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Soil quality parameters and carbon stock as influenced by fodder grasses and organic amendments in an alfisol of northeastern India

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Introduction

Intensive tillage, cultivation along the slope, low input, minimal nutrient replacement and high rainfall are among major causes of land degradation in the north eastern hill (NEH) region (Ghosh *et al*. 2009). Maintaining and enhancing soil quality are crucial to sustaining agricultural productivity and environmental quality (Lal, 2004). Continuous cropping, without use of conservation-effective measures, has negative effects on the soil and environment (*e.g*., loss of SOC, soil erosion, water pollution). Thus, soil management methods are needed that enhance use efficiency of inputs, reduce losses and minimize adverse impacts on the environment (Bilalis *et al*. 2009). Perennial grasses provide year- round ground cover, which reduces run-off and soil erosion from sloping land (Ghosh *et al*. 2009).
Cultivation of forages in degraded and sloping lands not only supply green palatable fodders to livestocks but also rehabilitates the degraded soils by improving physico-chemical properties. Forages have strong root systems compared to field crops (such as rice, maize *etc*.), protect soil and improve aggregation (Ghosh *et al*. 2009). Soils under perennial grasses and those which are undisturbed for a long time are potential C sinks because the grasses add organic matter (OM) to soils through root growth, and decline in OM decomposition because of lack of tillage. Further, conversion of degraded cropland soils to forages and perennial grasses lead to C sequestration (Grandy and Robertson, 2007).

Thus, present investigation was conducted with the objective to assess the impact of perennial forage grasses and organic amendments on soil properties and C-sequestration potential.

Materials and Methods

Field experiments were conducted at the experimental farm of Indian Council of Agricultural Research (ICAR), Research Complex for NEH region, Umiam, India for three consecutive years (2008-2011). The experiment was sited at 25°41'21″ N and 91°55′25″E, with an altitude of 980 m a.s.l. The site receives an average annual rainfall of 2349 mm. Soil of the experimental site is well drained, and classified as *Typic Paleudalf* (silty clay loam). The soil was severely degraded as evidenced by the presence of gravels on the surface. The available N, P and K contents at initiation of the present study were 218.6, 16.27 and 235.5 kg/ha. The pH and SOC concentrations were 5.4 and 15.2 g/kg, respectively.
Four forage grasses (broom grass, congosignal grass, hybrid napier and guinea grass) were grown under three nutrient sources [control (grown with inherent soil fertility), organic manure and inorganic fertilizers] in a factorial randomized block design. Forage grasses were planted at a spacing of 90 x 50 cm for broom grass and 75 x 50 cm for other three grasses. Recommended doses of nutrients were 80: 60: 40 kg/ha N, P_2O_5 and K_2O, respectively. During first year, full dose of P and K along with 50% N was applied before planting the grass slips in first week of May. Remaining 50% applied in two equal splits in first week of July and mid-august. From second year onwards, 30% N along with full P and K were side dressed during mid-May after a weeding before onset of monsoon. The reaming 70% was applied in three equal splits (for broom in two splits) after each cutting. Farmyard manure (FYM) was applied on the basis of N-equivalent, and the P requirement was supplemented through the input of rock-phosphate in case of organic sources of nutrient supply. Four cuttings of forages were taken each year beginning in May, and at an interval of 50-60 days, and the green fodder yields were recorded. In case of broom grass, only 3 cuttings were taken annually. Weeding was done after every harvest and the weed biomass was retained as in-*situ* mulch. Soil samples were obtained from each plot for 0 -15 cm for physico-chemical and biological parameters.

Results and Discussion

Results revealed that green fodder yield increased in each successive year and 3-year average green fodder yield was significantly higher with hybrid napier (133.6 Mg/ha) than other grasses (Table 1). Among nutrient sources, the average green fodder yield under organic amendment (105.2 Mg/ha) was 19 % and 45 % higher than that under inorganic fertilizer (88.3 Mg/ha) and control (72.3 Mg/ha), respectively. The available N, P, K and soil organic carbon (SOC) contents were significantly higher under organic compared to those under other nutrient sources. The SOC concentration (17.2 g/kg) and stock (32.2 Mg/ha) after 3-years under organic treatment was 5.3 and 2.1% and 13.3 and 8.1 % higher than that recorded under inorganic and control, respectively (Table 1). Soil microbial biomass carbon (SMBC) was significantly higher under organic compared to control and inorganic.

Table 1. Green fodder yield and soil quality parameters as influenced by treatments (3 years pooled data)

Fodder crops	**Green fodder yield (Mg/ha**	**Bulk density (Mg/m^3)**	**Soil microbial biomass carbon (µg/g soil)**	**SOC (g/kg)**
Broom grass	19.0	1.27	211	16.2
Congosignal grass	96.5	1.25	223	16.4
Hybrid napier	133.6	1.24	235	16.7
Guinea grass	105.3	1.25	224	16.4
SEm (±)	2.65	0.02	6.38	0.5
CD (*p*=0.05)	7.96	NS	NS	NS
Nutrient sources				
Control	72.3	1.27	204	15.5
Organic	105.2	1.22	240	17.2
Inorganic	88.3	1.25	227	16.6
SEm (±)	1.87	0.02	5.42	0.21
CD (*p*=0.05)	7.34	0.05	21.29	0.72

SOC - soil organic carbon, CD - critical difference, SEm – standard error of mean, NS - not significant

The higher yields in case of continuous application of organic manure compared to conventional farming was attributed to the fact that the nutrient from organic manure, particularly N, plays a vital role in leaf growth via its involvement in cell division and as a primary component of enzymes for all the living systems and processes (Duru *et al.* 1997). The relative abundance of roots; and root distribution and density within the soil profile are genetically determined and vary with soil type, moisture regime, nutrient availability, organic matter distribution, and soil management (Myers *et al.*, 1994).

The SOC concentrations and stock was the highest under organic followed by inorganic. Continuous applications of organic amendments can enhance SOC concentration, available P and K and improve soil quality (Jiang *et al.*, 2006). Concentrations of SOC and total N were enhanced by 22% and 20% under organic farming compared to conventional farms (Condron *et al.* 2000).

Conclusion

The study indicated suitability of fodder grasses and organic amendments in improving quality of marginal degraded hill soils.

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