume Nyagatare, Christian Shingiro

School of Agriculture Engineering, College of Agriculture, Animal Sciences and Veterinary Medicine, University of Rwanda, Nyagatare, Rwanda

Abstract

Rwanda, same to other corners of the worlds has awareness to use organic fertilizers (composts) both for nutrient supply to plant (fertilizers) and for improving soil physical conditions (soil amendment). This has pushed the government of Rwanda and private sectors working in Rwanda to put more effort to boost the production and use of compost. However, the demand rate is increasing than the production rate due to the insufficient and accessibility of row materials and sometimes to the lack of awareness and skills for small farmers. Moreover The sanitary products (i.e toilet waste) has recently and currently seen as a low-cost alternative to supplement available composts in different countries of the worlds and in Rwanda and if these products are not managed carefully, underground water pollution, waste of land for new pits and waste of water for flashing toilets will continue to occur. The aim of this study was to assess the effects of human compost on the some soil chemical properties and on green bean productivity compared to other available composts (cow and vermicompost). The treatments were control (without any compost), human compost, cow compost and vermicompost. The effect on soil chemical properties were assessed by sampling soil in the cultivated plot and bring them to laboratory for analysis of soil pH and electrical conductivity (EC) whereas effect on green bean yield was assessed by counting number of pods and their weight for each treatment. The results showed that there is a significant increase of soil pH, soil EC and organic carbon in soil under human compost than in other composts for (0-15) cm depth. Concerning the effect on green bean yield, the yield obtained in plot amended by human compost was significantly higher than that obtained in plots amended by cow compost and vermicompost, meaning that the fertilizer value of the sanitary products was higher than that of available composts. Sanitary products (human waste) can be reused as nutrient source and soil amendment but care must be taken on its salinity.

Keywords

Composts, Chemical Properties, Green Bean Yield

Received: October 13, 2019 / Accepted: 12 4, 2019 / Published online: December 27, 2019

1. Introduction

Agriculture is the basis of Rwanda's economy and the primary means of subsistence since approximately 80% of the labor force is engaged in agriculture [1]. The Economic Development and Poverty Reduction Strategy (EDPRS) identifies agriculture as one of its priority economic sectors for stimulating economic expansion and having the greatest contribution on poverty reduction and national development as a whole [2]. Moreover the government of Rwanda recognizes that increased production can on the other hand affect negatively the environment with erosion, loss of soil fertility and water pollution from agro-chemicals [3]. This is due to over-cultivation, exploitation of new and often marginal land, increased use of mineral fertilizer and high population pressure which lead to limited available land and

* Corresponding author
E-mail address: Uwamahoroliliane07@gmail.com (L. Uwamahoro)

thus to the disappearance of traditional techniques of soil fertility regeneration such as fallowing practices [4]. Increasing fertilizer usage is an integral part of the Government of Rwanda's strategy to increase agricultural productivity and it is a critical component of the nation's "Vision 2020" economic development plan [5]. A survey conducted during the 2000A season by the MINAGRI's Division des Statistiques Agricoles (DSA) and the Food Security Research Project (FSRP) revealed information on recent use of inorganic fertilizers, organic fertilizers, and complementary investments in anti-erosion barriers [6]. It is recognized that inappropriate use of mineral fertilizers could have a negative effect on the environment such as leaching to underground water sources and the emission of "greenhouse gases", which contributing to global warming and climate change [7]. In addition based on the research conducted by the authors in [8], all the lakes, rivers and swamps studied have been observed to high eutrophication, with nutrient levels of key agrochemical related chemical species (Nitrogen; Phosphorous and Potassium) above the set National Standards for natural waters. Moreover, Rwandan Fertilizer Policy is largely about the increased the use of chemical fertilizers but this policy does contain recommendations and actions targeting the better use of organic fertilizers [9]. The use of organic fertilizer is also emphasized by Crop Intensification Program in the management of soil fertility and the promotion of compost making is an important activity in Crop Intensification Program and it is targeted that 100% of farmers use organic fertilizers. The use of organic fertilizers in sustainable agriculture benefits farmers, consumers and the environment in many ways. Organic fertilizers provide nutrients under organic forms and enhance soil resistance to erosion by improving the soil's organic matter content. Recently, cow manure was the only, source of the compost, but in these days there is awareness of composting of collected waste (like garbage waste from the market or green waste from agriculture fields) by anaerobic and aerobic composting and the government has put its effort in this process. However, the demand is still big and the availability is also limited since it takes time in collection/composting to have enough compost compared to the demand with few or zero cow Rwandan farmer is rearing, therefore, new source of organic fertilizer is thus needed.

Human waste is considered as valuable nutrient source in a number of countries, for example in China, in Japan, in Korea, but also in some countries of Africa and South-America nutrients of wastes are utilized in agriculture [10]. Recently, human waste use in agriculture has been considered as taboo in Rwandan culture but currently there is acceptance amongst farmers in Rwanda for this new organic fertilizer and the survey done at Rulindo district by the author in [11] has revealed that there is a positive impact of using human excreta on crops production. A study done on assessing the effect of human compost on growth and yield characteristics of maize and another carried out on banana yield have shown its potential [12].

The exploitation of human waste in agriculture will also solve the issue of management of this waste because human waste can be hazardous if not handled safely by underground water pollution and causing difficulties in empting the pit latrines once they are full. This study will provide information on efficiency of human compost on soil chemical and physical properties and on green bean yield compared with other available composts and there is a need of this research to the farmers since it will reveal whether the compost from human waste can be also used in agriculture both for nutrient supplement and for soil conservation as it is more available and cheap to every farmer. For researchers and scientific community who are interested in organic fertilizers will benefit from the research outcomes for further research like control of human compost hygiene. This research is again important to government; institutions like RAB, MININFRA, REMA and WASAC which will use the research outcomes to know whether there is a need of adequate management of this source and good infrastructure of human waste collection both for agriculture and sanitation purposes. The main objective of this sturdy is to check effectiveness of human compost on some soil chemical characteristics and on green bean yield compared to other available composts and the hypotheses to be tasted are that "There is high increasing effect of Human compost on pH, EC, OC, available in soil compared to other composts" and that human compost will give more green bean yield than other composts. These hypotheses have been set based on both ideas of farmers using human compost as fertilizers and to the survey done by author in [11] where both say that the yield has increased since the day they started using human compost.

2. Materials and Methods

2.1. Study Area Description

The study was conducted in eastern province of Rwanda, Bugesera district, Nyamata sector. The area receives the long rains between Mid-march – June, while the short rains between Mid-October – December. The minimum and maximum mean temperature average is 20 and 30°C, respectively and the temperature average range is 29°C. The soil of the site is loamy sand in (0-15) cm and sandy loam for (15-30) cm. They dry quickly even after a great rain [13].

2.2. Composts Applied in this Study

During this study, three type of compost have been applied, which are cow compost, vermin-compost and human compost. The cow compost which is used in this research was made by the farmer rearing two cows. The cow manure has been dumped as a pile and covered by grasses for six months nearby the research plots. Vermi-compost used in this trial, was made from collected biodegradable organic market mixed with cow manure (at the ration of 1:1). That mixture was land filled for three months and after that the mixture have been brought to a wooden pit for allowing air circulation and covered by the black sheet for limiting the light to enter into the pit. Worms were then introduced and the composting continued for an additional three months. The Human waste compost used in this research was produced in a public toilet. The public toilet was used by different people and there was an opening behind the house, through which they add sawdust and ash in order to absorb moisture. When the pit of the public toilet filled up, it was closed and sealed and no fresh waste was added since users switched to using a second pit. After three months, the compost was dry and transported to a damping site and damped in a pit covered by grasses to keep the temperature high for again six months. In the composting pit the highest temperature during composting was 70°C on big part of the pit which can ensure the absence of helminthes´ eggs and coliform bacterial. The compost was turned twice during the six months and the temperature was controlled.

2.3. Characteristics of Used Composts

Table 1. Characteristics of used composts.

Compost/Parameters	pH	EC ds/m	OM %	N %	P mg/kg	K g/kg
Human compost	8.1	12.3	51%	16.22	12.01	5.12
Vermicompost	6.82	1.8	48.32%	7.09	6.2	21.6
Cow compost	7.63	3.9	39.41%	4.08	14.9	16.3

2.4. Experimental Design and Treatments

The study has been conducted during short rain season using green beans as test crop because they are very sensitive to drought. The experiment has been conducted on plots laid out in a randomized complete block design with four replications. There are four treatments comprising T_1: Control, T_2: Compost from human waste, T_3: Cow dung compost and T_4: Vermicompost.

2.5. Land Preparation, Compost Application and Bean Production

The study has been conducted on land that was previously under cultivation of sweet potatoes. Before planting, land was prepared to the required tilth through hand hoeing. The site was sub-divided into 12 plots each measuring (2×4) m^2 and the plot is long in the direction of the slope with 1 meter separating each plot to another. The composts (10t ha^{-1}) were incorporated into the soil by spreading it over the whole plot and mixed with the soil at one hoe deep (10 cm) seven days before planting date. At planting date (at the beginning of short rain season) furrows parallel to the width and perpendicular to the length of the plot have been made on each plot. Additional compost (5t ha^{-1}) has been placed along the furrows and the seeds of green bean (*Phaseolus vulgaris*) placed above the compost and a small layer of soil was added to cover the furrows. The seed spacing was 40 cm (inter-row spacing) by 20 cm (intra-row space). Beans were grown without additional mineral fertilizer and supplemental irrigation was used only three times in a season to supplement the rainfall. Weeding was performed at 4^{th} week when the crops were at development stage and again at 7^{th} week at the flowering and pod formation stage. Fresh and green beans have been harvested one time on 78^{th} day from the day planting.

2.6. Data Collection and Measurement

2.6.1. Soil and Composts Sampling and Measurement

Before applying the composts, also three Compost samples were also taken at different points of the pile (At the top, in the middle and at the bottom) from each compost used in this study, mixed to make one composite sample and kept aside and brought to the laboratory for analysis.. All soil samples have been collected at the end of the experiment. Disturbed samples were taken within the row in depths, 0-15cm and 15-30 cm. Each plot was with 10 rows and one sample from each row was collected, and then thoroughly mixed to form a composite sample of a plot. The soil pH and electrical conductivity have been determined in laboratory by electronic pH-meter and electrode, respectively whereas texture has been determined by densimetric method of BOYOUCOUS.

2.6.2. Plant Sampling and Counting

To obtain number of pods per tree of bean and total weight of beans during harvesting the whole plot was not harvested; only 30 trees of beans near the center is harvested to avoid the edge effects. The number of pods

per bean plant from the harvesting area were counted and summed up to have a total number of pods per each plot, and then average number of pods per plot was calculated to have a representative value. After counting, the pods of each tree, all pods were gathered together and weighed. Average is made to have weight of pods per treatment.

2.7. Statistical Analysis and Data Management

The data were subjected to analyses of variance (ANOVA) using the Genstat Discovery edition 4. ink statistical package. The used statistical threshold value for considering effect to be significant during data analysis is p value ≤ 0.05.

3. Results and Discussions

3.1. Results

Table 2. Variation of soil chemical properties in 0-15 cm depth and French bean yield.

Treatments	pH	EC (ds/m)	EC (ds/m)	Weight kg/ha
Human compost	6.2±0.18 c	1.2±0.41 c	440±111 b	1784±493 e
Vermicompost	5.6±0.26 a	0.79±0.86 a	312±60 a	1362±572 cd
Cow compost	5.7±0.35 a	0.9±0.14 ab	218±95 a	957±547 ab
Control	5.2±008 b	0.71±0.05a	218±95 a	619±196

Mean value ± Standard deviation, treatments with the same letters are not significantly different at p ≤ 0.05.

Table 3. Variation of soil chemical properties in 15-30 cm.

Treatments	pH	EC (ds/m)
Human compost	4.82±0.31a	4.52±1.7d
Vermicompost	4.84±0.51 a	2.6±0.86 ab
Cow compost	4.6±0.25 a	3.2±1.1 c
Control	4.9±009 a	2.22±0.6a

Mean value ± Standard deviation, treatments with the same letters are not significantly different at p ≤ 0.05.

3.2. Discussions

3.2.1. Effect of Different Composts on Soil pH

In 0-15 cm depth of the soil amended by human compost, vermicompost and cow compost there is a significant increase in pH level compared to the control treatment. The significant increase of soil pH after human compost than after the other composts was most likely caused by the addition of alkaline ash 12.8 as pH [14] and charcoal to the human waste for moisture removal during composting. Similar observations were found by author in [15] who reported that human compost lead to increased soil alkalinity over time and author in [16] showed that human manure has a liming effect on acidic soil. For 15-30 cm, the results showed no significance difference between the treatments, which may also be due to the short time of application. In comparison of all composts effect on soil pH, human compost has significantly increased the soil pH than cow compost and vermicompost, whereas there was no significant difference between the cow compost and vermicompost which may be due to these two composts having cow dung as raw material. This shows that application of human composts can be used as one way to enhance soil pH for acidic soil more quickly than with vermicompost and cow compost, but that vermicompost and cow compost also increased pH to some degree.

3.2.2. Effect of Different Composts on Soil EC

Overall EC in all treatment has significantly increased due to the different composts applied; however human compost increased significantly EC than the other compost compared to the control. For the depth 0-15 cm, cow compost and vermicompost did not have significant effect on soil EC compared to the control and by comparing all composts; there is only a significance difference between human compost and vermicompost on increasing of soil EC. The depths of (15-30 cm) behaved differently. Both human and cow composts have significantly increased EC in soil compared to the control. By comparing the effects of all used composts, human compost differ significantly to other composts, however no significant difference between vermicompost and cow compost. Human compost showed a high increase of soil electrical conductivity, because the compost itself has a high EC value compared to the other composts. This high EC value can be caused by the human diet with a higher intake of cooking salt and also to the usage of different cleaning material by the people used the toilets which may increase the concentration of ions in the compost (Na^+ and Cl^-). Ash, and possibly urine added in human compost also may result in high EC. [15] has also shown the

same but they have found the high EC value was in (0-15cm) depth while this research found high EC value in (15-30cm) but this was not caused by the treatments, instead it is the previous behavior of the soil of the area since it is the same even in the control. In addition author in [17] has shown that the salts are located mainly at the depth of (0-20 cm) in sand soil.

3.2.3. Effect of Different Composts on Number of Pods and Their Weight

Human compost outperformed vermicompost and cow manure on the bean yield. This trend is followed; Human compost > Vermicompost > cow manure > control plots (1784±493) kg/ha, 1362.5±572.44 kg/ha, 957.5±196 kg/ha and 619.3±196.02 kg/ha respectively). Beans fertilized with human compost has significantly shown a higher productivity (number of pods and total bean weight) compared to those fertilized by vermicompost and cow compost ($P \leq 0.015$ and $P \leq 0.018$ for number of pods and weight respectively). This was most likely due to the high content and higher availability of nitrogen and potassium found in human compost. There is no significant difference found between beans fertilized by cow compost and vermicompost which may be due to that both compost showed some similar characteristics since cow dung has been added to vermicompost during composting process. Compared to the control, only human compost showed a significant difference for both number pods and weight which was not expected due to high content of K in cow compost and vermicompost, but it could be due to that these composts take time to release the nutrients through mineralization. Another study reported that application of compost to soil improve the growth attributes of the bean and has shown that vermicompost improve yield compared with a no amended control [18]. A study done on maize production using human compost confirm that it has given higher production than other used composts due to that human waste the large feedstock and mineralized faster, thus making nutrient available to crops [19]. A similar study using spinach revealed that application of human faeces and urine resulted in increased fresh and dry matter yields [20]. From these results, human compost is potential source of nutrients for crop production.

4. Conclusions and Recommendations

In comparing the effects of different composts on some soil chemical parameters and on growth parameters of green beans, results showed that crops treated with human compost generally performed much better except on soil salinity. This is in terms of soil pH and plant yield as compared to soil and crops treated with cow compost and vermicompost. The study has shown that crops treated with also vermicompost generally performed much better than cow compost.

This research has revealed that human waste is also a big source of organic fertilizers, which can exploited in agriculture sector but care must be taken during composting of human waste by safe handling and much control are needed to keep its electrical conductivity not high. Also further researches are recommended to check whether there are no effects of the health of human being if used to all type of crops especially crops with edible roots.

Acknowledgements

Authors thank University of Rwanda, College of Agriculture, Animal Sciences and Veterinary Medicine Nyagatare campus especially Dr Guillaume Nyagatare, the main supervisor of this research, for planning, guidance, and coordination of this journey. Authors also thank Mr. Micomyiza valentin, a private farmer, for the provision of human compost and land where this research has been conducted.

References

[1] MINAGRI. (2015). Rwanda Fertilizer Policy. Kigali.

[2] MINECOFIN. (2013). The Republic Of Rwanda Economic Development And Poverty Reduction Strategy. Kigali: EDPRS2.

[3] REMA. (2013). Rwanda State of Environment and Outlook. KIGALI.

[4] Tugizimana, J. (2015). Effects of Soil and Water Conservation Techniques on Soil Productivity and Bean grain Yield in Nyamasheke District, Rwanda.

[5] MINAGRI. (2012). The Business Case for Investing in the Import and Distribution of Fertilizer in Rwanda. KIGALI.

[6] Kelly, A. (2001). Fertilizer Consumption In Rwanda: Past Trends, Future Potential, and Determinants. Kigali: Policy Workshop on Fertilizer Use and Marketing, organized by MINAGRI and USAID.

[7] MINAGRI. (2014). national fertilizer policy. kigali.

[8] REMA. (2014). Impact of Fertilizer use in Rwanda. Kigali.

[9] ITC. (2008). Overview Of Organic Agriculture In Rwanda And Options For Policy And Trade Development. Kigali.

[10] Sirkka, M. (1997). Human faeces as a resource in agriculture.

[11] Bazimenyera, J. (2016). Impact of Exploiting Human Excreta on Crops Production In Rwanda. kigali: East African Journal of Science and Technology.

[12] Jothimani, G. (2013). Assessing the effect of ecosan compost on growth and yield characteristics of Maize. Tamil Nadu: International Journal of Research Studies in Biosciences (IJRSB).

[13] Bugesera District Development plan (2013-2018).

[14] Andreasen, T. (2017). Wood Ash Induced pH Changes Strongly Affect Soil Bacterial Numbers and Community Composition.

[15] Sangare, D. (2015). Ecological sanitation products reuse for agriculture in Sahel: effects on soil properties. Vienna: Copernicus Publications on behalf of the European Geosciences Union.

[16] Mnkeni PNS, Austin LM (2014). Fertiliser value of human manure from pilot urine-diversion toilets. Pretoria: Research gate.

[17] Ben-Hur, M. F. H. Keren, Li, R. Ravina, I. and Shalit, G. (2001) Water and Salt Distribution in a Field Irrigated with Marginal Water under High Water Table Conditions, Soil Sci. Soc. Am. J. 65, 191-198.

[18] Asamoah, J. (2015). Effects of Different Composts on The Peformance of Green Beans (master's dissertation). Retrieved from http://hdl.handle.net/123456789/8038.

[19] Violet, N. (2015). Evaluating the agronomic effectiveness of human faecal compost on Maize yields, Its influence on soil chemical properties and soil fauna abundance. Nairobi.

[20] Kutu, F. R., Muchaonyerwa, P., Mnkeni, P. N. S. (2010). Complementary nutrient effects of separately collected human faeces and urine on the yield and nutrient uptake of spinach (Spinaciaoleracea). Waste Management and Research. 29, 535-539.