Effect of Cover Cropping and Tillage System on Carbon and Nitrogen Dynamics in Field Rice Cultivation

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Introduction

Greenhouse gases from agricultural soil would have one of the major impact on the global worming. Cover cropping and no-tillage treatment might be an important tool to improve the emission of global warming gases and enhance the potential of soil carbon sequestration. In this study, soil CO_2 flux (SCF), soil carbon (SC) and soil water content (SWC) were examined under the different soil management including cover cropping and tillage systems.

Material & Methods

An Experiment site was used at the Experimental Farm of Ibaraki University on a Humic Allophane soil (Haplic Andsolos) in Kanto region, Japan. Experimental design was a randomized complete block design with four replications in 3m×6m, consisting tillage systems and cover crop spices in the filed rice cultivation. Tillage systems were main plots, which were plow, rotary, and no-tillage. A subplot treatment was cover crop type which included hairy vetch, rye and fallow (native weeds).

Cover crop was seeded in October, 2002, and each tillage treatment was done in April, 2003. Field rice was planted in April and harvested in September. Cover crop was seeded in the same plots in October, 2003. In following spring, field rice was planted again after each tillage treatment in April, and harvested in October 2004. This experiment is carrying until September 2007.

Soil carbon content samples (0~2.5cm, 2.5~7.5cm, 7.5~15cm, 15~30cm) were taken with soil sampler in Apr. every year 2003-2007 and analyzed with C-N coder. Soil inorganic nitrogen content samples (0-30cm, 30-60cm, 60-90cm) were taken in March, June and October every year form 2003 and analyzed for inorganic nitrogen content. Chambers method was adapted to measure the CO_2 flux during field rice growing season.

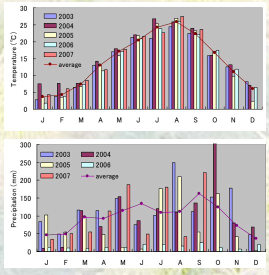


Figure 1. Average temperature and precipitation during experiment. (2002-2007)

* Monthly average temperature and precipitation (2002-2007) : from the observational data of the Ibaraki University Experimental farm.

* Monthly average temperature and precipitation (1982-2002) : from the weather business support center Tsuchiura observation point.

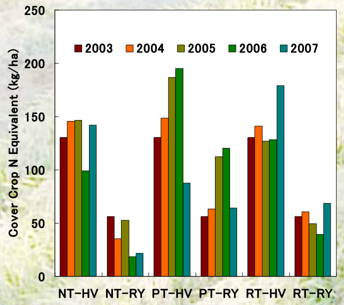


Figure 2 Estimated fertilizer N equivalent value provided to field rice by winter cover crop.
NT: no-tillage, PT: plow tillage, RT: rotary tillage
HV: hairy vetch and RY: rye.

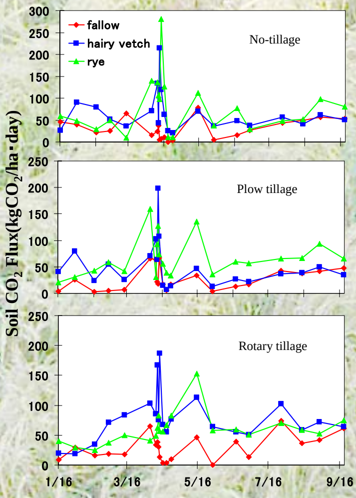


Figure4. Soil CO_2 Flux during a field rice cultivation at different tillage systems and cover crop types in 2007.

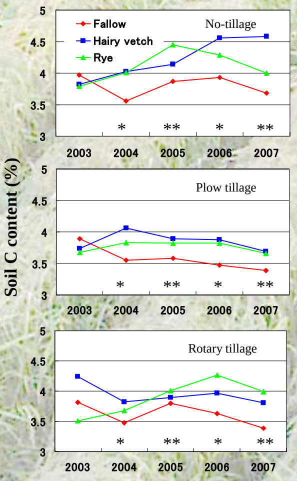


Figure 5. Soil carbon content dynamics in 0-2.5 layer (2003-2007).
* And ** Indicate significant difference in cover crop (P<0.05 and P<0.01)

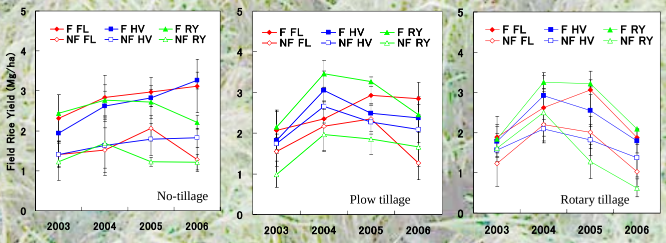
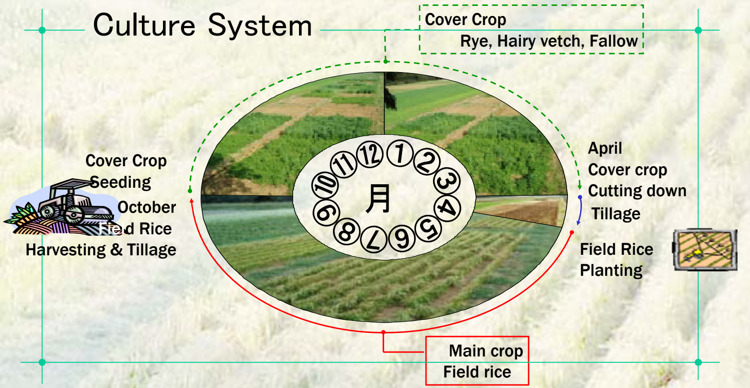
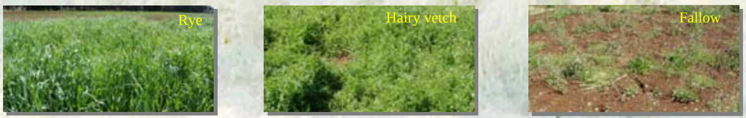


Figure 6. Changes of field rice yield in different tillage system, cover crop and N fertilizer level during 2003-2006.

F: N fertilizer, NF: no N fertilizer, FL: fallow, HV: hairy vetch and RY: rye.





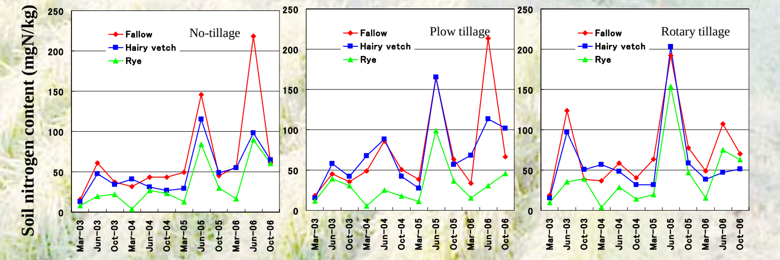


Figure 3 Soil inorganic nitrogen changes in deep soil layer (60-90cm) (2003-2006)

Results & Discussion

➢Temperature and Precipitation

During cover crop growing season, temperature was higher in March, August and September in 2007 than 20 years average compared with other year. Lower precipitation in spring 2007 brought low fertilizer N equivalent value of cover crop an low cover crop DM accumulation (Figure 1).

➢Fertilizer Nitrogen Equivalent Value

Significant differences of field rice yield between N level were absorbed from 2003 to 2007 (P<0.05). The estimation of the fertilizer N equivalent value showed that across tillage treatment, hairy vetch was higher than rye and fallow, and across the cover crops, PT was highest compared with RT and NT (Figure 2).

➢Soil Inorganic Nitrogen

Soil inorganic nitrogen contents during the experiment were lowest in rye , however, there were little difference were observed between hairy vetch and fallow. There were significant differs between tillage treatment. The result indicated that rye can protect nitrogen leaching to underground (Figure 3).

➢Soil CO_2 Flux (SCF)

The SCF was significantly lower in fallow than in Rye and Hairy vetch, and that was also significantly higher in no-tillage than in plow tillage and rotary tillage. However, the SCF is similar in fallow and hairy vetch in field rice growing season (Figure 4) .

➢Soil Organic Carbon (SOC)

The effect of cover cropping and tillage systems on soil C content was small in no-tillage treatment in 2003. However, soil organic carbon content was increased as continued no-till with hairy vetch. The significant difference was observed between cover crop treatment. However, SOC decreased with years in PT and RT. Across the tillage system, soil C content was lowest in fallow, but higher in Hairy vetch and rye at 0~2.5cm soil depth layer (Figure 5) .

➢Field Rice Yield

There were significant differences of field rice yields between N level treatment. Field rice yield was highest in hairy vetch with NT treatment and increased continually from 2003 to 2006. Field rice yield tend to decrease in PT and RT, however, across the tillage system, Field rice yields were higher in rye and hairy vetch compared with fallow (Figure 6).

Conclusion

Fall planted rye was successfully to prevent N leaching, and both of rye and hairy vetch was also effective to enhance the soil carbon content. In addition CO2 emission was refracted to the cover crop residue amount and their quality. There were little difference of yield response between tillage system and cover crop types until 2005, however, magnitude differences were observed in 2006 and 2007 for rice production. No-till field rice yields were significantly higher than rotary and plow treatments. No-till with cover crop system may have great potential to cope with both sustaining crop yields and enhaince soil carbon pool in *Andisoil*.