

Application of Indigenous Microorganisms (IMO) for Bio-Conversion of Agricultural Waste

Chiemela F. Anyanwu¹, Serafin L. Ngohayon², Ricardo L. Ildefonso³, Joseph L. Ngohayon⁴

^{1,2} Ifugao State University, Nayan, Lamut, Ifugao, Philippines

^{2,3} Ifugao State University, Potia campus Alfonso Lista, Ifugao, Philippines

Abstract: *The present investigation was conducted to evaluate the effect of Indigenous microorganism (IMO) in decomposing compost pile mixtures of farm wastes and plant materials [(carbonize rice hull/ corn husk/ chicken manure/ Ipillpil dry leaves (Leucaena glauca)/ Kakawati dry leaves (Gliridia sepium)] for the purpose of increasing nutrient content values of bio-organic fertilizer. Samples of IMO was collected from a bamboo forest in Potia, Alfonso Lista, Ifugao, Philippines and cultured. Two (2) rates of IMO concentrations (2Tbsp and 3Tbsp) mixed in one liter (1L) of distilled water as treatment was sprayed on 50 kilos of compost pile in a cage bin under a constructed shade. The experiment was laid out in a complete randomized design (CRD) with three replications. Nutrient analysis of compost residues after 30days of decomposition showed increased percentages of macro and micro nutrients with the application of 3Tbsp of IMO.*

Keywords: Indigenous Micro-organism, IMO, farm waste, plant materials, decomposition, nutrient content.

1. Introduction

Agricultural production produces abundant plant waste that is mostly utilized due to high content of cellulose which is slow to decompose by naturally occurring microorganism. Most of these agricultural wastes are burned in the field resulting to environmental pollution and causing respiratory diseases.

It is estimated that the provinces in the Northern Philippines which are mostly agricultural areas produces about 1.6 million metric tons of corn, or 22.98 percent of the total corn production and 2.08 million metric tons rice production, or 12.85 percent of the total production in the country [1]. This equals to huge amount of crop residues. In the province of Ifugao, in the municipality of Alfonso Lista, yellow corn is planted to about 19,000 hectares of land [2], yielding tons of corn husk every cropping season.

Crop residues are potential materials which can be used for composting. Compositing is an age long process by which organic matter is decomposed through the action of microorganism. Among these microbes are; bacteria, actinomycetes, fungi, algae and protozoa. High organic matter content of compost and biological activity makes it effective in a variety of applications, such as soil erosion control, bio-filtration, bioremediation, improving soil structure, moisture retention, and as bio-fertilizer [3].

Compositing technology is potentially useful for solving the problem of air and water pollution [4], mitigating health hazards caused by indiscriminate disposing of waste [5], revitalizing depleted soils nutrient, drastic reduction in waste material and destruction of weed seeds and pathogenic microbes [6], as well as a source of soil amendment and reduction in the use of chemical fertilizer [7]. Application of compost residue in agricultural production has been reported to suppress soil borne plant pathogens and increase yield of crops [8].

Composting is a viable means of transforming various organic wastes into products that can be used safely and beneficially as bio-fertilizers and soil conditioners. Problems associated with the use of raw and unstable organic wastes as soil amendments can be resolved through composting, such as malodors, human pathogens, and undesirable chemical and physical properties. During composting, organic wastes are decomposed; plant nutrients are mineralized into forms available to plants, pathogens are destroyed, and malodors are abated [9]. Although, decomposition of organic matter occurs naturally, it can be accelerated by human intervention.

Indigenous Micro Organisms (IMO) are naturally occurring microbes that has adapted to the environmental condition where they are found and as such, are capable of accelerating rapid decomposition of organic materials found in the same location. Singh and Sharma (2003) [10], inoculated various kinds of wastes (mixed solid waste, municipal solid waste and horticultural waste) with different micro-flora. Acceleration of decomposition of crop residues high in lignin with the application of IMO has been reported [11]. Microbial inoculation in relation to waste decomposition for agricultural production offers the advantage of releasing essential compounds stored in plants and animal waste to a stable state that can be used again for plant growth [12]. As reported by [13], microbial inoculants are vital component in the agro-ecosystems as they play an important role in reducing indiscriminate use of chemical fertilizers and offers farmers an attractive economically acceptably substitute for improving soil properties. Microbial inoculant produces metabolites that facilitate decomposition of organic waste and increase humus quality [14]. The nutrient status of sorghum stalk and wheat straw compost was improved after inoculation with *Aspergillus niger* and *Penicillium spp.* [15].

When complex organic materials such as; plants, animal excrements, and organic fertilizers enter the soil, IMO break these down into simpler compounds or elements that can undergo ionic interactions [16]. Compost residues impart

more benefits than fertilization of crops. Compost improves soil structure and tilth, lower bulk densities of agricultural waste, by increasing permeability and porosity. It also creates a favorable environment for microorganisms to produce substances that aids in binding soil particles together. Composting of organic matter before incorporation into the soil is more beneficial than direct application. It helps in stabilizing nitrogen and make is less capable of leaching and reduces odor that is usually produce in decaying organic matter [17]; [18]; [19].

This study was carried out with the objective of investigating the effect of indigenous micro-organism (IMO) collected from bamboo forest in decomposing farm waste and plant material for the purpose of increasing nutrient contents qualities of bio-organic fertilizer.

2. Materials and Methods

Experimental Site

The experiment was undertaken at the Ifugao State University, Potia campus, Alfonso Lista, Ifugao, Philippines.

Collection of Indigenous Microorganism (IMO) Samples

Indigenous Micro-organisms (IMO) were collected from a bamboo forest in Potia, Alfonso Lista, Ifugao Philippines

Procedure for the collection of IMO samples

Four (4) wooden boxes measuring '12x12 and 4 inches deep' were filled with steamed rice and covered with paper towel and plastics. The wooden boxes were buried in a 3 inches hole under a bamboo tree and covered with bamboo leaves and allowed to stay for five (5) days (Figure 1).



Figure 1

Culture and sampling of IMO

Collected micro-organism embedded in the steamed rice was cultured by mixing equal amount liquid molasses in a clay pot (1:1) to the steamed rice. The mixture was stored away from sunlight in a cool dry enclosure for seven (7) days.

Preparation and application of IMO

Two (2) concentrations of liquid IMO samples (2Tbsp, 3Tbsp) were mixed in one liter of distilled water each to get a suspension.

Preparation of farm waste/plant materials and decomposition.

Compost pile (carbonize rice hull/ corn husk/ chicken manure/ Ipillpil dry leaves (*Leucaena glauca*)/ Kakawati dry leaves (*Gliridia sepium*) were combined in a ratio of 1:1 on dry weight basis and properly mixed for a total weight if 50 kilos (figure 2). Decomposition was carried out in a cage bin measuring 25x25 cm constructed inside a shade made of bamboo tree.



Figure 2: Farm waste and plant materials

IMO samples (suspension) (2TbspL, 3Tbsp/L) was sprayed on the compost piles and covered with polyethylene bag. Distilled water without IMO was used as control treatment. The compost pile was watered occasionally to maintain adequate moisture content. Manual turning was done every week to maintain aeration. Treatments were arranged in a completely randomized design (CRD), with three treatments including the control and four replicates.

Temperature Measurements

Temperature inside the pile was monitored daily at 8am, 12noon and 4pm at different locations of the compost pile using a thermometer inserted 25 cm deep into the pile and average taken to represent the daily temperature.

pH determination

Representative samples from the compost piles were taken after 30days and mixed thoroughly. Samples was suspended

in water (w/v, 1:10), shaken for 30 min on rotary shaker and the pH of the supernatant was determined using a pH meter (Scientific Instruments Co. (Italy) model 9000/3).

Nutrient analysis

Ten (10) grams of representative samples were taken after 30 days of decomposition for nutrient analysis. (Macronutrients) = (Nitrogen (N), Phosphorous (P), Potassium (K), and Micronutrients = (Fe, Mn, Zn, and Cu). Organic carbon content was determined using the method described by [20]. Percent nitrogen (N) determination was by micro-kjedahl method according to [21], while phosphorus (P) was by wet oxidation [22]. Potassium, Cu, Fe, Mn, and Zn was determined by dry ashing [23].

Statistical Analysis

One way ANOVA was used to make comparisons among the different IMO concentrations for the parameters at 0.5% confidence level. Microsoft excel computer software was used to analyze data.

3. Results and Discussion

Temperature (°C)

Temperature plays an important factor in composting [24]. As microbes decompose organic material, large amount of energy is release in the form of heat which increases the temperature in the pile. This is however, related to the population of microorganism present in the pile [25]. Changes in temperature during the composing period are shown in figure 3.

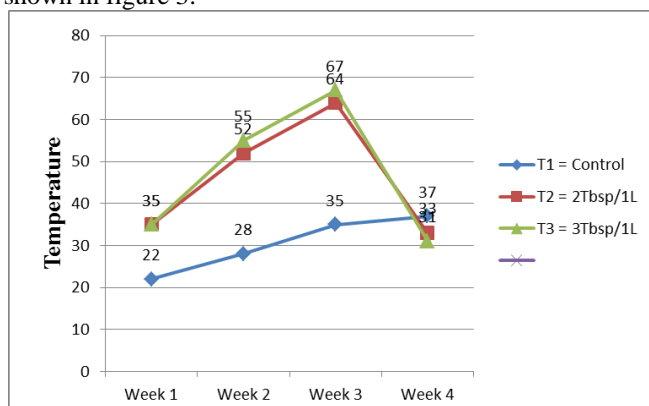


Figure 3: Temperature profile during decomposition (°C)

The results indicated that the temperature within the pile was between 22-35 °C during the first week of decomposition (the mesophilic stage) and gradually increased in the second week to 28 - 55 °C. By third week leading to the thermophilic phase, the temperature progressively increase to 35 - 67 °C and started to decline to 22-37 °C by the fourth week.

As shown in figure 3, T3 and T2 recorded higher percentage of temperatures than the control treatment during the mesophilic and thermophilic phases of decomposition (first and second week), indicating that the presence of IMO accelerated decomposition, thus increasing the temperature in the pile. Towards the end of the fourth week, the temperature

decreased in T3 and T2 piles, an indication of reduction in decomposition, possibility due to decrease in organic carbon of the compost materials as it has been used up by the microorganism for metabolism.

As reported by [26], high temperatures are usually indicators of an increased rate and extent of decomposition of organic matter. As temperature increases so also will be greater oxygen uptake and faster rate of decomposition. Compost pile temperatures between 32°C and 60°C (90° and 140°F) indicate rapid composting [27]. Temperatures greater than 60°C (140°F) reduce the activity of many of the most active organisms [28]. Therefore, the optimum temperature range is between 32° and 60°C [29].

In this study average temperature obtained with the application of IMO were within the optimum temperatures. Similar results have also been obtained by other authors [30]; [31]. Results from this study revealed that higher populations of IMO (3Tbsp/1L) effectively influence decomposition of farm waste.

C/N ratio

Carbon and nitrogen ratio of compost residue from farm waste mixtures and plant material treated with different rates of IMO is presented in Table 1. Results indicated that T3 had the lowest mean value of C: N (19.5) followed by T2 (22.5) and T1-Control (40. 5) respectively. C:N ratio represents an important parameter for measuring the activities of the microorganisms during composting process [32]. Microorganisms require carbon for growth, energy for metabolism, and nitrogen for protein synthesis.

Table 1: C: N ratio of compost after 30 days of decomposition with IMO application

Treatments (IMO)	Initial C:N ratio of compost pile	After 30 days of decomposition
T1 - Control	50	40. 5a
T2 - 2Tbsp/1L	50	22. 5b
T3 - 3Tbsp/1L	50	19. 5b

Means with the same letters are not significantly different at 0.05% probability level

A proper ratio of carbon and nitrogen is paramount for adequate degradation of organic matter by microorganism. As shown in table 1, the control treatment had a C: N ratio of 40.5 indicating less decomposing activity and thus, a high value of carbon. A major product of plant decay is nitrogen (N) while the undigested portion is primarily carbon (C). A situation as seen in the control treatment can be attributed to the absence of IMO in the compost pile as compared to T2 and T3 with low values of carbon content. Similar results has been obtained by other authors [33]; [34]; [35];[36]. Carbon and nitrogen ratio between 20 and below has also been reported [37]; [38]; [39] as an acceptably ratio to determine the maturity of a compost pile.

pH

pH values of the compost residue is presented in Table 2. A

neutral pH is 7.0, while a pH less than 7.0 is considered acid and a pH greater than 7.0 is considered alkaline. In this study, pH of the compost residue ranged between 6.8 -7.4.

Organic matter Content (%)

Organic matter improves soil structure and water holding capacity. Percentages of organic matter content of compost residue are presented in table 2. Results indicate that organic matter content decreased during the composting process especially with the IMO treatments T3 and T2 (43, 45%). As reported by [40], decrease in organic matter content can be attributed to volatilization of carbon dioxide due to the degradation of waste material by the action of microorganism [41].

Table 2: Physical characteristics of compost residue after 30 days decomposition

Treatment IMO Solution	pH	Organic matter (%)	Moisture content (%)	Odor	Color
T1 - control	7.4	60	50	Slightly Foul	Brown
T2 -2Tbsp/1L	6.8	45	35	earthy odor	Dark brown
T3- 3Tbsp/1L	6.8	43	35	earthy odor	Dark brown

Moisture content (%)

Finished compost should have moisture content between 35% - 45%. In this study, moisture content between 35 - 50 % was attained in the compost residue (Table 2). T2, T3 had moisture contents of 35% as compared to the control with 50%. The finish compost residue in T2 and T3 had dark brown color with earthy smell, while the control treatment exhibited foul smell with brown color (Table 2).



Figure 3: Compost residue

Macronutrients

Nitrogen, phosphorus and potassium are important macronutrients required most for plant growth and development [43]. The amount of these nutrients present in a compost residue is important for increasing the quality of bio-organic fertilizer [44]. As presented in table 3, the percentages of NPK in the compost residue were higher in T2 and T3 (6.4%, 3.82 %,) than the control treatment (2.18%). Among the treatments, T3 had higher percentage of

macronutrient than T2. This may be due to higher number of microorganism present in 3Tbsp/1L than in 2Tbsp/1L. As reported by [45], faster rate of lignin decomposition can be achieved with increased concentration of inoculant. Macronutrients in compost residue can also increase through loss in organic carbon in the form of carbon dioxide during composing as a result of microorganism metabolism. In similar studies, [46]; [47]; [48], reported increase in macronutrient in compost residue with increase concentration of micro-flora.

Micronutrients

In this study, Fe, Mn, Zn, and Cu increased moderately in T2 and T3 compared to the control (Table 3). T3 showed higher value than T2. As reported by [49], the process of composting is an efficient process of concentrating micronutrients which are desirable for plant growth and development. Composting concentrates nutrients and provides for their slow-release, which can result in more efficient plant uptake and less fertilizer leaching [50]. Composting converts crop residues into a better organic fertilizer. Agricultural waste such as rice hull, are often low in major nutrients such as nitrogen (N) and phosphorus (P), but rich potassium (K), they can be highly beneficial because they contain micronutrients, enzymes and micro-organisms that are useful in the soil for plant growth and development. The concentration of micronutrients found in compost depends on the feedstock used. Therefore, compost is more desirable when it is a mixture of different feedstock [51]. Since organic materials for composting contain products of agriculture or horticulture, it is logical to expect these nutrients to be present in the compost. Studies have shown that compost manures have beneficial effects greater than those to be expected from nitrogen, phosphorus, potash, and humus content alone [52].

4. Conclusions

Generally, successful composting depends on a number of factors that have both direct and indirect influence on the activities of the microorganisms. They include the type of raw material being composted, its nutrient composition, moisture content, temperature, acidity or alkalinity and aeration. Microorganisms that do much of the work need high temperatures, plenty of oxygen, and moisture

In this investigation, our findings revealed that Indigenous microorganism (IMO) were found to be effective in accelerating decomposition of farm waste and plant materials that yielded high levels of macro and micro nutrients in the residue that can be used for various purposes such as production of organic fertilizer.

5. Acknowledgement

This research is funded by Research and Development Department (RDET), Ifugao State University, Nayon, Lamut Ifugao.

Table 3: Nutrient composition of compost residue

Treatment	Macro- nutrient			Micro-nutrients			
	30 days decomposition			30 days decomposition			
	N (%)	P ₂ O ₅ (%)	K (%)	Fe ppm	Cu ppm	Zn ppm	Mn ppm
IMO Solution							
T1 - control - 0/1L	4.4	1.08	1.20	40	17	150	198
T2 - 2Tbsp/1L	6.2	3.08	2.12	58	20	180	222
T3 - 3Tbsp/1L	6.4	3.82	2.18	61	22	182	280

References

- [1] Department of Agriculture-Region 2 (DA-2) Agricultural News Bulletin Dec. 2013
- [2] Department of agriculture (DA-CAR) Alfonso Lista, Ifugao, Philippines Agricultural Report, 2010.
- [3] Alexander R. Compost markets grow with environmental applications. Bio-Cycle Magazine, March:43–44, 1999.
- [4] Hargreaves, J.C., Adl, M.S., Warman, P.R.. A review of the use of composted municipal solid waste in agriculture. Agric. Ecosyst. Environ.123, 1-14, 2008.
- [5] Salar RK, Aneja KR. Thermophilous fungi from temperate soils of northern India. J. Agri. Technol., 2: 49-58, 2006.
- [6] Bernal M.P.; J.A. Albuquerque and R. Moral. Composting of animal manures and chemical criteria for compost maturity assessment. A review Bioresource Technol. 100: 5444-5453, 2009.
- [7] Badr El-Din S.M.S.; M. Attia and S.A. Abo-Sedera. Field assessment of composts produced by highly effective cellulolytic microorganisms. Biol. Fertil. Soils, 32:35. 2000.
- [8] Hoitink, H.A.J., Inbar, Y. & Böhme, M.J. Status of compost-amended potting mixes naturally suppressive to soilborne diseases of floricultural crops. Plant Disease 75: 869 – 873, 1991.
- [9] Parr, J.F. and S.B. Hornick. Utilization of municipal wastes. p. 545-559. In: Soil Microbial Ecology: Applications in Agricultural and Environmental Management. F.B. Metting (ed.) Marcel Dekker, Inc., New York, U.S.A, 1992
- [10] Singh A., Sharma S. Effect of microbial inocula on mixed solid waste composting, vermicomposting and plant response. Compost Sci. Util., 11: 190-199, 2003.
- [11] Khadem, S.A., Galavi, M., Ramrodi, M., Mousavi, S.R., Roustae, M.J., Rezvani-Moghadam, P. Effect of animal manure and superabsorbent polymer on corn leaf relative water content, cell membrane stability and leaf chlorophyll content under dry condition. Aus. J. Crop Sci. 4,8, 642-647, 2010.
- [12] Barker, A.V., Bryson, G.M. Comparisons of composts with low or high nutrient status for growth of plants in containers. Comm. Soil Sci. Plant Ana. 37, 1303-1319, 2006.
- [13] Berc J, Muñoz O, Calero B. Vermiculture offers a new agricultural paradigm. Biocycle. 45(6):56-7, 2004.
- [14] Barker, A.V., Bryson, G.M. Comparisons of composts with low or high nutrient status for growth of plants in containers. Comm. Soil Sci. Plant Ana. 37, 1303-1319, 2006.
- [15] Gaur A.C., Sadasivam K.V. Theory and practical considerations of composting organic wastes. In: Thampan P.K., Ed., Organics in Soil Health and Crop Production, Peekay Tree Crops Development Foundation, Cochin, pp. 1-22, 1993.
- [16] Anastasia A, Varese GC, Voyron S, Scannerini S, Filipello Marchisio V. Characterization of fungal biodiversity in compost and vermicompost. Compost Science and Utilization 12:185–191, 2004.
- [17] Badr El-Din S.M.S.; M. Attia and S.A. Abo-Sedera. Field assessment of composts produced by highly effective cellulolytic microorganisms. Biol. Fertil. Soils, 32:35. 2000.
- [18] Kaur T, Brar B S and Dhillon N S. Soil organic matter dynamics as affected by long term use of organic and inorganic fertilizers under maize-wheat cropping system. Nutr.Cycl.Agroecosyst.81, 59-69, 2008.
- [19] Mikan S. Z, Muller T. Impact of effective microorganisms and other biofertilizers on soil microbial characteristics, organic-matter decomposition, and plant growth. J Plant Nutr Soil Sci 172: 704-712, 2009.
- [20] Walkey A, Black CA. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chronic acidification method. Soil Sci. 37: 29-38, 1934.
- [21] Bremer JM. Determination of nitrogen in soil by Kjeldahl method.J.Agric. Sci. (Camb.)55: 11-23, 1960.
- [22] A. O. A. C. Association of official Analytical chemists. Official Methods of Analysis 13th Edition, Washington, DC, 1980a.
- [23] A. O. A. C. Association of official Analytical chemists. Official Methods of Analysis 13th Edition, Washington, DC, 1980b.
- [24] Finstein M. S.; F.C. Miller and P.F. Strom. Waste treatment composting as a controlled system. Biotechnol. 8: 363-398. 1986.
- [25] van Veen JA, van Overbeek LS, van Elsas JD). Fate and activity of microorganisms introduced into soil. Microbiol. Mol. Biol. Rev. 61:121-135. 1997.
- [26] Lei F., Gheynst J.S.V. The effect of microbial inoculation and pH on microbial community structure changes during composting. Proc. Biochem., 35: 923-929, 2000
- [27] Kaviraj and S. Sharma.. Municipal solid waste management through vermicomposting employing exotic and local species of earthworms. Bioresource Technol., 90: 169 173, 2003.
- [28] Lekasi J.K., Tanner J.C., Kimani S.K., Harris P.J.C.). Cattle manure quality in Maragua District, Central Kenya: Effect of management practices and development of simple methods of assessment. Agr. Ecosyst. Environ., 94: 289-298, 2003.
- [29] Lei F., Gheynst J.S.V. The effect of microbial inoculation and pH on microbial community structure changes during composting. Proc. Biochem., 35: 923-929, 2000
- [30] Roger S.W., Jokela E.J., Smith W.H. Recycling composted organic wastes on Florida forest lands. Dept. of Forest Resources and Conservation, Florida Cooperative Extension Services, University of Florida, USA 1991.
- [31] Lekasi J.K., Tanner J.C., Kimani S.K., Harris P.J.C. Cattle manure quality in Maragua District, Central Kenya: Effect of management practices and development

- of simple methods of assessment. *Agr. Ecosyst. Environ.*, 94: 289-298. 2003
- [32] Leonard, J., Composting, An Alternative Approach to Manure Management, *Advances in Dairy Technology* 13: 431, 2001
- [33] Bass, L., T.E. Bilderback, and M.A. Powel, *Composting, A Guide to Managing Yard Waste*, North Carolina Cooperative Extension Service. North Carolina. 1992
- [34] Misra, R.V., R.H. Roy and H. Hiraoka, *On Farm Composting Method*, FAO, Rome, 2003.
- [35] Higa, T. Effective microorganisms: A new dimension for nature farming. In: *Proceedings of the Second International Conference on Kyusei Nature Farming*. J.F. Parr, S.B. Hornick, and M.E. Simpson (eds.) U.S. Department of Agriculture, Washington, D.C., U.S.A., p. 20-22, 1994.
- [36] El-Meniawy M.A., Microbiological Studies on the Production of Non-Traditional Animal Feed from Agricultural wastes. M. Sc. Thesis, Faculty of Agriculture, Al- Azhar University, Cairo, Egypt, 2003.
- [37] Khalid A., Arshad M., Zahir Z.A. Phytohormones: microbial production and applications. In: Uphoff N., Ball A.S., Fernandes E., Herren H., Husson O., Laing M., Palm C., Pretty J., Sanchez P., Sanginga N., Thies J., Eds, *Biological Approaches to Sustainable Soil Systems*, Taylor & Francis/CRC, Boca Raton, Florida, pp. 207-220. 2006.
- [38] Bass, L., T.E. Bilderback, and M.A. Powel, *Composting, A Guide to Managing Yard Waste*, North Carolina Cooperative Extension Service. North Carolina. 1992.
- [39] Higa, T. Effective microorganisms: A new dimension for nature farming. In: *Proceedings of the Second International Conference on Kyusei Nature Farming*. J.F. Parr, S.B. Hornick, and M.E. Simpson (eds.) U.S. Department of Agriculture, Washington, D.C., U.S.A., p. 20-22, 1994.
- [40] El-Meniawy M.A. Microbiological Studies on the Production of Non-Traditional Animal Feed from Agricultural wastes. M. Sc. Thesis, Faculty of Agriculture, Al- Azhar University, Cairo, Egypt. 2003.
- [41] Khalid A., Arshad M., Zahir Z.A. Phytohormones: microbial production and applications. In: Uphoff N., Ball A.S., Fernandes E., Herren H., Husson O., Laing M., Palm C., Pretty J., Sanchez P., Sanginga N., Thies J., Eds, *Biological Approaches to Sustainable Soil Systems*, Taylor & Francis/CRC, Boca Raton, Florida, pp. 207-220. 2006.
- [42] Lekasi J.K., Tanner J.C., Kimani S.K., Harris P.J.C. Cattle manure quality in Maragua District, Central Kenya: Effect of management practices and development of simple methods of assessment. *Agr. Ecosyst. Environ.*, 94: 289-298. 2003.
- [43] Moldes A.; Y. Cendon and M.T. Barral. Evaluation of municipal solid waste compost as a plant growing media component, by applying mixture design. *Bioresource Technology*, 98, 3069-3075, 2007.
- [44] Wong SY, Lin S. Composts as soil supplements enhance plant growth and fruit quality of strawberry. *J. Plant Nutr.*, 25: 2243-2259. 2002.
- [45] Singh A., Sharma S. Effect of microbial inocula on mixed solid waste composting, vermicomposting and plant response. *Compost Sci. Util.*, 11: 190-199. 2003.
- [46] Abd El-Maksoud H.K.; M. Azazy and R.A. Abdel-Aziz. Biotransformation of the organic fraction of municipal solid waste to compost and its manural effect on wheat straw. *Egypt. J. Soil Sci.*, (2):267-275, 2002.
- [47] Kaviraj and S. Sharma. Municipal solid waste management through vermicomposting employing exotic and local species of earthworms. *Bioresource Technol.*, 90: 169 173. 2003.
- [48] Eida M.F. Application of biological farming principals for producing safe vegetable crops. M. Sc. Thesis, Faculty of Agriculture, Kafrelsheikh University, 2007.
- [49] Zorpas A.A.; A. Dimitris; K. Panagiotios; H. Maria and Z. Giovannis. Compost quality and use from sewage sludge, organic fraction of municipal solid waste and natural zeolite-clinoptilolite. In: Venglovsky, J., Greserova, G. (Eds.), *RAMIRAN 2002 10th Intern. Conf. Hygiene Safety, Strbske Pleso, High Tatras, Slovak Republic*, May 14 18, pp. 381 389. 2002.
- [50] Hornick, S.B. Factors affecting the nutritional quality of crops. *Amer.J. Alternative agriculture*. 7:63-68. 1992.
- [51] Ramadass, K., Palaniyandi, S. Effect of enriched municipal solid waste compost application on soil available macronutrients in the rice field. *Arch. Agron. Soil Sci.* 53, 497-506. 2007.
- [52] Mhlontlo S, Muchaonyerwa P and Mnkeni P N S. Effects of sheep kraal manure on growth, dry matter yield and leaf nutrient composition of a local amaranthus accession in the central region of the Eastern Cape Province, South Africa. *Water SA* 33 (3), 363-368. 2007.

Author Profile



Chiemela F. Anyanwu finished his undergraduate degree in Biology at Philippine Union College, Philippines in 1996. He obtained his MS in Biology at the Institute of Graduate Studies Adventist University of the Philippines in 2000, and PhD in Plant Breeding at the Institute of Graduate Studies, Central Luzon State University, Philippines in 2006. He is presently an Assistant Professor at Ifugao State University (IFSU).



Serafin L. Ngohayon finished his undergraduate degree in Psychology at Isabela State University, Philippines in 1990. He obtained his MA and PhD in Psychology at Hiroshima University, Japan in 1999 and 2002 respectively under the Mombukagakusho Scholarship Program offered by the Japanese Government. He is presently the President of Ifugao State University (IFSU) and President of the International Distance Education Accreditation League (IDEAL).



Ricardo L. Ildefonso finished his undergraduate degree in Agriculture at Nueva Viscaya State Institute of Technology Philippines in 1981. He obtained his MS in Agriculture at Isabela State University in 1987, MA in Technology Education at Central Luzon State University, Philippines in 1992. He finished his PhD at the La Salette University in 1997. Presently, he is the Campus Executive Director of Ifugao State University, (IFSU) Potia campus.



Joseph L. Ngohayon finished his undergraduate degree in Agriculture at Ifugao state college of Agriculture and Forestry, Philippines in 1986. He obtained is MS in crop science at Isabela State University, Philippines in 1990. At present he a Professor at the College of Agriculture and Forestry, Ifugao State University, Potia campus.