Research article

Current Conditions and Constraints in Management of Organic Manure in Mid-hills of Eastern Nepal

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Abstract Soil fertility in mid-hills of Nepal has been largely maintained with application of locally made organic manure namely farmyard manure. It is often believed that organic manures in mid-hills of Nepal are of inferior quality, lacking in essential nutrients such as nitrogen, phosphorus and micronutrients due to inadequacy of technical knowledge and management strategies. So, this study focuses on knowing the present conditions and constraints in productions, application of organic fertilizers for agricultural sustainability in mid-hills of Nepal. This study was conducted on the basis of questionnaire survey, interviews, group discussions and field visits in 13 Village Development Community (VDC) of Dhankuta District. Manure samples were tested for their maturity, nutrient content and pathogenicity. The results showed that all the famers in the study area used organic fertilizer in their farm; most of them also used chemical fertilizers, but use of potassium fertilizer was less. Loss of nutrients and heat through runoff or leaching was a major problem as most of the farmers used heap method for composting in open, with improper methods used. Use of starter during composting was negligible. The amounts of organic manure produced increased with the number of livestock owned by the farmer. In general, frequency of application of organic manure corresponded to number of crops cultivated in the year irrespective to maturity of manure. Self-heating test and C/N ratio of manure samples showed that farmers used immature manure resulting in lower mineral content and presence of pathogenic bacteria.

Keywords organic manure, conditions and constraints, maturity, stability, nutrient contents

INTRODUCTION

Agricultural lands rich in soil organic matter are vital in increasing in soil productivity and resilience functions. These functions include increase in soil nutrients, increasing water holding capacity, providing habitat to organism in the soil, reduction in soil erosion and sedimentation. Nepal, being an agricultural country, a significant numbers of farmers in mid-hills uses organic manure in the form of farmyard manure for maintaining and enhancing soil fertility. Maskey et al. (2002) find out that more than 85% of farmers apply farmyard manure or compost in their fields. Farmers have been using indigenous knowledge and techniques for making organic fertilizers using organic matter in the form of forest litter, crop residues etc. collected from neighboring forest and pastures and manures from animals reared by the farmers. In the past, organic fertilizers contributed to the maintenance of a balanced input output of soil nutrients. But, in recent years, with change in cropping pattern, where more cash crops are produced and increase use of chemical fertilizers has resulted in nutrient loss of soil. Gami et al. (2001) and Upadhyay et al. (2005) observed a decline in the soil organic carbon stocks due to changes in land use, intensive cultivation, and poor management of manure. A review by Dahal and Bajracharya (2011) also revealed that in recent years, majority of farmers have switched to conventional usage of chemical fertilizers and intensified cropping systems as much as 3 or 4 crops per year, though a significant of

farmers still rely upon compost or FYM. Use of chemical fertilizers is not sustainable in mid-hills of Nepal where most of the farmers are small scale farmers with low purchasing power as chemical fertilizer are costly with poor accessibility. Moreover, overdependence of inorganic fertilizer causes land degradation and poor soil quality.

Unlike the conventional agricultural practices that often lead to impoverishment of soil quality and reduced productivity of lands, sustainable soil management practices such as using farmyard manure and compost should be adopted by farmers for sustainable development of agriculture in mid-hills of Nepal. But, with current scenario of low quality of organic fertilizers, it is necessary to understand what factors are prevailing.

This study focuses on different factors, condition and constraints existing in organic manure production, application and management to understand the maturity, nutrient contents and pathogenicity of organic fertilizers so that the problems are outlined for better future management.

METHODOLOGY

Site Description

This study was conducted in 11 VDC (Village Development Committee) and 2 municipalities of Dhankuta District (Fig.1). These areas were chose on the basis of agricultural land area, population engaged in agriculture and agricultural productivity importance. The topography of Dhankuta District is hilly with minimum elevation at 120 m to highest at 2,702 m. Dhankuta District is a major agricultural region with more than 83.45% of people engaged in agriculture whereas the national average is 65.6%.

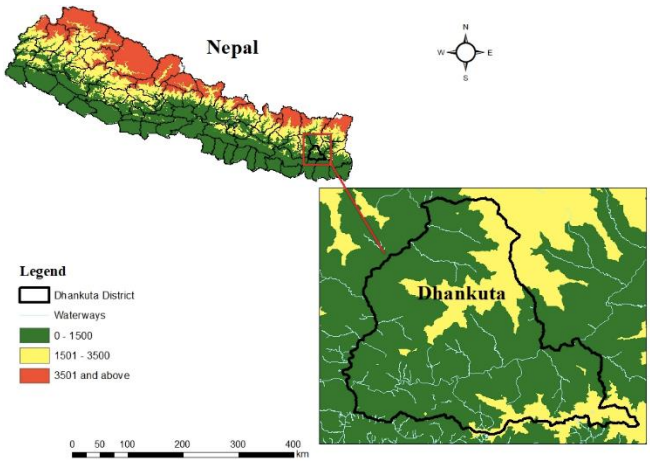

Fig. 1 Map of study area

Household Interviews

Interviews were conducted in 11 VDC and 2 Municipalities' of Dhankuta District. Total of 102 farmers were selected for the interview using simple random method. To minimize the errors due to possible lack of knowledge in managing the fields, only those farmers who owned the field were interviewed excluding farmers working in rented fields. Questionnaire was designed to understand farmers` knowhow in making organic manure, types of fertilizer used, application amount and effects of fertilizers on productivity and soil structure. The results of questionnaire survey are qualitatively analyzed based on the answers and group discussions with the farmers.

Maturity Test of Organic Manure

A total of nine samples of farmyard manure were sampled from various locations in the study area for testing its maturity and stability. The samples collected were more than a year old and ready to use according to the local farmers. The samples were subjected to self-heating test using Dewar's vessel where water content of samples were maintained at 50-60%, as dryness can limit microbial activity. The Dewar self heating test was first introduced in Europe in 1982 (Jourdan, 1982) and is widely used for measuring maturity and stability of compost as it is easy to use and interpret the results. Self-heating is important because it drives the compost process, and regardless of other traits, the presence of heat in compost is widely held to be a sign of immaturity (Gallenkamper et al., 1993). Composts are commonly recognized to have three states or potentialities; cured, mesophilic and thermophilic. Therefore, maturity of compost can be divided into three categories (Table 1). C/N ratio, which is often used for determining the maturity of organic manures, was conducted for the samples using combustion method by N/C coder.

Table 1 Interpretation of result for self-heating test

Rise of temp. over ambient (° C)	Actual temp. in vessel (° C)	Class of stability	Interpretation
0-5	20-25	A	Matured, cured
5-25	25-45	B	Mesophilic, active
25-50	45-70	C	Thermophilic, very active

Source: 2005-2009 Wood End Laboratory Inc.

Nutrient Test of Organic Manure

The value of compost is determined by its ability to provide soil with organic matter and soil macronutrients nitrogen, phosphorus and potassium. Soils, which have deficiency in these essential nutrients have low fertility, affecting the productivity. Organic carbon and nitrogen content of manure samples were determined by combustion method using N/C coder, phosphorus by absorption spectroscopy and potassium by LAQUA twin potassium ion meter B-731.

Pathogenicity Test for *Escherichia coli*

Pathogenicity test were conducted using Petan check 25 ESCM from EIKEN Chemicals for analyzing the presence of *E. coli* in manure samples. Three replicates of each sample were tested. The plates were put in incubator at 24° C for a period of 48 hours. Presence of pink and blue colonies showed the presence of *E. coli* in the sample. The colonies were counted and categorized into various order of pollution according to the number of colonies detected.

RESULTS AND DISCUSSION

Information on Land Area and Livestock Owned

Sixty three percent of the farmers in the area were small-scale farmers with less than 0.5 ha of land owned and cultivated, which is less than national average of 0.8 ha. Thirty three percent of farmers had land area in between 0.5 to 1.5 ha. Only four percent were large-scale farmers with land area more than 1.5 ha. (Table 2).

With 5.8 heads of livestock and poultry per household, Nepal has one of the highest density of livestock per unit area cultivated area in upland parts of world (Sharma and Subedi, 1994). Livestock plays an important role in Nepalese agriculture, providing farmer with manure, fuel for household, protein source for consumption and income source with sale of livestock products. Livestock accounted were big animals like cow, buffalo; medium animals like goat, sheep and small animals like hens and chicken. Generally, large-scale farmer had more number of livestock

with medium scale and small-scale farmers having comparatively less (Table 2). The results of questionnaire survey showed that the amount of manure produced corresponded to the numbers of animals owned. Also, applications of manure corresponded to number of plantation, irrespective of maturity and stability of it.

Table 2 Area of cultivated land and animals owned

	Small scale farmer (Less than 0.5 ha)	Medium scale farmer (0.5 to 1.5 ha)	Large scale farmer (More than 1.5 ha)
Farmer percentage	63%	33%	4%
Livestock per farmer	15	17	34

Note: Number of respondent =102 farmers. Total number of animals =1662.

Information on Use of Fertilizer and on Production and Application of Organic Manure

Farmers indicated using conjunction of farmyard manure (FYM) and chemical fertilizer as a major supplement for managing soil fertility. Farmers are using chemical fertilizer with FYM as they feel that only FYM cant increase the productivity. The use of chemical fertilizer in the context of mid-hills of Nepal is unsustainable as chemical fertilizer is not accessible easily due to lack of infrastructure like roads and high price. Farmers are using N, P fertilizers but application of K fertilizer was negligible. Farmers for making farmyard manure used indigenous method and lacked training. Table 3 shows the amount of FYM applied, application rate, frequency, method used and preparation period and use of starter. Most of the farmers applied manure twice or more times a year according to the number of plantation. Farmers preferred to heap method than pit method as construction of pit required money and labor. Also, almost all the compost piles were in open, without any cover making it susceptible to loss of heat and nutrients. Due to deforestation and lack of fodder for the livestock, the quality and the quantity of farmyard manure have decreased. The improper handling and making of farmyard manure has resulted in loss of nutrients. Shrestha et al., (2009) suggested that soil fertility is largely maintained through the application of compost and manure but in recent years a decline in soil fertility has been reported. Also, improper handling of manure can lead to environmental and health problems through surface runoff or leaching of nutrients and pathogenic microorganism (Ishikawa et al., 2012).

Table 3 Types, application rate, frequency, method used, time period and use of starter for composting manure

Types of fertilizer used	Application rate of manure	Frequency	Method	Time period for composting	Use of starter
Organic manure (10%)	< 2.5 t/ha (55%)	1/year (16%)	Heap method (61%)	3-6 months (31%)	Yes (2%)
Organic manure and fertilizer (90%)	2.5-5 t/ha (25%)	2/year (54%)	Pit method (35%)	6-9 months (50%)	No (98%)
Only fertilizer (none)	5 t/ha (20%)	3 or more/year (30%)	Others (4%)	9 months and above (19%)	-

Note: Number of respondent =102 farmers.

Farmers' Perception on Productivity and Change in Soil Structure with Application of Organic Manure and Chemical Fertilizer

Figures 2 and 3 shows the farmers' response to productivity with application of organic manure and chemical fertilizer respectively. Seventy eight percent of the farmer have the perception that application of organic manure, there was increase in productivity, with twenty two percent of farmer saying there was no change. On the other hand, eighty eight percent of the farmer thinks that productivity has increased with application of chemical fertilizer; with twelve percent of farmer answering there was no change. This perception of farmers' can be explained on the fact

that organic manure takes longer period to increase soil fertility of the soil, but long-term application of organic manure has positive effect in soil properties such as fertility, structure, and water holding capacity etc. Whereas chemical fertilizer can increase productivity in shorter period, but long-term application can adversely effect soil properties which can be seen in Figs. 4 and 5 which shows farmers' response to change in soil structure with application of organic manure and chemical fertilizer. Seventy percent of the farmer responded with application of manure, soil had softened. Whereas, fifty four percent of farmer replied soil had hardened with application of chemical fertilizer.

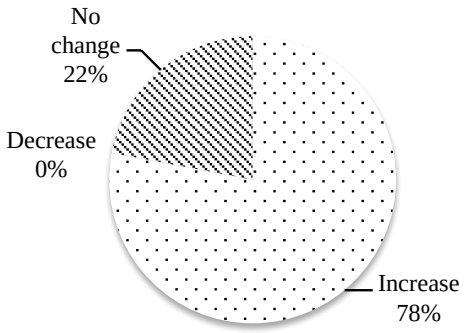

Fig. 2 Farmers' response to productivity with manure application

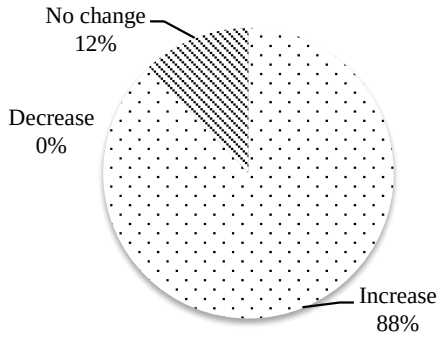

Fig. 3 Farmers' response to productivity with chemical fertilizer application

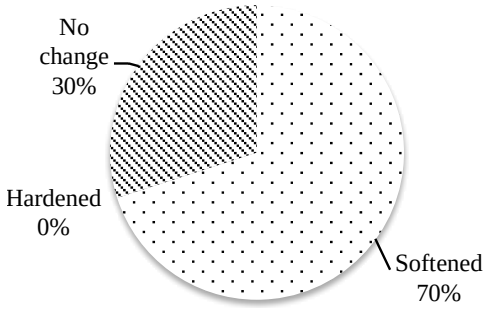

Fig. 4 Farmers' response to change in soil structure with manure application

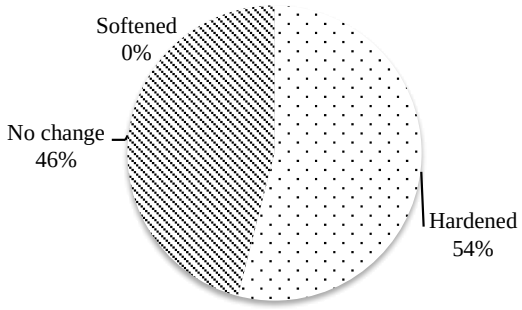

Fig. 5 Farmers' response to change in soil structure with fertilizer application

Maturity of Manure

Biological stability of organic manure is an important aspect of composting because of its effect in utilization in agriculture. Immature and poorly stabilized composts may pose problems during use and storage. Immature composts may contain high amounts of free ammonia, certain organic acids or other water-soluble compounds, which can limit seed germination and root development. Result of maturity test showed (Table 4) all the sample was classified into active or immature compost. C/N ratios of starting material, temperature and moisture content are some of the factors, which can affect the maturity of compost. In the research area it was seen that farmers were not aware of these factors.

Table 4 Results of maturity test

Sample name	Ambient temp. (° C)	Actual temp. in vessel (° C)	Water content maintained at	Class of stability	Interpretation of result
Sample 1 to 9	15±2	25-45	50-60%	B	Mesophilic, active compost

Note: Refer table 1 for interpretation of result.

C/N of Manure

One of the most important aspects of the maturity and total nutrient balance is the ratio of organic carbon to total nitrogen. A C/N of about 25-30 is considered optimum for starting material as microorganism utilizes about 30 parts of carbon to 1 part of nitrogen during metabolism. The result of C/N of the samples is shown in the table 5. The entire sample has C/N ranging from 17 to 12. C/N value from 15 to 20 is considered favorable for compost. But, in the case of cow manure starting C/N may be lower than 20. According to Golueke, (1977), C/N of cow manure is 17. If C/N is lower than 20, loss of nitrogen through ammonia volatilization occurs, reducing the nitrogen content of final product. This process is enhanced by high pH and temperature and is seen during the first two weeks of composting. C/N of starting material should be considered and planned before starting composting as both high C/N and low C/N have adverse effect on the final product of compost, which can hamper soil fertility and plant growth.

Table 5 Results of C/N of samples

Sample name	Sample no.1	Sample no.2	Sample no. 3	Sample no. 4	Sample no. 5	Sample no. 6	Sample no. 7	Sample no.8	Sample no. 9
C/N	12±0.02	13±0.1	14±0.03	17±0.1	16±0.06	13±0.002	13±0.002	12±0.03	14±0.1

Note: Values are mean ± SD (n=3).

Pathogenicity of Manure

The function of organic manure is to provide soil with essential nutrients and be environment friendly, free of pathogenic microbes namely coliform bacteria. Using manure, which contains pathogenic bacteria can cause health and environmental problems. The test of pathogenicity for the sampled manure is shown in table 6. Sample 1 and 2 had moderate pollution, whereas all samples from 3 to 9 were categorized in high pollution category. This result can be attributed to the fact that the samples were not completely matured as shown in self-heating test. Also, as most of the composting is done in open areas without any cover, which increases the possibility of loss of heat generated during composting process. Pathogenic bacteria are killed if heat is around 60 °C for a period of 2 weeks.

Table 6 Results of pathogenicity test

Sample name	No. of colonies	Judgment	Evaluation of degree of pollution
Sample 1 to 2	60-200	++	Moderate pollution
Sample 3 to 9	More than 200	+++	High pollution

Note: Where, no colonies (-) is no pollution, less than 20 colonies (±) is very low pollution, 20- 60 colonies (+) is low pollution, 60-200 colonies (++) moderate pollution, more than 200 colonies (+++) high pollution, uncountable colonies (++++) very high pollution. Source: ES no. 14, Aug- 1999.

Nutrient Content of Manure

The evaluation of agronomic values of manure is depends on the amount of organic carbon and macronutrients available to the plants. Table 7 shows the results of total carbon, total nitrogen, total phosphorus and potassium present in the sampled manure. The total carbon % ranged from 18.9% to 47.6%. These result is in agreement with Batjes, 1996 who found that the optimum value of total organic carbon higher than 10%. The high value of carbon content might be also be the result of slow decomposition of carbon, which depends on various factors like climate, organic matter types and microbial metabolism. The total nitrogen present in the manure samples was between 12250 to 27900 mg/kg, which coincides with the average value 25000 mg/kg in mid-hills of Nepal (Tripathi and Jones, 2003). The total phosphorus in the samples were in the range between 1354 to 6310

mg/kg which is less than average value for finished compost which ranges from 6000 to 20000 mg/kg. The value of potassium was in between 150 to 1200 mg/kg, which is less for finished cow compost. Irshad et al., 2013, suggested finished cow compost has around 9000 mg/kg of potassium. The low nutrient content of manure may be due to methods used for composting. Heap method, which is widely practiced, is done in open, which is susceptible to low nutrient content as maintained by Tripathi and Jones (2003).

Table 7 Results of nutrient content

Sample name	Carbon %	Total N (mg/kg)	Total P (mg/kg)	K (mg/kg)
Sample no. 1	22.8±0.03	19400±5.8	3707±7.5	1093±0.0
Sample no.2	27.2±0.06	21000±5.7	5103±32.4	1040±28.1
Sample no.3	18.9±0.02	13250±10.0	1383±30.1	274±5.8
Sample no.4	47.6±0.03	27900±15.3	5820±3.5	150±0.6
Sample no.5	19.0±0.06	12250±5.7	1354±26.2	486±5.8
Sample no.6	30.5±0.01	23790±5.8	5083±32.08	590±5.8
Sample no. 7	25.4±0.03	18980±10.0	6310±10.71	576±10.0
Sample no.8	19.9±0.03	17120±10.0	3525±27.74	970±17.1
Sample no.9	26.2±0.04	19000±5.7	5028±30.24	1200±0.0

Note: Values are mean ± SD (n=3).

CONCLUSION

This study discusses the present conditions and constraints in management of organic manures in mid-hills of Nepal. The result of household interview showed that farmers were using farmyard manure and chemical fertilizer. There was rise in use of chemical fertilizer as farmer felt that only organic manures are insufficient for increasing productivity. Farmers were aware of drawbacks of using chemical fertilizer, but due to low fertility of manure, there was increase use of chemical fertilizer. The methods and immature manure used can be cause of low fertility content of manures. Results of immaturity of sampled manures, supports the above cause. Imbalance of C/N may have resulted in low C/N. C/N of starting material can be increased or decreased as per the conditions with increase of carbon or nitrogen sources. Heat loss during composting and immaturity of manures might be the reason for high pathogenicity. The results of carbon and nitrogen content showed satisfactory results, whereas phosphorus and potassium were low. It should be noted that as manures are kept in open, there is possibility of nutrient loss through runoff and leaching. Better composting methods such as using a cover during composting can reduce loss of heat and nutrient. Using a starter can help in better decomposition and elimination of pathogenic bacteria. Knowledge and training on manure maturity should be taught to farmer to change farmers' perception on manure maturity.

REFERENCES

Batjes, N.H. 1996. Total carbon and nitrogen in the soils of the world. European Journal of Soil Science, 47, 151-163.

Dahal, N. and Bajracharya, R.M. 2011. Prospects of soil organic carbon sequestration; Implication for Nepal's mountain agriculture. Journal of Forest and Livelihood, 9, 1-14.

Gallamkamper, B., Becker, G. and Kohler, A. 1993. Criteria for judging the decomposition of biowaste compost. Conference Report, Ministry for Research and Development (BMFT), 22-23 Nov.1993, Hamburg.

Gami, J., Ladha, J., Pathak, H., Shahi, M., Pandey, S., Joshi, D. and Mishra, R. 2011. Long term changes in yield and soil fertility in twenty year rice, wheat experiment in Nepal. Biology and Fertility of Soils, 34,73-78.

Golueke, C.G. 1997. Biological reclamation of solid waste. Rodale Press Inc. Emmans Pennyslvania, USA.

Irshad, M., Eneji, A.E., Hussain, Z. and Ashraf, M. 2013. Chemical characteristics of fresh and composted livestock of manures. Journal of Soil Science and Plant Nutrition, 13 (1), 115-121.

Ishikawa, Y. and Mihara, M. 2012. Changes in *Escherichia coli* efflux from farmland by surface runoff and percolation under different application methods of manure. International Journal of Environmental and Rural Development, IJERD, 3 (2), 188-192.

Jourdan, B. 1982. Standardizing selected methods for determining the degree of decomposition of municipal composts. Abfall Wirtschaft Forschungsbericht. Univ. Stuttgart.

Kaneko, S. 1999. Analysis of presence of microbes in food processing with Petan check (Stamp procedure). E.S. No. 14.

Maskey, S., Shrestha, R.K., Shrestha, B., Tripathi, B.P., Bhattarai, E.M., Munakarmy, B.C. and Khadka, Y.G. 2002. Strategies for soil fertility research in the hills of Nepal. Soil Science Division, Nepal Agricultural Research Council; DFID Nepal/Hill Agriculture Research Project, Kathmandu, Nepal.

Sharma, H.B. and Subedi, T.R. (Eds.), 1994. Nepal district profile. National Research Associates, Shirhu Siddhartha Press, Kathmandu, Nepal.

Tripathi, B.P. and Jones, J.E. 2003. Improving manure quality and its use in maize and upland rice production in the hills of western Nepal. Agricultural Research for Enhancing Livelihood of Nepalese People, Proceedings of 2nd SAS-N Convention, 30 July - 1 Aug. 2003, Kathmandu.

Upadhyay, T.P., Sankhayan, P.L. and Solberg, B. 2005. A review of carbon sequestration dynamics in the Himalayan Region as a function of land-use change and forest/soil degradation with reference to Nepal agriculture, ecosystem and environment. 105, 449-465.

Woods End Laboratory INC. 2009. Application of Dewar self-heating test to measure completion of compost.