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RESEARCH ARTICLE

EFFECT OF CO-COMPOST MADE FROM CATTLE MANURE AND SAWDUST ON THE GROWTH AND YIELD OF OKRA (*ABELMOSCHUS ESCULENTUS L.*)

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ABSTRACT

Co-composting is an effective and environment friendly method of solid waste management to make valuable organic soil amendment which helps to maintain soil fertility in a sustainable way. An experiment was conducted to make co-compost using cattle manure (CM) and sawdust (SD) in different ratios (w/w) for the correct mixing proportion of raw materials to investigate the nutrient status of co-compost, and to evaluate the potential value of co-compost after incorporation into soil to form a nutrient rich growth media for *Abelmoschus esculentus* L. The experiment was laid out in a Completely Randomized Design (CRD) with five treatments and three replications comprising of only SD, only CM, sawdust-cattle manure mixture in the ratio of 1:1 (SD: CM=1:1), 1:2 (SD: CM= 1:2) and 2:1 (SD: CM= 2:1) by weight. Compost samples were collected for nutrient analysis after 75 days of composting. The highest value of total N, P and S were obtained in CM compost. Organic carbon (OC) and C:N ratio were found higher in SD compost. Higher growth and yield of okra were recorded under SD:CM= 1:2 treatment. On the basis of the experimental results, combined application of SD and CM at 1:2 ratio was the right mixing proportion. So, the organic fertilizer mixed with SD and CM at 1:2 ratio would be an efficient soil amendment that would improve soil quality, promote plant growth and increase yield.

KEYWORDS

Co-composting, cattle manure, sawdust, nutrient, yield, sustainable agriculture.

1. INTRODUCTION

The promotion of sustainable agricultural practices has become the prerequisite to control rapid deterioration of soil fertility and productivity to meet the growing food demand for increasing population. The increasing use of inorganic fertilizer is the major obstacle that decreases soil quality day by day. To restore soil condition and productivity, the use of organic fertilizers is one of the best management practices (Gruhn et al., 2000; Usman et al., 2015; Ali et al., 2017; Joardar et al., 2018). In that case, organic wastes could be considered as perfect sources to produce organic fertilizer or soil amendment which helps to convert the infertile land to nutrient rich growth medium. Side by side, this management strategy of organic waste helps to reduce the environmental problems caused by transportation and unscientific disposal of huge amount of waste producing every day (Burton et al., 2003; Zhang et al., 2003).

Among different types of management approaches of organic waste, composting of organic waste- has recently dragged attention because it is an economically feasible and environmentally sound technology to produce humus like organic product through microbial decomposition of organic waste under aerobic condition and produce a good quality organic soil conditioner (Kshmanian et al., 2000; Fernandez et al., 2014). When more than one feedstock is used in the same vessel to produce particular compost is referred to as a special method called co-composting. The most popular combination of waste for co-composting is mixing animal waste (cow dung, poultry litter, pig manure, fecal sludge etc.) with agro based wastes (rice straw, sawdust, wheat straw, water hyacinth, food waste etc.) (Ogunwande et al., 2008; Anwar et al., 2015; Neves et al., 2009).

Cattle manure and sawdust are very common and mostly available organic wastes. Every day a huge amount of CM is producing worldwide. Because of its high nutritional value it has been used as organic fertilizer as one of the best management approaches (Abou El-Magd et al., 2006; Ogundare et al., 2015). On the other hand, SD is a waste or byproduct of sawmill. Due to increasing use of wood and wooden product, a huge amount of SD is also producing daily. Recently, scientists have given attention to use this waste as soil amendment in agriculture as it contains very high carbon content (more or less 50%) (Garner, 2014; Parry, 2007; Dumitraescu et al., 2009). Though the other nutrient contents (especially N) of SD are low but when it is added with nitrogen rich organic waste with appropriate proportion, it becomes an effective compost fertilizer (Okalebo et al., 2002). Carbon-nitrogen (C:N) ratio of wastes is one of the important factors that affects compost characteristics (Ali et al., 2015; Igbokwe et al., 2015; Oluchukwu et al., 2018). In case of co-composting, mixing CM of low C:N ratio with SD of high C:N ratio can be a perfect combination to produce a good quality compost for improving soil structure, texture, C:N ratio, porosity, aggregate stability, biochemical properties as well as plant productivity (Bernal et al., 2009; Dimambro et al., 2016; Ashiono et al., 2017).

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Moreover, SD being a stable organic product, it decompose slowly which helps to reduce greenhouse gas emission and release nutrient into soil for long time.

Okra (*Abelmoschus esculentus* L.) is a widely known and economically important vegetable that is grown commercially in different parts of the world (Arapitas, 2008; Saifullah et al., 2009). Almost 42 thousand metric tons of okra was produced in 2009-10 from 10 thousand hectares of land in Bangladesh (BBS, 2011). Okra is a rich source of different types of nutrients like- fiber, carbohydrate, vitamin A, B_6, C, proteins, folic acid and minerals like Ca, Mg and Fe (Yadav et al., 2001; Dilruba et al., 2009). It was hypothesized that, co-compost will play an active role in the growth and production of okra than the sole application of CM and SD compost. The effective and perfect proportion of CM and SD for co-composting will also be identified. Co-compost would be considered as a good source of organic fertilizer which will play a crucial role to reduce the use of inorganic fertilizer and will help to promote sustainable agriculture. Side by side, co-composting will be the best management approach of different types of organic waste. The objective of the present study was to prepare co-compost from CM and SD, and to find out the best mixing combination that would be a good soil organic fertilizer for sustainable agriculture.

2. Materials and Methods

2.1 Study area

Pot experiment was carried out in the agricultural field laboratory of Soil, Water and Environment Discipline, Khulna University, Bangladesh and all the analysis were conducted in the laboratory of the discipline.

2.2 Sample collection

Soil sample for this experiment was collected from the agricultural field inside the Khulna University campus. Cattle manure (CM) and sawdust (SD) were collected from local dairy farm and sawmill, respectively, situated nearby Khulna University campus.

2.3 Sample preparation

2.3.1 Soil

The collected soil sample was processed in the field laboratory. At first, soil sample was air dried by spreading on the floor then the larger aggregates were broken down by using wooden hammer and the soil sample was passed through a 2-mm sieve for plant growth.

2.3.2 Co-compost

For preparing co-compost, CM and SD were weighed and mixed in three different ratios as follows: SD = Sawdust (3.0 kg); CM= Cattle manure (3.0 kg); SD:CM (1:1) = Sawdust (1.5 kg) + Cattle manure (1.5 kg); SD:CM (1:2) = Sawdust (1.0 kg) + Cattle manure (2.0 kg); SD:CM (2:1) = Saw dust (2.0 kg) + Cattle manure (1.0 kg). Co-composts were prepared by following the method described in Deepasundari and Mariappan (Deepasundari et al., 2015). The feed stocks were mixed properly by adding proper amount of water and kept into pots covered by plastic papers for decomposition. The pots were opened for heat release and aeration after 48 hours later. After that, the mixtures were covered and left for two months for decomposition. Occasional opening was done for heat release and proper aeration. Next, after 75 days matured composts were collected, processed and stored for further chemical analysis and experiment.

2.4 Experiment set-up

2.4.1 Design and layout

In the experiment, there were five treatments along with control (no compost) and three replications for each treatment, total eighteen pots of equal volume (area=232cm^2, height=25.4cm) were used. The pots were filled with 2.5 kg of preprocessed soil. The experiment was laid out in Complete Randomized Design (CRD). Compost was applied in each pot at the rate of 10 t ha^{-1} except control.

2.4.2 Experimental plant and seed sowing

Okra, a very popular vegetable plant, was taken as experimental plant because of its high yield and shorter fruiting time (Mondal et al., 2014). Only the healthy, plump and large sized seeds were collected for sowing. Four seeds were sown in each pot.

2.4.3 Intercultural activities

Tap water was applied for the growth of okra when needed. After seed sowing, proper care was taken to control pest infestation, other damages and to raise healthy and strong seedling. Fungicide was applied as pesticide. 10 days later of seed sowing, thinning of seedling was done by leaving one well developed seedling in each pot.

2.4.4 Harvesting and vegetative growth parameters

After 40 days from seed germination, matured okra was harvested and leaf number of each plant, plant height (cm), number of fruits per plant, fresh weight per fruit (gm) were recorded after harvest. Plant height (cm) was measured with the help of a meter scale from the ground level to the tip of the upper most leaf. Number of fruit was counted and recorded. Weight (g) of fruit was weighed by using electric balance.

2.5 Chemical analysis of compost and soil

The collected compost was sun dried, grind in a grinder and mixed thoroughly to make homogeneous sample prior to chemical analysis in the laboratory. The pH, EC, OC, Total N, P, K, and S of both compost and soil samples were determined by using the methods mentioned in Imamul Huq and Alam (Imamul Huq et al., 2005).

2.6 Statistical analysis

Collected data from the experiment were statistically analyzed by using ANOVA technique (Minitab 16.0). Comparison and significant variation among the data were also calculated by using it. Graphs were prepared, and other data calculation was done by using Microsoft Excel 2010.

3. Results and Discussion

3.1 Properties of soil

Some basic soil properties are presented in the Table 1. The soil was clay loam in texture, slightly alkaline and non-saline in nature (Soil Survey, 1993).

Table 1: Some basic properties of soil

Properties	Results
Soil Organic carbon (SOC)	1.71%
pH	8.17
Electric conductivity (EC)	0.074 dSm^{-1}
Nitrogen (N)	0.34%
Phosphorous (P)	0.13%
Potassium (K)	0.43%
Sulfur (S)	0.72%
Sodium (Na)	3.64%

3.2 Properties of prepared co-compost

The analytical results of different properties of co-composts are presented in Table 2. The pH and EC values were significantly higher in SD:CM(1:1) and SD:CM(1:2) combinations, respectively. The maximum OC (15.40%) was obtained in SD, since SD is a C rich material [14–15] and minimum (13.06%) in CM. The OC content differed significantly ($p<0.05$) among different treatment combinations and followed the order: SD > SD:CM(2:1) > SD:CM(1:1) > SD:CM(1:2) > CM. Nitrogen content (2.91%) was found significantly higher in CM since CM is considered as a good source of N [12–13] and the lowest obtained in SD (1.26%) by following the order: CM > SD:CM(1:2) > SD:CM(1:1) > SD:CM(2:1) > SD. Significantly higher amount of P and S were found in CM and K (0.49%) was found highest in SD:CM(2:1). In case of C:N ratio, as SD and CM are considered as great source of C and N, respectively, so, significantly higher C:N ratio (13.33:1) was obtained in SD and the lowest value (5.19:1) was in CM. Similar results were also revealed by Oluchukwu et al., [20]. The C:N ratio of other treatments were in the order of SD:CM(2:1) > SD:CM(1:1) > SD:CM(1:2) which perfectly followed the treatment combination ratio. In this experiment, OC, N, P, K values of composts are in the range of constituents of matured compost given by Gotaas (Gotaas, 1956).

3.3 Effects of co-compost on plant growth

3.3.1 Visual observation of okra plant

Seed germination was observed four days after seed sowing. First germination was observed in the pot treated with CM compost. After thirty three days, the plants treated with SD:CM(1:2) and only CM compost showed first flowering and fruiting also. After 40 days from seed sowing, the highest vegetative growth and yield were observed under SD:CM(1:2) compost treated plants.

Table 2: Some basic properties of co-compost

Properties	Treatment				
	SD	CM	SD:CM(1:1)	SD:CM(1:2)	SD:CM(2:1)
pH	6.75^{b}	6.49^{c}	7.13^{a}	6.85^{b}	6.80^{b}
EC	1.006^{c}	1.173^{b}	1.004^{c}	1.426^{a}	1.258^{b}
Moisture content (%)	33.5±0.03	11.6±0.02	13.5±0.03	12.6±0.02	16.1±0.05
Organic carbon (%)	15.40±0.05^{a}	13.06±0.08^{d}	15.13±0.22^{b}	14.94±0.10^{c}	15.21±0.08^{a}
Total Nitrogen (%)	1.26±0.05^{c}	2.91±0.18^{a}	1.71±0.13^{b}	1.88±0.10^{b}	1.66±0.20^{b}
Phosphorous (%)	0.41±0.013^{c}	1.1± 0.017^{a}	0.86±0.013^{b}	0.97±0.034^{a}	0.81±0.112^{b}
Potassium (%)	0.45±0.02^{bc}	0.34±0.02^{d}	0.47±0.04^{ab}	0.42±0.02^{c}	0.49±0.03^{a}
Sulfur (%)	1.28±0.02^{c}	2.72±0.25^{a}	2.05±0.18^{b}	2.37±0.25^{bc}	2.29±0.27^{b}
Sodium (%)	2.4±0.28^{a}	2.5±0.00^{a}	2.6±0.14^{a}	2.76±0.42^{a}	2.84±0.14^{a}
C:N ratio	13.33±0.62^{a}	5.19±0.99^{c}	8.87±0.71^{b}	7.96±0.44^{b}	9.24±1.10^{b}

Values are the average ± standard deviation. Different letters above the values are significantly difference among the means

3.3 Effects of co-compost on plant growth

3.3.1 Visual observation of okra plant

Seed germination was observed four days after seed sowing. First germination was observed in the pot treated with CM compost. After thirty three days, the plants treated with SD:CM(1:2) and only CM compost showed first flowering and fruiting also. After 40 days from seed sowing, the highest vegetative growth and yield were observed under SD:CM(1:2) compost treated plants.

3.3.2 Plant height

The average plant heights under different treatments at 40 days are shown in Table 3. Plant height differs with types of treatment and treatment combinations. The maximum plant height (44±1.53 cm) was found in SD:CM(1:2) where lowest (33.3±1.53cm) was observed in control and followed the order as SD:CM(1:2) > CM> SD:CM(1:1)> SD:CM(2:1) > SD > control. Statistical analysis revealed that, CM alone and combination SD:CM(1:2) showed significantly higher ($p< 0.01$) plant height.

Table 3: Effect of composts on different plant attributes

Treatment	Plant attributes			
	Plant height (cm)	No of leaves/plant	No of fruits/plant	Fresh weight (g/fruit)
Control	33.3±1.53^{d}	6.3±0.58^{c}	2.33±0.58^{d}	5.6±0.35^{c}
SD	33.4±0.80^{d}	7.3±0.58^{c}	3.33±0.58^{cd}	5.4±0.77^{c}
CM	42.0± 1.0^{a}	11.0±1.0^{a}	5.0±0.0^{a}	9.0±0.90^{a}
SD:CM(1:1)	39.2±2.43^{b}	10.7±0.58^{a}	3.7±0.58^{b}	7.0±0.55^{b}
SD:CM(1:2)	44.0±1.53^{a}	12.0±1.0^{a}	5.67±0.58^{a}	10.0±1.0^{a}
SD:CM(2:1)	36.3±0.58^{c}	9.3±1.15^{b}	3.67±0.58^{b}	6.61±0.98^{b}

Values are the average ± standard deviation. Different letters indicate the significant ($p=0.05$) differences

3.3.3 Number of leaves per plant

The application of compost at different ratios produced different number of leaves per plant. The number of leaves at 40 days are presented in Table 3 and followed the order: SD:CM(1:2) > CM > SD:CM(1:1) > SD:CM(2:1) > SD. The maximum number of leaves (12.0±1 plant^{-1}) was found in 1:2 ratios of SD and CM mixture where minimum (6.3±0.58 plant^{-1}) was observed in control. Analysis of variance (ANOVA) showed that there was a significant difference ($p<0.001$) in total number of leaves per plant under different treatments. CM alone and treatment combinations SD:CM(1:1) and SD:CM(1:2) were statistically similar but significantly higher than the rest of the treatments though SD:CM(1:2) treatment produced the maximum number of leaves per plant than that of others.

3.3.4 Number of fruits per plant

The application of compost had positive effects on the yield of okra as compared to control (Table 3). The highest number of fruits per plant was observed in SD:CM(1:2) treatment (5.67 plant^{-1}), followed by CM (5.0 plant^{-1}), SD:CM(1:1) (3.7 plant^{-1}), SD:CM(2:1) (3.67 plant^{-1}) and SD (3.33 plant^{-1}). Statistical analysis showed that there was a significant difference ($p<0.001$) in total number of fruits under different treatments. In spite of highest yield under SD:CM(1:2), statistically, CM and SD:CM(1:2) treatments were similar and highly significant and differed with others.

3.3.5 Fresh weight (FW) per fruit (g)

The average FW per fruit varied with different rate and composition of co-compost. SD:CM(1:2) treatment (10.2±1 fruit^{-1}) produced the highest fresh weight per fruit and lowest in both control and SD (Table 3). FW per fruit was significantly higher and statistically similar ($p>0.001$) for plant treated with SD:CM(1:2) and CM compost though SD:CM(1:2) produced higher fresh weight (g) per fruit.

From the experimental results, it was clear that, co-compost or combined application of SD and CM showed better growth performance than the sole application of SD and CM compost. The highest plant height, leaves per plant, fruits per plant and fruit FW were obtained from SD:CM(1:2) (Table 3). These results are similar with the findings of Wang et al.,; Deepasundari and Mariappan (Wanh et al., 2004; Deepasundari et al., 2015). Another researcher Ashiono et al., stated that, highest seedling growth of Blue gum was found in the soil treated with co-compost of CM and SD at a ratio of 1:1 (Ashiono et al., 2017). In spite of numerous positive results, Adekunle did not find out any effective result after co-compost application, where he used poultry litter and sawdust on okra plant (Adekunle, 2013). Since, the highest results obtained from SD:CM(1:2) combination than that of other two SD:CM(1:1) and SD:CM(2:1), that means, a right proportion of feedstock is prerequisite and a very important factor for preparing perfect co-compost enriched with plant nutrients which is also observed by Oluchukwu et al. (Oluchukwu et al., 2018). In case of sole application of SD and CM, the growth performance of okra under SD treated soil was very low than under CM. The probable reason might be the nutrient content of SD is generally low (except C) and due to high C:N ratio it is slow to decompose but CM is a very potential source of plant nutrients (especially N) that helps to increase plant growth and production (Okalebo et al., 2002; Ashiono et al., 2017). Moreover, CM is a very good source of nutrients for okra (Haque et al., 2015).

Some other experimental results by Ali et al., and Igbokwe et al., revealed that, if a carbon rich material (SD) was mixed with nitrogen rich source (CM), then the produced compost is considered as more efficient for plant growth and the reason of effectiveness of co-compost lies on a very important factor called the C:N ratio (Ali et al., 2015; Igbokwe et al., 2015). In our experiment, the C:N ratio of SD was found high and C:N ratio of CM was comparatively low (Table 2). Both the conditions were unfavorable for plant growth. But when SD and CM were mixed together at a particular combination SD:CM(1:2), the optimum C:N ratio was obtained and highest plant growth was observed in that case. This is because, SD with high C:N ratio act as bulking agent and promote decomposition process by supplying sufficient C to microbes and on the other hand, N was delivered from low C:N ratio product (CM) to carbon rich product for increasing its decomposition rate which help to maintain soil fertility and supply adequate amount of nutrients for plant growth and yield (Bernal et al., 2019; Dimambro et al., 2016; Ashiono et al., 2017).

4. Conclusion

Co-compost was produced by mixing SD and CM at different rate to observe the nutritional value, changes of nutrient characteristics among different treatments and the effects of co-composts on the growth performance of okra. The results showed that the quality of compost increased when SD and CM was mixed at 1:2 ratio than the sole SD and CM compost. Total N, P and S were high in CM compost and the highest values of OC, C:N ratio were observed in SD compost. The growth characteristics of okra plant revealed that the application of co-compost (SD:CM, 1:2) was better than any other combinations. So, co-composting of SD and CM at 1:2 ratio might be the optimum combination for making an efficient organic fertilizer from organic waste products. This co-compost would help to decrease the indiscriminate use of inorganic fertilizer which is responsible for soil quality deterioration and will play a promising role to boost up and maintain soil fertility and productivity for sustainable agriculture.

REFERENCES

1993. Soil survey manual, Soil Survey Division Staff, Chapter 3 Soil conservation service. US Department of Agriculture, Washington, DC.

Abou El-Magd, M.M., El-Bassiony, A.M., Fawzy, Z.F. 2006. Effect of organic manure with or without chemical fertilizers on growth, yield and quality of some varieties of broccoli plants, Journal of Applied Sciences Research, 2, 791–798.

Adekunle, O. 2013. The effect of combined application of poultry manure and sawdust on the growth and yield of okra, Journal of Agricultural Science, 5, 169-175. DOI:10.5539/jas.v5n10p169

Ali, K., Arif, M., Shah, F., Shehzad, A., Munsif, F., Mian, I.A., Mian, A.A. 2017. Improvement in maize (*Zea mays* L.) growth and quality through integrated use of biochar, Pakistan Journal of Botany, 49, 85–94.

Ali, M.M., Khan, F.A., Hossain, M.M., Rahman, A.N.M.I. 2015. Preparation of cattle manure compost using sawdust and rice straw, Bangladesh Journal of Animal Science, 44, 64–68. DOI: 10.3329/bjas.v44i1.23145

Anwar, Z., Irshad, M., Fareed, I., Saleem, A. 2015. Characterization and recycling of organic waste after co-composting-a review, Journal of Agricultural Science, 7, 68–79. DOI: 10.5539/jas.v7n4p68

Arapitsas, P. 2008. Identification and quantification of polyphenolic compounds from okra seeds and skins, Food Chemistry, 110, 1041–1045. doi: 10.1016/j.foodchem.2008.03.014

Ashiono, F.A., Wangechi, H.K., Kinyanjui, M.J. 2017. Effects of sawdust, forest soil and cow dung mixtures on growth characteristics of blue gum (*Eucalyptus saligna*) seedlings in South Kinangop forest, Nyandarua, Kenya, Open Journal of Forestry, 7, 373–387. DOI: 10.4236/ojf.2017.74022.

BBS (Bangladesh Bureau of Statistics). 2011. The yearbook of agricultural statistics of Bangladesh. Statistics Division, Ministry of Planning, Government of People Republic of Bangladesh, Dhaka.

Bernal, M.P., Alburquerque, J.A., Moral, R. 2009. Composting of animal manures and chemical criteria for compost maturity assessment-a review, Bioresource Technology, 100, 5444–5453. doi:10.1016/j.biortech.2008.11.027

Burton, H., Turner, C. 2003. Treatment strategies for sustainable agriculture. Manure Management, second ed., Silsoe Institute, Lister and Durling printers. Flitwick Bedford, UK.

Deepasundari, R., Mariappan, V. 2015. The combined application of cow dung and sawdust on the growth and biochemical characteristics of *Vigna radiata (L.)* Wilczek, International Journal of Environmental Biology, 5, 66–71.

Dilruba, S., Hasanuzzaman, M., Karim, R., Nahar, K. 2009. Yield response of okra to different sowing time and application of growth hormones, Journal of Horticultural Science and Ornamental Plants, 1, 10–14.

Dimambro, M.E., Steiner, J., Rayns, F., Wallace, P. 2016. Literature review: compost stability – impact and assessment, final report, Environment Agency. DOI: 10.13140/RG.2.2.15076.58248

Dumitraescu, C., Saucivc, I., Manciulea, I., Zaha, C. 2009. Obtaining biofertilizer by composting vegetable waste, sewage sludge and saw dust, Bulletin of the Transilavania University of Brasor, 2, 117–122.

Fernández, J.M., López-de-Sá, E.G., Polo, A., Plaza, C. 2014. Short term stabilization of organic matter in physically, chemically, and biochemically protected pools in soils amended with municipal wastes, Clean-Soil Air Water, 42, 487–493. DOI: 10.1002/ clen.20130 0127

Garner, E. 2014. Sawdust as a mulch and soil amendment for rhododendrons and azaleas, In: A. N. Roberts, A. R. S. Bulletin (Eds.), Journal American Rhododendron Society, 5, 58.

Gotaas, H.B. 1956. Composting – sanitary disposal and reclamation of organic wastes, WHO Geneva.

Gruhn, P., Golett, F., Yudelman, M. 2000. Integrated nutrient management, soil fertility and sustainable agriculture: current issues and future challenges. Food, agriculture and environment discussion, Paper 32. International Food Policy Research Institute, Washington DC, USA, 1–3, ISBN 0-89629-638-5.

Haque, M., Rashid, H.O., Pervin, E. 2015. Effect of the combination of cowdung and poultry litter on the yield of okra (*Abelmoschus esculentus* L.). Basic Research Journal of Agricultural Science and Review, 4, 193–198. ISSN 2315–6880

Igbokwe, P.K., Asadu, C.O., Okpe, E.C., Okoro, S.E. 2015. Manufacture of bio-fertilizer by composting sawdust and other organic waste, International Journal of Novel Research in Physics, Chemistry and Mathematics, 2, 6–15. ISSN 2394-9651

Imamul Huq, S.M., Alam, M.D. 2005. (Eds.), A handbook on analysis of soil, plant and water. BACER-DU, University of Dhaka, Banglaesh, ISBN-984-32-1770-5

Joardar, J.C., Rahman, M.M. 2018. Poultry feather waste management and effects on plant growth, International Journal of Recycling of Organic Waste in Agriculture, 7, 183–188. DOI: 10.1007/s4009 3-018-0204-z

Kashmanian, R.M., Kluchinski, D., Richard, T.L., Walker, J.M. 2000. Quantities, characteristics, barriers and incentives for use of organic municipal by products, land application of agricultural, industrial and municipal by-products, Science Society of America Books Series, 6, 128–167.

Mondal, M.R.I., Sultan, M.K., Nur, S., Sarkar, M.J.U., Alam, M.S., Rahman, M.H.H., Krishi Proyukti Hatboi (Handbook of agro-technology). 2014. 6th ed. Bangladesh agricultural Research institute, Gazipur, 1701.

Neves, L., Ferreira, V., Oliveira, R. 2009. Co-composting cow manure with food waste: the influence of lipid content, International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering, 3, 529–534.

Ogundare, S.K., Owa, F.D., Etukudo, O.O., Ibitoye-Ayeni, N.K. 2015. Influence of different nitrogen sources on the growth and yield of three varieties of okra (*Abelmoschus esculentus*) in Kabba, Kogi State, Nigeria, Agricultural Sciences, 6, 1141–1147. DOI: 10.4236/as.2015.610109

Ogunwande, G.A., Osunade, J.A., Ogunjimi, L.A.O. 2008. Effects of carbon to nitrogen ratio and turning frequency on composting chicken litter in turned windrow piles, CIGR E–journal, 10, 1–16.

Okalebo, J.R., Gathua, K.W., Woomer, P.L. 2002. Laboratory methods of soil and plant analysis: a working manual second ed., Sacred Africa, Nairobi.

Oluchukwu, A.C., Nebechukwu, A.G., Egbuna, S.O. 2018. Enrichment of nutritional contents of sawdust by composting with other nitrogen rich agro-wastes for bio-fertilizer synthesis, Journal of Chemical Technology and Metallurgy, 53, 430–436.

Parry, M.L. 2007. Climate change 2007–Impacts, adaptation and vulnerability: working group II contribution to the fourth assessment report of the IPCC. Cambridge: Cambridge University Press, 4.

Saifullah, M., Rabbani, M.G. 2009. Evaluation and characterization of okra (*Abelmoschus esculentus*.moench.) genotypes, SAARC Journal of Agriculture, 7, 91–98.

Usman, M., Madu, V.U., Alkali, G. 2015. The combined use of organic and inorganic fertilizers for improving maize crop productivity in Nigeria, International Journal of Scientific and Research Publications, 5, 1–7. ISSN 2250–3153.

Wang, P., Changa, C.M., Watson, M.E., Dick, W.A., Chen, Y., Hoitink, H.A.J. 2004. Maturity indices for composted dairy and pig manures, Soil Biology and Biochemistry, 36, 767–776. DOI: 10.1016/j.soilbio.2003.12.012

Yadav, S.K., Dhankhar, B.S. 2001. Correlation studies between various field parameters and seed quality traits in okra cv. Varsha Uphar, Seed Research, 29, 84–88.

Zhang, Y., He, Y. 2006. Co-composting solid swine manure with pine sawdust as organic substrate, Bioresource Technology, 97, 2024–2031. DOI: 10.1016/j.biortech.2005.10.004.