Changes of Soil Environment by Green Manure under Rice-based Cropping System

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Abstract

The green manure crops are important for the long-term productivity and quality of agroecosystems. The cultivation of green manure crop is considered as a good management practice by increasing soil organic matter and fertility levels. This experiment was conducted to improve the soil environment under rice-based cropping system at paddy soil (fine loamy, mixed, nonacid, mesic, family of Aeric Fluventic Haplaquepts) in National Institute of Crop Science (NICS), Korea in 2006 to 2007. The variation of soil temperature in green manure plots was lower than without green manure (control) during spring season (April to May). The temperature variation of no tillage plot (broadcast before rice harvest) was the lowest among treatments. After green manure cropping, the soil bulk density and porosity ratio were improved at the top soil. The production of green manure was the highest (fresh weight 30,380, dry weight 5,540 kg ha^{-1}) at hairy vetch and barley mixture plot by partial tillage. However, mixture treatment had no improvement on soil organic matter. After rice cropping with green manure application, soil quality was improved such as soil physical properties except mixture treatment. Therefore, we suggest that soil quality should be improved by green manure cultivation under rice-based cropping system.

Media summary

Understanding the chemical and physical changes of soil, and soil temperature by green manure cultivation under rice-based cropping in paddy.

Key Words

Green manure, Paddy, Soil temperature, Soil physical, Cropping system

Introduction

The cultivation of green manure crops plays an important role in agricultural system for soil quality and sustainability. Especially legume crops convert nitrogen gas in the atmosphere into soil nitrogen that plants can use. The inclusion of leguminous crops into rice-based cropping patterns may contribute toward improving the prospects of soil bulk density, soil porosity and soil organic matters, primarily because legumes are able to fix atmospheric nitrogen by rhizobium and stabilize soil such as mycorrhizae (Clark et al., 2007; Schulz et al., 1999). In Korea, the intensity of cropping in major rice ecosystems has increased over four decades and spectacular product and yield increases have been achieved. However, there was decrease in soil quality, especially soil organic matter (Her 1982; Jung et al 2001).

Therefore, these experiments were carried out to improve the soil environment under rice-based cropping system at paddy soil

Methods

The experiment was conducted to improve the soil environment after rice harvest at paddy soil (fine loamy, mixed, nonacid, mesic, family of Aeric Fluventic Haplaquepts) in NICS, Korea from September 2006 to Oct. 2007. Hairy vetch (*Vicia villosa*) and barley (*Hordeum vulgare*) were seeded by partial tillage and broadcasted before rice was harvested. Partial tillage plot divided into hairy vetch only and hairy vetch + barley mixture. After green manure application, rice cultivation was practiced by no fertilization and herbicide. The soil chemical, physical characteristics and crop growth were investigated by standard methods of Rural Development Administration (RDA), Korea.

Results

Bulk density of 0-10 cm soil depth was less than that of 10-20 cm soil depth. Green manure cultivation resulted in a reduction of soil bulk density in 0-10 soil depths (Table 1). However, bulk density decreased only at BTBBH plot in 10-20 cm soil depth. After rice practice with green manure application, bulk density showed a reduction in both 0-10 and 10-20 cm soil depth. The porosity of soil was same trends compare with bulk density of soil (Table 2). Incorporation of green plant materials improved the soil physical properties was evident from values of bulk density and porosity of soil in hairy vetch plot (Table 1, 2).

Table 1. Effect of green manure on bulk density (Mg m^{-3}) of soil under rice-based cropping system

Treatments	Before green manure application		After rice harvest	
	Soil depth (cm)		Soil depth (cm)	
	(0-10)	(0-20)	(0-10)	(0-20)
CP[1)]	1.24	1.39	1.19	1.34
PTHV[2)]	1.19	1.39	1.06	1.19
PTM[3)]	1.16	1.39	1.10	1.19
NTHV[4)]	1.23	1.33	1.13	1.17

1) CP: Conventional Practice, 2) PTHV: Partial Tillage (Hairy Vetch seeding), 3) PTM: Partial Tillage (Mixture), 4) NTHV: No Tillage (Hairy Vetch seeding by broadcasting before harvest).

Table 2. Effect of green manure on porosity (%) of soil under rice-based cropping system

Treatments	Before green manure application		After rice harvest	
	Soil depth (cm)		Soil depth (cm)	
	(0-10)	(0-20)	(0-10)	(0-20)
CP	53.3	47.6	55.1	49.5
PTHV	55.2	47.7	60.0	55.1
PTM	56.1	47.5	58.4	55.3
NTHV	53.4	49.9	57.2	55.8

Soil temperature (3 cm depth) of control plot without green manure crop varied from 0.3 to 30.6 ℃ (average 11.7 ℃). All of the green manure cultivation treatment decreased soil temperature. Specially, NTHV plot dramatically decreased as mean temperature 10.6 ℃ (1.4 to 21.7℃). These results indicated that cultivation of green manure crops might be influencing soil carbon build-up by decreasing soil temperature.

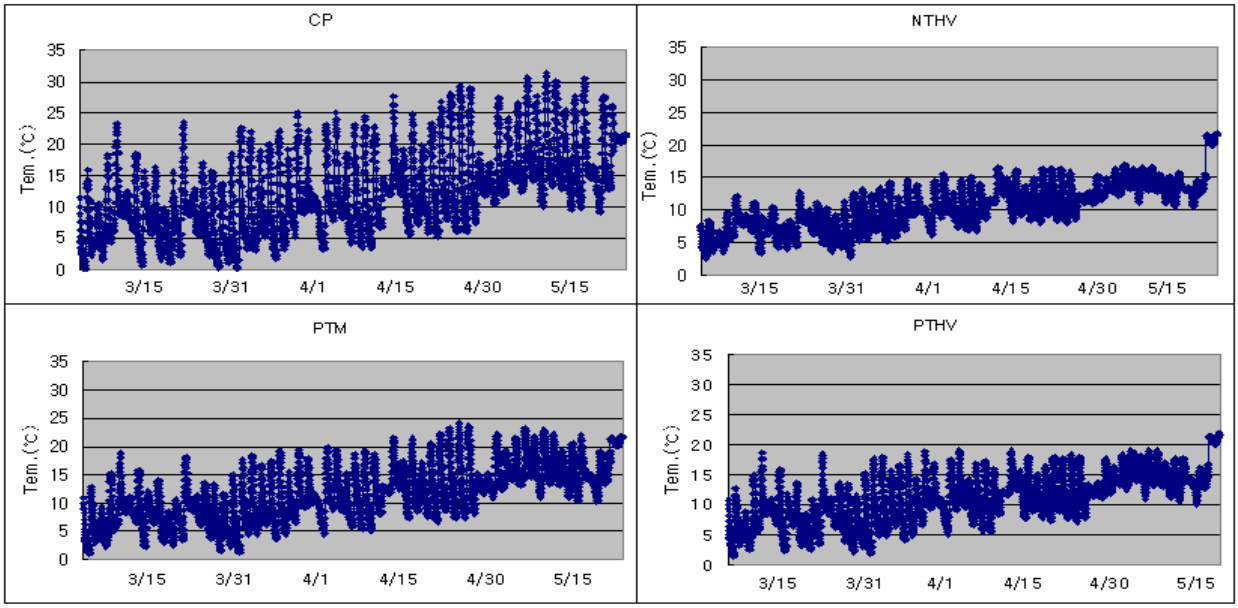

Fig. 1. The soil temperature according to cultivation method of green manure in spring season (April to May). Temperature was measured every 30 min. at 3 cm soil depth (Thermo Recorder, TR-71U/TR-72U).

As green manure is organic material, incorporation of green plant material, increased little bit the accumulation of soil organic matter during the growth period of green manure crops and rice except PTM plot (Fig. 2). Organic matter concentration was reduced in all PTM treatments possibly due to the decomposition of barley plant.

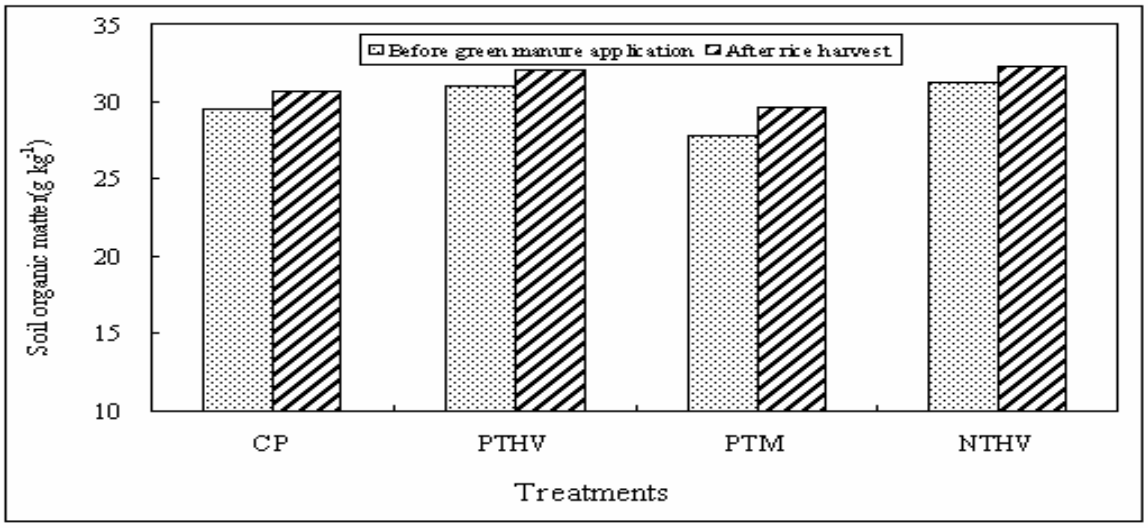

Fig. **2. Effect of green manure on organic matter (g kg^{-1}) of soil under rice-based cropping system.**

The production of green manure was the highest (fresh weight 30,380, dry weight 5,540 kg ha^{-1}) at hairy vetch and barley mixture plot by partial tillage. Rice yield had no difference in green manure application plot compare with conventional practice except PTM plot (Table 4).

Table 4. Yield of green manure crops and rice under rice-based cropping system

Treatments	Green manure productivity (kg ha^{-1})			C/N ratio	Rice yield (kg ha^{-1})
	Fresh	Dry	Nitrogen		
CP	-	-	-	-	4,142
PTHV	27,750	4,340	127	13.9	4,421
PTM	30,380	5,540	113	32.5	4,011
(Hairy vetch)	(16,380)	(2,470)	(86)	(13.0)	
(Barley)	(14,000)	(3,070)	(27)	(52.0)	
NTHV	28,000	4,500	133	14.4	4,440

Conclusion

The cultivation of green manure crop improved soil physical properties such as bulk density and porosity even when there had no significantly increase in the amount of soil organic matter in the paddy. Additionally, soil temperature was decreased in spring season by green manure crops. These results indicated that that soil quality should be improved by green manure crops under rice-based cropping system.

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