Effects of Rice-green Manure Crop Cropping Systems on Soil Characteristics and Rice Yield in Paddy Field

Hyeoun-Suk Cho[1], Weon-Teai Jeon[1], Ki-Yeung Seong[1], Chung-Guk Kim[1], Kwang –Ho Jeong[1] and Woo-Yeong Park[1]

Key words: Green manure crops, Legume, Gramineae, Cropping system, Rice yield, Paddy soil

Abstract

Supplying rate of nitrogen at HV was 172.8 kg ha^{-1}, HV/B was 64.3 kg ha^{-1} and B was 38.6 kg ha^{-1}. The Rice yield was 7.05 ton ha^{-1} when the nitrogen supply was the largest with HV and 5.42 ton ha^{-1} was produced on HV/B. The chemical characteristics of soil have lower pH and exchangeable cations(Ca and Mg) at B, HV and HV/B, rather than at CF because green manure was applied at the former step. However, the physical characteristics of the soil and the porosity showed different tendency which was that it was better at the green manure crops than CF. Nitrogen nutrient balance was showed the most balanced at CF and field of application of green manure crops were required the appropriate management if future crops would be cultivated because nitrogen nutrient could be exhausted or accumulated.

Introduction

What environment friendly agriculture is the method using none of chemical materials such as pesticides and fertilizers and trying to use the organic matter which can be easily revolved back to the nature. Europe and the U.S. try to promote the soil fertility through rotation of cropping system for environment friendly agriculture and one of their representative exemplary crops is the green manure crop. The green manure crops are returned to soil when the plants are still green. The green manure crops plays the key role in reducing of chemical fertilizers, improvement of soil fertility, reduction of soil erosion, weed control and landscapes composition. Green manure crops are gradually spreading throughout the country with the governments 'Green Korea' policy and the increased price of chemical fertilizers. Typical green manure crops are barley green manure, hairy vetch, milk vetch and clovers. Usually green manure crops are cultivated at winter fallow fields and returned back to the soil at coming spring being used as green manure crops. Gramineae green manure that returned back to soil contains high C/N rate so that it has greater effect when it comes to improving soil characteristics rather than supplying fertilizers. Moreover, legume crops highly contain nitrogen and have low C/N rate therefore they can bring great effect of supplying fertilizers. Also, if gramineae crops and legume crops are mixed-planting, they can provide not only great effect of supplying fertilizers but also improving soil characteristics. Consequently, this study was conducted at Korea's typical soil, loamy soil, to figure out the effect of how barley green manure, hairy vetch

[1] Crop Environment Research Division, National Institute of crop Science, RDA, Suwon, 441-857, *Republic of Korea, E-Mail: chohs@korea.kr, Internet www.nics.go.kr*

and the mixed-planting hairy vetch with barley green manure affect on the yield of rice, usage of nutrient and soil characteristics.

Materials and methods

A field study was conducted in sandy loam of paddy fields at Crop Environment Research Division farm, National Institute of Crop Science (NICS), Suwon, in Korea. Firstly hairy vetch and barley were cultivated in winter at experimental field and then applicated to the soil and cultivated rice (Unkwang byeo). Treatments were composed of hairy vetch (HV), barley (B), hairy vetch and barley (HV/B), custom fertilizing (CF) and none fertilizing (NF). Chemical fertilizers such as N, P_2O_5 and K_2O did not give all fertilizer except CF. Chemical Fertilizer was applied with N-P_2O_5 –K_2O=9-4.5-5.7kg/10a, and chemical fertilizer was used with urea for T-N, magnesium phosphate for P_2O_5 and potassium chloride for K_2O respectively based on the rate of split application. The green manure crops were sowed by machine of drill seeding at 14th of October, 2009 and applicated to soil at 17th of May, 2010. Rice transplantation was conducted by 30*15cm plant spacing on 7th of June. Right before application to soil, green manure crops of 1m^2 was harvested and its fresh-weight was measured and then hot-air dryer for 24 hours at 100℃ were dried. After that, its dried-weight was measured. The nutrient contents of rice and green manure crops harvested two plants and hot-air dryer for 24 hours at 50℃ were dried and then we grinded it and analyzed T-N with CNS Analyzer (LECO CNS-2000). The measurement of Bulk density and porosity of the soil were collected by core samples and it was dried and weighed them. Soil pH was measured with a pH meter. Exchangeable cations and available phosphate of soil was measured with ICP (GBC SDS-270) and CNS Analyzer (LECO CNS-2000) was used to figure out amount of T-C.

Results and Discussion

Yield of the green manure crop was the largest at HV, 5.59 ton ha^{-1} and the yield of nitrogen was 172.8 kg ha^{-1} at this time. Yield of green manure of HV/B was 3.93 ton ha^{-1} and production of nitrogen was 64.3 kg ha^{-1} which was less than that of HV but more 1.7 times more than that of B. The yield of HV/B and B mixed-planting were similar, however, HV/B mixed-planting was higher in nitrogen production (table 1). The reason was that nitrogen contents were increased by cultivating a hairy vetch and barley at the same time.

Table 1: Yield of green manure crops and nitrogen according to treatments

Treatments	Dry yield of green manure crops (ton ha^{-1})	Yield of nitrogen (kg ha^{-1})
Barley (B)	3.44bc*	38.6c*
Hairy vetch (HV)	5.59a	172.8a
Hairy vetch/Barley (HV/B)	3.93b	64.3b

* Means within a column not followed by same letters are significantly different by DMRT 5%.

Yield of rice at HV was 7.05 ton ha^{-1} which was a lot more than any other green manure crops and the reason was that as a green manure crop the amount of nitrogen

which was supplied was much more. HV/B produced 5.42 ton ha^{-1} which were less than that of HV but more than that of B. Moreover it produced longer Culm length, more number of spikelet per m^2 and number of spikelet/panicle than those of B but less than those of HV (table 2).

Table 2: Yield and components of rice as affected by treatments at harvest time

Treat-ments	Culm length (cm)	Panicle length (cm)	No. of panicles per m^2	No. of spikelet/ panicle (ea)	Percent ripened grain (%)	1000-grain weight (g)	Rough rice yield (ton ha^{-1})
B	58.8	17.1	204.8	102	92	27.5	4.69c*
HV	72.4	17.3	335.7	129	83	26.5	7.05a
HV/B	62.1	16.9	250.0	113	86	27.1	5.42b
CF	60.0	17.0	197.6	94	87	27.7	4.01d
NF	59.6	18.0	178.6	103	81	27.8	4.19cd

* Means within a column not followed by same letters are significantly different by DMRT 5%.

Soil of application of green manure crops showed lower pH contents than that of CF and among green manure crops, B showed the least amount which was 5.19. Exchangeable cations (Ca, Mg) showed lower amount with application of green manure crops than CF and there was no difference among green manure crops. Exchangeable K, T-C and Av.P_2O_5 hardly showed any difference also. Bulk density was 1.3~1.4 kg/m^3 showed no difference between any kinds of green manure crops at below table; HV/B and HV, contain characteristics of legume green manure crops, produced more porosity than B and CF(table 3).

Table 3: The changes of soil physico-chemical characteristics after examination

Treat-ments	pH (1:5)	T-C (g kg^{-1})	Av.P_2O_5 (mg kg^{-1})	Ex. Cations ($cmol^+$ kg^{-1})			Bulk density (Mg /m^3)	Porosity (%)
				Ca	Mg	K		
B	5.19	6.6	112	3.11	0.62	0.56	1.4	46.0
HV	5.63	6.4	112	3.01	0.58	0.59	1.4	49.0
HV/B	5.50	5.7	121	3.05	0.57	0.55	1.3	50.1
CF	5.72	6.3	111	3.71	0.72	0.59	1.4	47.0
NF	5.74	6.9	103	3.38	0.64	0.58	1.4	45.8

The total yield of rich was 14.64 ton ha^{-1} with HV, 14.54 ton ha^{-1} with HV/B which were more than other treatment. Usage of nitrogen was 61.7% with HV/B which was the highest. In HV, total yield of rice was highest as 14.64 ton ha^{-1} but the usage of

nitrogen was low. The reason was that the amount of inputted nitrogen from green manure was 2.7~4.5 times more than in the other processes. Nitrogen nutrient balance was quite adequate with CF which was 2.9 kg ha^{-1}. Among green manure crops, 48.9 kg ha^{-1} of nitrogen with HV was accumulated on the soil meanwhile when it comes to HV/B, -38.5 kg ha^{-1} more than input was consumed (table 4). If you use long-term HV/B treatment in paddy soil, nitrogen shortage would be caused therefore it is quite advisable to supervise.

Table 4 : Usage of nitrogen and nitrogen balance as affected by treatments at harvest time.

Treatments	Total yield (ton ha^{-1})	Usage of nitrogen (%)	Nitrogen balance (kg ha^{-1})		
			N input	N output	Input-Output
B	8.91	4.7	38.60	64.9	▽26.3
HV	14.64	35.2	172.80	123.9	48.9
HV/B	14.54	61.7	64.30	102.8	▽38.5
Control(CF)	11.28	26.7	90.0	87.1	2.9
Control(NF)	8.50	-	-	63.1	▽63.1

References:

Sohn Sang Mok.(2000): Problems and solution of soil fertility enhancement in Korea organic farming. Korea. J. and Organic agriculture 8:53~77

Chang-hyu Yang, Jin-Hee Ryu, Taek-Kyum Kim, Sang-Bog Lee, Jae-Duk Kim, Nam-Hyun Baek, Sun Kim, Weon-Yung Choi, and Si-Ju Kim.(2009): Effect of green manure crops incrporatin with rice cultivatin on soil fertily improvement in paddy field. Korea. J. Soil Sci. Fert. Vol. 42(5): 371~378

Beom-Hen Sng, Kyung-A Lee, Weon-Tai Jeon, Min-Tea Kim, Hyun-Suk Cho, In-Suk Oh, Chung-Guk Kim, and Ui-Gum Kang.(2010). Effects of green manure crops of legume and gramineae on growth responses and yield in rice cultivation with respect to environment friendly agriculture. Korea. J. Crop Sci. Vol. 52(2): 144~150.

Yong-Hwan Lee, Sang-Min Lee, Jwa-Kyung Sung, Du-Hol Choi, Han-Myeng Kim, and Gab-Hee Ryu.(2006). Development of soil management technique in organic·rice cultivation. Korea. J. and Organic agriculture Vol. 14(2):205~217

Weon-Tai Jeon, Ki-Yeong Seong, Jong-Ki Lee, Min-Tae Kim, Hyun-Suk Cho.(2009). Effects of seeding rate on hairy vetch(*Vicia villosa*)-Rye(*Secale cereale*) mixtures for green manure production in upland soil. Korea J. Crop Sci. Vol. 54(3):327~331