Integrated Nutrient Management and Continuous Cropping on Important Physical Properties of Soil in Terraced Land

Manoj Dutta* and Vizokhonyu Yhome

Department of Soil Conservation, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus, Medziphema, Nagaland (797 106), India

Article History

Manuscript No. 313
Received in 30th April, 2012
Received in revised form 25th August, 2012
Accepted in final form 6th September, 2012

Correspondence to

**E-mail*: manojdutta1997@yahoo.com

Keywords

Terraced land, integrated nutrient management, soil physical properties

Abstract

Twelve treatments involving N, P and K (NPK) fertilizers, farmyard manure (FYM), poultry litter, forest litter, *Azospirillum* and Zn either alone or in various combinations were applied continuously for nine years to evaluate the effect of integrated nutrient management practices on important soil physical properties in a terraced land. The percent aggregates >0.25 mm and mean weight diameter (MWD) increased significantly in all the treatments whereas, water holding capacity (WHC) and hydraulic conductivity increased significantly in all the treatments except ½N + PK and Forest litter burned + ½ FYM over control. The bulk density in NPK + FYM, NPK + Poultry litter, NPK + Forest litter and NPK + FYM + Zn decreased significantly (6.2, 4.6 5.4, and 10.0%, respectively) as compared to addition of NPK alone. Addition of FYM, poultry litter and forest litter with NPK increased 9.8, 16.7 and 5.1% in aggregates >0.25 mm, respectively as compared to NPK alone. Increase in MWD in different nutrient management practices ranged from 54.4 to 163.6%. The integrated application of poultry litter or FYM along with NPK was more effective in enhancing MWD.

1. Introduction

Bench terracing is one of the most reliable conservation measure frequently employed to manipulate surface topography of hill slopes suited to intensive agriculture. Sound fertility management practices are obviously needed to ensure a steady improvement in soil fertility together with other soil physical properties congenial for plant growth and to have long-term enhanced productivity. Soil organic matter is a management sensitive soil property and an important soil quality determinant as it affects soil fertility and plant growth conditions as well as environment quality parameters by influencing a number of physical, chemical and biological properties of the soil (Chauhan et al., 2008). The impact of integrated nutrient management practices and continuous cropping on important soil physical properties on terraced land in Nagaland has not been studied. The present investigation was carried out to evaluate the effect of integrated nutrient management practices and continuous cropping on some important soil physical properties in a terraced land under rain-fed conditions of Nagaland. The results of this investigation would help in formulating proper nutrient management practices on terraced land.

2. Materials and Methods

A hill slope (22%) was bench terraced in 2001 at the institutional farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema, Nagaland, India. Three numbers of bench terraces, 26.0 m long and 3.5 m wide were constructed manually. A field experiment on these terraces was established in 2001 and has been maintained since then. The climate of the experiment site is sub-humid tropical. The soil samples collected in *kharif* 2009 after following nine years of integrated nutrient management and continuous cultivation of upland rice forms the basis of this investigation.

The experiment was laid out in Randomized Block Design with twelve treatments, replicated thrice in plots of 2.0 × 3.0 m^2 size separated by a bund of 15 cm. A border of 25 cm along the riser was left. During each year, the plots were manually prepared to ensure fine tilth of soil. The recommended dose of 60 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1} for rice was applied through urea, single super phosphate and muriate of potash. The farmyard manure (FYM), poultry litter and forest litter were applied @ 10.0 t ha^{-1}, 3.3 t ha^{-1} and 5.0 t ha^{-1}, respectively. For ½ N (30 kg ha^{-1}) through FYM, poultry litter and forest litter, calculated amounts of these organic sources containing 0.5,

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1.5 and 0.1% N, respectively were applied (6.0, 2.0 and 30.0 t ha^{-1}, respectively) to the soil. Zinc (Zn) was applied @ 10 kg ha^{-1} in the form of $ZnSO_4.7H_2O$ as basal dose. *Azospirillum* biofertilizer was used as seed treatment @ 20 g kg^{-1} of seed. For forest litter burned + ½ FYM treatment that resembles farmers' practice in Nagaland, forest litter @ 5.0 t ha^{-1} was evenly spread on the soil surface and burned. The ash was incorporated thoroughly into the soil. The FYM, poultry litter and forest litter were applied one month before sowing according to the treatments and mixed well in the soil. Upland rice variety Teke (landrace) was sown with a spacing of 20 cm row to row using a seed rate of 75 kg ha^{-1}.

Soil samples from individual plots were collected after the harvest of rice crop and air dried at room temperature. Two third of each samples were ground to pass through 2 mm sieve and stored for analysis. The remaining portion of soil samples was preserved for analysis of specific soil properties. Undisturbed core soil samples were also collected for determination of bulk density and hydraulic conductivity of the soil.

Water holding capacity (WHC) was determined as per the procedure outlined by Piper (1966). Saturated hydraulic conductivity was calculated from Darcy's equation as described by Baruah and Barthakur (1997). Aggregate stability in terms of mean weight diameter (MWD) and percent macro-aggregates were calculated by using the equation given by Van Bavel (1949). The statistical analysis of the data was done as per procedure outlined by Gomez and Gomez (1984).

3. Results and Discussion

3.1. Bulk density

The bulk density of soil ranged from 1.16 to 1.33 g cm^{-3} with an average of 1.25 g cm^{-3} (Table 1). After nine years of following integrated nutrient management and continuous cropping the bulk density in NPK + FYM, NPK + Poultry litter, NPK + Forest litter and NPK + FYM + Zn showed a significant decrease over NPK. The bulk density in ½N + PK + ½N through forest litter and ½N + PK + ½N through FYM was significantly lower as compared to ½N + PK + ½N through poultry litter and NPK treatments.

The decrease in bulk density over control in different treatments ranged from 1.5 to 12.8% with an average of 7.0%. The significant decrease in bulk density in NPK + FYM, NPK + poultry litter, NPK + forest litter and NPK + FYM + Zn over NPK was 6.2, 4.6, 10.0 and 5.4%, respectively. The decrease in bulk density in ½N + PK + ½N through forest litter, ½N + PK + ½N through FYM and ½N + PK + ½N through poultry litter over NPK was 10.8, 9.2 and 3.8%, respectively. Bajpai et al. (2006) also reported that application of green manure, FYM or crop residue as a substitute of N reduced the bulk density significantly.

3.2. Water holding capacity (WHC)

Water holding capacity of the soils varied from 39.5 to 54.6% with an average of 46.6% (Table 1). The WHC in all the treatments increased significantly except in ½N + PK, and Forest litter burned + ½ FYM treatments over control. The WHC in NPK + Forest litter, NPK + FYM + Zn, NPK + FYM and NPK + Poultry litter increased significantly as compared to NPK. The increase in WHC was maximum in ½N + PK + ½N through forest litter over all other treatments. The WHC in ½

Table 1: Effect of various nutrient management practices on soil physical properties

Treatment No. and particulars	Bulk density (g cm^{-3})	WHC (%)	Hydraulic conductivity (cmhr^{-1})	Aggregates> 0.25 mm (%)	MWD (mm)
Control	1.33	39.5	2.2	52.7	1.1
½N + PK	1.31	43.2	2.4	58.4	1.7
NPK	1.30	44.1	2.5	64.5	1.9
NPK + FYM	1.22	48.8	3.0	70.8	2.6
½N + PK + ½N FYM	1.18	46.1	2.8	69.2	2.3
NPK + Poultry litter	1.24	48.1	2.7	75.3	2.9
½N + PK + ½N Poultry litter	1.25	47.9	2.7	72.2	2.8
NPK + Forest litter	1.17	49.3	3.0	67.8	2.2
½N + PK + ½N Forest litter	1.16	54.6	3.2	72.7	2.6
½N + PK + Azospirillum	1.28	46.2	2.6	67.9	2.1
NPK + FYM + Zn	1.23	49.2	2.9	71.5	2.9
Forest litter burned + ½ FYM	1.27	42.5	2.4	65.1	1.8
SEm±	0.02	1.27	0.09	1.76	0.11
CD (p=0.05)	0.05	3.74	0.27	5.18	0.33

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N + PK + ½N through poultry litter, ½N + PK + ½N through FYM and ½N + PK + *Azospirillum* also increased significantly over NPK and ½N + PK treatments.

The increase in WHC over control in different treatments ranged from 7.6 to 38.2% with an average of 19.7%. Addition of NPK + Forest litter, NPK + FYM + Zn, NPK + FYM and NPK + Poultry litter caused significant increase of 11.8, 11.6, 10.7 and 9.1%, respectively in WHC as compared to addition of NPK. The increase in water holding capacity of the soil with integrated application of inorganic fertilizers and organic sources might be related to both the increase in organic matter content of the soil and consequently improvement in its physical properties. Singh et al. (2006) and Laxminarayana (2006) also reported that the application of organic manures either alone or in combinations with inorganic fertilizers progressively improved the water holding capacity of the soil.

3.3. Hydraulic conductivity

The hydraulic conductivity of soil increased in all the treatments except in ½N + PK, and Forest litter burned + ½ FYM treatments over control (Table 1). Incorporation of forest litter and FYM along with NPK recorded significantly higher hydraulic conductivity as compared to only NPK application. Substituting ½ N through FYM or forest litter also brought about a significant enhancement in hydraulic conductivity over NPK application. This significant increase in hydraulic conductivity in these treatments over NPK treatment might be due to increase in organic matter content and resultant increase in porosity of the soil. Similar observations were also made by Bellakki et al. (1998). Babhulkar et al. (2000) also reported that the bulk density of soil under combined application of inorganic fertilizers and FYM decreased as compared to other treatments resulting in significant improvement in hydraulic conductivity.

3.4. Percent aggregation

The aggregates >0.25 mm of the soil ranged from 52.7 to 75.3% with an average of 67.3% (Table 1). The addition of NPK or ½N + PK either alone or with organic sources in all combinations continuously for nine years brought about a significant increase in percent aggregates>0.25 mm as compared to control. Addition of NPK with FYM or poultry litter caused a significant increase in percent aggregates>0.25 mm as compared to NPK. Substituting ½ N through poultry litter or forest litter also brought about a significant increase in percent aggregates>0.25 mm over NPK. The increase in percent aggregates>0.25mm over control in different treatments ranged from 10.8 to 42.9% with an average of 30.3%. The increase in percent aggregates in NPK + Poultry litter, NPK + FYM + Zn, NPK + FYM and NPK + Forest litter over NPK was 16.7, 10.9, 9.8 and 5.1%, respectively.

The data established that addition of NPK fertilizers with FYM or poultry litter improved aggregation relatively more than addition of NPK with forest litter. The higher aggregation in these treatments might be due to higher organic matter content resulting from application of organics in these treatments that together with clay and other soil constituents favour particle aggregation. These findings are in accordance with the findings reported by Bellakki et al. (1998). Selvi et al. (2003) also reported that application of FYM along with NPK fertilizers caused significant increase in the water stable aggregates.

3.5. Mean weight diameter (MWD)

The MWD of soil ranged from 1.1 to 2.9 mm with an average of 2.2 (Table 1). The MWD of soil in all the treatments showed a significant increase over control. The highest MWD was recorded in NPK+ Poultry litter and NPK + FYM + Zn treatments and the lowest was in control. Addition of NPK with FYM and poultry litter caused a significant increase in MWD as compared to NPK alone. Substituting ½ N through poultry litter, forest litter or FYM also resulted in a significant increase in MWD as compared to NPK. The increase in MWD over control in different treatments ranged from 54.4 to 163.6% with an average of 113.2%. The significant increase in MWD in NPK + FYM, NPK + Poultry litter, NPK + FYM + Zn, ½N + PK + ½N through FYM, ½N + PK + ½N through poultry litter and ½N + PK + ½N through forest litter treatments was 36.8, 52.6, 52.6, 21.1, 47.4, and 36.8% higher over NPK, respectively. The higher MWD in these integrated treatments might be due to higher percent aggregates in these treatments as compared to NPK. These findings are in accordance with the observations reported by Dutta and Sarma (2004).

4. Conclusion

An in-depth analysis of data revealed that integrated nutrient management practices on an average, increased MWD the most followed by macro-aggregates, hydraulic conductivity and WHC. Further, as these soil properties are management sensitive, their improvement with time in terraced land could be achieved under different integrated nutrient management practices.

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