VOL. 12, NO. 7, JULY 2017 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

MUNGBEAN RESIDUE INCORPORATED AT DIFFERENT INCUBATION PERIODS AFFECTS SOIL CHEMICAL PROPERTIES

Ghassan J. Z.[1, 2], W. Zakaria[3], A. R. Shaari[3] and C. H. Mohammud[2]
[1]Department of Horticulture, College of Agriculture, University of Tikrit, Salah Al-deen, Iraq
[2]School of Bioprocess Engineering, University Malaysia Perlis, Jejawi Arau, Perlis, Malaysia
[3]Faculty of Engineering Technology, University Malaysia Perlis, Unicity campus, Padang Besar, Malaysia
E. Mail: gasanjaied@yahoo.com

ABSTRACT

A pot trial was conducted in the greenhouse of the Institute of Sustainable Agrotechnology, University Malaysia Perlis, Padang Besar, Perlis, Malaysia to analyze the influence of mungbean residue on the properties of soil. The treatments involved three levels of mungbean residue at three incubation periods (5%+ 1 week, 5%+ 2 weeks, 5%+ 4 weeks, 10%+ 1 week, 10%+ 2 weeks, 10%+ 4 weeks, 15%+ 1 week, 15%+ 2 weeks and 15%+ 4 weeks) and acontrol treatment. The experiment was conducted within a randomized complete block design (RCBD) with five replicates. The collected data were analyzed using Analysis of Variance (ANOVA) via statistical analysis system (SAS). The measured parameters were significantly influenced ($p<0.05$) by the mungbean residue treatments. The results showed that the values of calcium, potassium, magnesium, CEC, phosphorous, organic carbon, organic matter and carbon: nitrogen ratio were significantly ($p< 0.05$) higher than that of the control treatment. The residual effects of mungbean residue significantly influence the soil nutrient content. It can be concluded that mungbean residue is effective in increasing the fertility of the soil.

Keywords: residue management, nutrient sources, green manure, soil chemical properties, soil fertility.

1. INTRODUCTION

Agricultural intensification in developing countries results in severe soil depletion. Therefore, alternative agricultural practices encourage the reduction in the use of expensive chemical fertilizers in order to sustain soil fertility. Recycling crop residue result in two positive outcomes: enhanced soil nutrient content and increased soil productivity. It will also decrease the utilization of fertilizers (Beres and Kazinczi, 2000). Crop residue is regarded as a source of organic matter for the soil and is crucial towards the soil cycling of nutrients. Several reports pointed out that crop residue are regarded as a crucial source of many macronutrients. Around 50 - 80% uptake of Zn, Cu and Mn by rice and wheat crops were recyclable via residue incorporation (Prasad and Sinha, 1995). Returning crop residue to the soil helps enhance the availability of nutrients in the soil. Proper crop residue management induces element mobility, resulting in its incorporation into the food chain. However, crop residue might also affect other factors, such as the soil pH and soil organic content. Organic acids that are produced from the degradation of crop residue are quite important to improve soil structure and plant growth. Despite these advantages, farmers from developing nations use crop residue as animal feed or construction materials rather than as soil amendment. The aim of this study was to investigate changes to soil properties due to the incorporation of mungbean residue incubated at different periods.

2. MATERIALS AND METHODS

2.1.Experimental location and soil properties

The field experiment was conducted inthe experimental farm of Institute of Sustainable Agrotechnology, University Malaysia Perlis, Padang Besar, Perlis, Malaysia, located at6.653 °N100.261 °E. The local climate is a typical tropical climate with an average annual rainfall of ~3000 mm, and an annual temperature of 27 °C. Some of the properties of the soil are tabulated in Table-1.

2.2. Experiment treatments

The treatment process was conducted in RCBD and replicated five times. The mungbean residue treatments were conducted at multiple levels: 50, 100, and 150 g per kg of soil, alongside a control treatment, which is equivalent to 5%, 10% and 15% per kg soil, respectively. The soil samples were incubated in a greenhouse. Soil samples were collected periodically at 1, 2, and 4 weeks of incubation. In order to determine the chemical properties of the soil prior to the addition of mungbean residue, the samples were taken from a depth of 0-30 cm. The mungbean was planted on 17th November 2015 and harvested on 18th December 2015. The chemical characteristics of the mungbean residue are shown in Table-2.

Each plot was represented by five pots. Some of the properties measured include pH, organic carbon (O.C), organic matter (O.M), total N, available P, C:N ratio, potassium (K) equivalent, magnesium (Mg) equivalent and calcium (Ca) equivalent.

2.3 Measurements of soil parameters

The pH of the soil was measured as per Blakemore *et al.* (1987) while the organic carbon content was measured as per Walkley and Black (1934). The total N and available P were measured as per Van Reeuwijk(2002) while the presence of K, Mg, and Ca were measured as per Holmgren *et al.* (1977).

ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

The soil pH was measured using a pH meter while the amount of total nitrogen (N) was determined using kjeldahl digestion and semi-micro distillation. The exchange cations (Ca, Mg, K) were measured using an Atomic Absorption Spectrophotometer (Varian, Australia, model spectra AA), while the total organic C was measured using Wakley and Black titrimetry. The actual content of organic matter was measured using Muffle furnace (Barnstead (USA) model F62730-33), while the phosphorus (P) content was measured using a UV-Visible Spectrophotometer (Thuramed (USA) model T 60).

2.4 Data analysis

The collected data were analyzed using the analysis of variance (ANOVA) for a randomized complete block design with five replications with the SAS (version 9.0) software package. The comparison of means was carried out by Duncan Multiple Range test at 95% level of probability.

3. RESULTS AND DISCUSSIONS

3.1 Soil properties

Prior to evaluating the influence of treatments on the soil chemical properties, a control sample was first analyzed. The surface soil (0-30 cm) has a texture of loamy sand with a pH of 5.1 (Table-1). The organic matter and N content of the surface layer (0-30 cm) were reported to be 3.7% and 0.13%, respectively. According to Young (1976), organic carbon value of 0.14% for the experimental site was low while total nitrogen and available phosphorus values of 0.13% and 44 ppm, respectively, were moderate. The soil was extremely acidic, with a pH value of 5.1. Generally, the soil was low in exchangeable bases, with potassium value (0.19%) being moderate.

Table-1. Selected soil properties of experimental site.

pH	**O.C** (%)	**O.M** (%)	**N** (%)	**P** (ppm)	**CEC**	**C:N**	**K** (%)	**Mg** (%)	**Ca** (%)	**Sand** (%)	**Silt** (%)	**Clay** (%)	**Textural class**
5.1	0.14	3.7	0.13	44	23	1.07	0.19	0.67	3.9	79.1	11.1	6.1	Loamy sand

3.2. Properties of mungbean residue

Table-2 shows thepH, organic carbon (O.C.), organic matter (O.M.), nitrogen (N), phosphorous (P), C: N ratio, potassium (K), magnesium (Mg) and calcium (Ca) concentration of mungbean residue prior to incubation. Generally, the organic carbon content of the mungbean residue indicated 27% of residue. The organic C levels in the mungbean residues were slightly lower than Honeycutt *et al*. (1993), Woomer *et al*. (1994), and Kuo *et al*. (1997) who established that plant residues have stable carbon content of about 40 % of total weight. The mungbean residue had high accumulation of phosphorus (2440 ppm P) as P is required for pods formation. Nitrogen is a key nutrient substance for microbial growth, and hence has tremendous effect on residue breakdown. Overall, the N content of the residue was high (3.6 %). The high N content of the mungbean residue is attributed to the nitrogen fixation characteristics of legumes (Brady, 1990; Wild, 1994). According to Fox *et al*. (1990) if the N content of the substrate is low (< 20 g/kg), decomposition is slow. The lower C/N ratio of the mungbean residue is expected, for it has the ability of fixing atmospheric nitrogen. White (1987) noted that plant residues of high quality (C/N < 25) lead to faster decomposition than one of low quality (C/N > 25).

Table-2. Chemical characteristics of the mungbean residue used in the experiment prior to incubation.

pH	**O.C**(%)	**O.M**(%)	**N**(%)	**P**(ppm)	**C:N**	**K**(%)	**Mg**(%)	**Ca**(%)
5.2	27	79	3.6	2440	6.75	29.6	11	36

3.3Effect of mungbean residue after different periods of incubation on soil properties

The influence of the incorporation of mungbean residue at different incubation periods on exchangeable Ca, exchangeable K, exchangeable Mg, cation exchange capacity, soil pH, available P, total N, organic carbon, organic matter and C:N ratio are presented in Table-3.

The incorporation of mungbean residue at different incubation periods significantly influence exchangeable Ca, exchangeable K, exchangeable Mg, cation exchange capacity (CEC), available P, organic carbon, organic matter and C: N ratio.

Table-3. Effect of mungbean residue after different periods of incubation on soil properties.

Treatments		Ex.Ca (me%)	Ex. K (me%)	Ex. Mg (me%)	C.E.C (me%)	pH	Ava. P (ppm)	Total N (%)	O.C (%)	O.M (%)	C:N ratio
Control		3.96 cd	0.19d	0.74e	23.40d	5.84a	46.40e	0.162a	0.176 e	2.10f	1.09f
1 week	5%	4.05 bcd	0.19d	1.16d	29.80a	5.18de	48.00 de	0.096bc	0.296 d	2.62 cd	3.61cd
	10%	4.02 bcd	0.20 d	1.32 cd	26.80abcd	5.20de	53.00 cd	0.114b	0.325 cd	2.50d	3.40d
	15%	4.48 ab	0.21d	1.40c	29.00 ab	5.82a	57.20c	0.118b	0.453 b	2.63c	4.75bc
2 weeks	5%	3.80d	0.34ab	2.10b	24.33d	4.94d	107.25 a	0.096bc	0.300 d	2.50d	2.87de
	10%	4.44 abc	0.30bc	2.14b	26.25 bcd	5.34cd	106.40 a	0.102bc	0.335cd	2.60 cd	2.10ef
	15%	4.40 abc	0.29c	2.26 ab	28.00 abc	5.36bcd	106.40a	0.107bc	0.470 ab	2.86b	1.20f
4 weeks	5%	4.03 bcd	0.36a	1.36 cd	23.00d	5.60 ab	70.00b	0.082c	0.396 bc	2.32e	4.72bc
	10%	4.26 abcd	0.34ab	2.12b	24.66 cd	5.72 ab	69.20b	0.086c	0.442 b	2.60 cd	6.33a
	15%	4.70a	0.33ab	2.42a	30.00a	5.58 abc	65.80b	0.102bc	0.528 a	3.13a	4.93b

Different alphabets in the same column show significant difference using Duncan's Multiple Range test ($P \leq 0.05$)

3.3.1 Effect of mungbean residue after different periods of incubation oncalcium, potassium and magnesium content

The Ca content of the soil increased from 3.80% (5% mungbean residue + 2 weeks incubation) to 4.70% (15%mungbean residue + 4 weeks incubation), as shown in Table-3.

The K content in the soil showed significant differences among the treatments. The K content in the soil was the highest at all levels at 4 weeks of incubation and 5% mungbean residue at 2 weeks of incubation (0.36, 0.34, 0.33 and 0.34 %), respectively, while the K content in the soil was lowest in the control and at 1 week of incubation (Table-3).

The application of mungbean residue to the soil significantly increased the content of Mg ($P \leq 0.05$) (Table-3). The highest increase took place at 15% mungbean residue at 4 weeks incubation. The Mg content increased by 227% by the application of 15% mungbean residue at 4 weeks incubation relative to the control.

Green manure plants are known to be excellent at increasing the pH of the soil. Wong *et al*. (1998) reported that this increase was directly proportional to the concentration of base cations (Ca, Mg and K) of the added organic material. Application of lime, organic matter, chemical fertilization and planting of tree and green manure crops are some common approaches for alleviating degraded red soils (Li, 1983). Changes to the soil pH will increase or decrease the ability to uptake nutrients from the soil for the plants. Brun *et al*. (2002) reported that the soil pH heavily influenced the bioavailability of micronutrient. On the other hand, decreased soil pH is dependent upon the intensification of the processes of decay and decomposition of organic matter, nitrification and oxidation of organic compounds in the soil.

3.3.2 Effect of mungbean residue after different periods of incubation on CEC and pH

Among different treatments, there were significant differences in CEC in the soil (Table-3). The highest rate in CEC was in 15% mungbean residue + 4 weeks incubation (30 %) and the lowest CEC was in 5% mungbean residue + 4 weeks incubation (23 %) (Table-3). According to Testa *et al*. (1992), the use of legumes may be able to produce high amounts of waste in order to reduce in leaching of cations and increase in CEC. The cation exchange capacity levels increased due to the application of plant residue, which agrees with Magdoff (1998) and Frempong *et al*., (2006).The incorporation of mungbean residue resulted in decrease pH of the soil. The degradation of vetch materials was assumed to acidify the soil, which agreed with McVay *et al*. (1989), who reported decreased soil pH after 21 days of vetch green manuring. A similar phenomenon was reported by Taye and Yifru (2011).

The introduction of crop residue into the soil as a source of organic matter will temporarily reduce the pH of the soil. Also, the pH of the soil is capable of influencing the bioavailability of metals in the soil. Higher microbial activity and CO_2 release into the soil in the presence of crop residue can also be effective in reducing soil pH. Shahrzad *et al*. (2014) reported that green manure crops (sorghum, sunflower, trifolium and safflower) resulted in the lowest pH of 7.5, 7.4, 7.3, and 7.4, respectively, compared to control treatment at 7.7.

3.3.3 Effect of mungbean residue after different periods of incubation on phosphorus and nitrogen content

The application of mungbean residue significantly increased the available P in the soil (Table-3). The amount of P in the soil increased at all levels (5%, 10% and 15%) at 2 weeks incorporation (107.25 ppm, 106.40 ppm and 106.40 ppm), respectively, while the control treatment reported a lower value (46.40

ARPN Journal of Agricultural and Biological Science

ppm)(Table-3).This suggests that the mungbean residue treatment could enhance the fertility of the soil, which agreed with Kowaljow and Mazzarino, (2007), Courtney and Mullen, (2008), Sommer *et al*. (2011) and Liu *et al*. (2013), all of whom reported that the residue converted to compost increased the Pcontent in the soil.

On the other hand, the total amount of N in the soil decreased compared with the control plot with the application of mungbean residue (Table-3).The lowest total nitrogen (0.082 %) was measured to be 5%mungbean residue + 4 weeks incubation treatment while the highest total nitrogen (0.162 %) was reported by the control. Due to the fact that N is the key nutrient for microbial growth, it is incredibly influential on residual breakdown (Mohammed *et al*., 2014), which is in line with Kaleeem *et al*., (2015), who reported that control treatment after 28 days resulted in the highest total N in the soil, at 30.9 $mg.kg^{-1}$, from *Glycine max* root, *Zea mays* shoot, *Zea mays* root, and *Popluseuramericana* leaves. However, Singh *et al*., (2008), Ogbodo (2011) and Behnam *et al*. (2014) disagreed with this, and reported that the available N in the soil increased with the incorporation of rice, mungbean, cotton, maize, wheat, and alfalfa instead.

3.3.4 Effect of mungbean residue after different periods of incubation on organic carbon, organic matter and C:N ratio

The content of organic carbon in the soil increased from 0.176% (control treatment) to 0.528% (15%mungbean residue + 4 weeks treatment). As pointed out previously, crop residue are regarded as a source of organic matter and are capable of dissolving organic carbon in soil.

Antoniadis and Alloway (2002) pointed out that increasing soil organic matter increased the dissolved organic carbon content of the soil. Diekow *et al*. (2005) reported that higher residue input associated with legume-based cropping systems significantly increased the soil organic carbon content.

The application of mungbean residue (15% mungbean residue + 4 weeks incubation) also increased the organic matter in the soil. Generally, soil receiving mungbean residue reported higher amounts of organic matter compared to those without (control).Most tropical soils under natural conditions have lower levels of organic matter due to high temperatures and precipitation, both of which are factors that accelerate decomposition. The organic matter content might increase from proper management and the incorporation of organic waste. The levels of organic matter in the soil were found to be quite low (Table-3). However, the levels substantially increased at the end of experiment in 15% mungbean residue + 4 weeks incubation treatment. This treatment increased the organic matter by49% relative to the control treatment. Similar results were reported by Kitamura *et al*. (2008) and Carolina *et al*. (2013). Liu *et al.* (2006) also reported the influence of mungbean residue in increasing the organic matter content the soil.

The C:N ratio of all treated soil showed higher C:N ratio in the soil relative to the control treatment. Among all of the treatments, 10%mungbean residue + 4 weeks incubation reported the best result but 10%mungbean residue + 2 weeks incubation and 15%mungbean residue + 2 weeks incubation did not show significant difference compared to the control treatment. Residue treatments increased the degradation induced by soil microorganisms. Moreover, higher stimulating effect on microbial activities resulted in more organic compounds being released into the soil post-degradation (Table-3). These compounds can form complexes with metals in soil (Sing *et al*., 2005).

4. CONCLUSIONS

The use of plant residue as green manure is a promising technology to reduce chemical fertilizers. Therefore, in this study, the effects of mungbean residue during different incubation periods were evaluated in a field experiment. The application of mungbean residue had a positive effect on increment of organic matter content in the soil, organic carbon, CEC, C:N ratio, exchangeable Mg, K, Ca, available P but decreased soil pH and total N. This study suggests that the application of mungbean residue enhances the soil chemical properties. Mungbean can also be used as a soil conditioner to improve its properties. Thus, mungbean crop residue can be used as a possible supplemental source of nutrients to improve the fertility of the soil.

REFERENCES

Antoniadis V. and Alloway B.J. 2002. The role of DOC in the mobility of Cd, Ni and Zn in sewage sludge-amended soils. Environmental Pollution. 117(3): 515-521.

Armin H., Abdollah J., Seyed B.M., Mohammad R. and Naser S. 2013. Effect of green manure on some soil physicochemical characteristics. International Journal of Agronomy and Plant Production. 4(11): 3089-3095.

Behnam K., Akbari F., Teixeira da Silva J.A. and Naeini S.A.M. 2014. The effect of crop residues on soil nitrogen dynamics and wheat yield. Advances in Plants and Agriculture Research. 1(1): 1-7.

Beres I and Kazinczi G. 2000. Allelopathic effects of shoot extracts and residues of weeds on field crops. Allelopathy Journal. 7(1): 93-98.

Biederbeck V.O. 1993. Productivity of four annual legumes as green manure in dryland cropping systems. Agronomy Journal. 85(5): 1035-1043.

Blakemore L.C., SearleP.L., Daly B.K. and Bureau S. 1987. Methods for chemical analysis of soils. New Zealand, NZ DSIR. (NZ Soil Bureau Scientific Report 80).

Brady N.C. 1990. The Nature and Properties of Soils. 10th ed. MacMilian Publ., New York, NY.p 621.

Brun F.G., HernándezI., Vergara J.J., Peralta G. and Pérez- Lloréns J.L. 2002. Assessing the toxicity of ammonium pulses to the survival and growth of *Zosteranoltii* Fernando. Marine Ecology Progress Series. 225: 177-187.

Carolina dos S.B.B., Luis G.A.S. S., Marlene C.A. and Luis E.A.S.S. 2013. Green manure and sewage sludge used to recover the fertility of a degraded oxisol. International Journal of Sciences. 2: 49-57.

Changitny M.H. 2003. Dissolved and water- extractable organic matter in soils: a review on the influence of land use and management practices. Geoderma. 113(3 and 4): 357-380.

Courtney R.G. and Mullen G.J. 2008. Soil quality and barley growth as influenced by the land application of two compost types. Bioresource Technology. 99(8): 2913-2918.

Diekow J.J., Mielniczuk J., Knicker H., Bayer C., Dick D.P. and Ko¨gel-KnabnerI. 2005. Soil C and N stocks as affected by cropping systems and nitrogen fertilisation in a southern Brazil Acrisol managed under no-tillage for 17 years. Soil Tillage Res. 81: 87-95.

Fox R.H., Myers R.J.K. and VallisI. 1990. The nitrogen mineralization rate of legume residues in soil as influenced by their polyphenol, lignin and nitrogen contents. Plant and Soil. 29(2): 251-259.

Frempong M.E., Ofosu - AnimJ. and Blay E.T. 2006. Nutrient supply strategies on growth and yield in okra (*Abelmoschus esculentus*. (L)) Moench. Ghana Journal of Horticulture. 5: 73-81.

Holmgren G.G., Juve R.L. andGeschwender R.C. 1977. A mechanically controlled variable rate leaching device. Soil Science Society of America Journal. 41(6): 1207-1208.

Honeycutt C.W., PotaroLJ., Avila K. L. and Halterman W.A. 1993. Residue quality, loading rate, and soil temperature relations with hairy vetch (*Vicia villosa* Roth) residue carbon, nitrogen, and phosphorus mineralization. Biology Agriculture and Horticulture. 9(3): 181-199.

Kaleeem A.M., TahirM. M., Sabir N. and KhurshidM. 2015. Impact of the addition of different plant residues on nitrogen mineralization-immobilization turnover and carbon content of a soil incubated under laboratory conditions. Solid Earth. 6(1): 197-205.

Kitamura A.E., AlvesM. C., SuzukiL. G.A.S. and GonzalezA. P. 2008. Recovery of a degraded soil with green manure and sewage sludge. Revista Brasileira de Ciência do Solo. 32(1): 405-416.

Kowaljow E. and Mazzarino M.J. 2007. Soil restoration in semiarid Patagonia: Chemical and biological response to different compost quality. Soil Biology and Biochemistry. 39(7): 1580-1588.

Kuo S., Sainju U.M. and JellumE.J. 1997. Winter cover cropping influence on nitrogen in soil. Soil Science Society of American Journal. 61(5): 1392-1399.

Li C.K. 1983. Red Soils of China. Science Press, Beijiang.

Liu C. H., LiuY., FanC. and Kuang S.Z. 2013. The effects of composted pineapple residue return on soil properties and the growth and yield of pineapple. Journal of Soil Science and Plant Nutrition. 13(2): 433-444.

Liu G.S., Luo Z.B., Wang Y., LiH.L., Wang G.F. and Ma J.M. 2006. Effect of green manure application on soil properties and soil microbial biomass in tobacco field. Journal of Soil and Water Conservation. 20: 95-98.

Magdoff F. 1998. Nutrient Management: Sustainable agriculture research and education programme. Bulletin 672, Michigan State University/Extension, Michigan, USA.

Mohammed A.M., NaabJ.B., NarteyE.and Adiku S.G.K. 2014. Carbon mineralization from plant residue amended soils under varying moisture conditions. Journal of Experimental Biology and Agricultural Sciences. 1(7): 491-498.

Mc Vay K.A., Radcliffe D.E. and Hargrove W.L. 1989. Winter legume effects on soil properties and nitrogen fertilizer requirements. Soil Science Society of America Journal. 53(6): 1856-1862.

Ogbodo E.N. 2011. Effect of crop residue on soil chemical properties and rice yield on an Ultisol at Abakaliki, Southeastern Nigeria. World Journal of Agricultural Sciences. 7(1): 13-18.

Pahlavan R., DahmardehK. H. and Narouirad M.R. 2009. Effects of application of different green manure sources in rotation with wheat on wheat yield and soil properties. The Proceedings of the International Plant Nutrition Colloquium XVI, Department of Plant Sciences, UC Davis, USA.

Prasad B. and SinhaS.K. 1995. Nutrient recycling through crop residues management for sustainable rice andwheat production in calcareous soil. Fertilizer News. 40(11): 15-25.

Shahrzad K., Mahmoud K., Khoshgoftarmanesh H., Mehran H. and Majid A. 2014. Effect of Incorporation of Crops Residue into Soil on Some Chemical Properties of Soil and Bioavailability of Copper in Soil. International Journal of Advanced Biological and Biomedical Research. 2(11): 2819-2824.

ARPN Journal of Agricultural and Biological Science

Singh B., Natesan S.K.A., Singh B.K. and Usha K. 2005. Improving zinc efficiency of cereals under zinc deficiency. Current Science. 88(1): 36-44.

Singh K.K., Srinivasarao Ch. and Ali M. 2008. Phosphorous and mungbean residue incorporation improve soil fertility and crop productivity in sorghum and mungbean-lentil cropping system. Journal of Plant Nutrition. 31(3): 459-471.

Sommer R., Ryan J., Masri S., Singh M. and Diekmann J. 2011. Effect of shallow tillage, moldboardplowing, straw management and compost addition on soil organic matter and nitrogen in a dryland barley/wheat-vetch rotation. Soil and Tillage Research. (115-116): 39-46.

Taye B. and Yifru A. 2011. Effect of green manuring in combination with nitrogen on soil fertility and yield of bread wheat (*Triticumaestivum*) under double cropping system of Sinana-dinsho, Southeast Ethiopia. Journal of Biodiversity and Environmental Sciences. 1(1): 1-11.

Testa V.M., TeixeiraL.A.J. and Mielniczuk J. 1992. Chemical characteristics of naPaleudult affected by crop systems. Revista Brasileira de Ciência do Solo. 16: 107-114.

Van Reeuwijk, L.P. 2002. Procedures for soil analysis. International soil references and information, sixth ed. Netherlands.

WalkleyA. and Black I.A. 1934. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science. 37(1): 29-37.

White R.E. 1987. Introduction to the principles and practice of Soil Science. 2nd ed. Blackwell Scientific Publications, Oxford London Edinburg Melbourne. p. 244.

Wild A. 1994. Soils and the environment: An introduction. Cambridge University Press. p. 287.

Wong M.T.F., NortcliffS. and Swift R.S. 1998. Method for determining the acid ameliorating capacity of plant residues compost, urban waste compost, farm yard manure and peat applied to tropical soils. Communications in Soil Science and Plant Analysis. 29(19&20): 2927-2937.

Woomer P.L., Martin A., Albrechit A.R. and Scharpenseel H.W. 1994. The importance of management of soil organic matter in the tropics. In: Woomer PL, Swift MJ (eds.) Biological Management of Tropical Soil Fertility. John Wiley Chichester, UK. pp. 74-80.

Young A. 1976. Tropical soils and soil survey. Cambridge Univ. Press. p. 467.