Effect of Green Manure Biomass and Rice Yield on Continuous Cropping by different Seeding rate of Hairy vetch in Paddy

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Abstract

Green manure crops play an inportant role in organic farming. Field experiment was conducted at paddy soil (fine loamy, mixed, nonacid, mesic family of Aeric Fluvaquentic Endoquepts) in 2008/2009 to 2009/2010 at the National Institute of Crop Science (NICS), RDA, Suwon, Gyeonggi province, Korea. This experiment was carried out to evaluate the biomass of hairy vetch (Vicia villosa) and growth of rice (Oryza sativa) by different seeding rates. Seeding rates of hairy vetch consisted of 30, 60, and 90 kg ha^{-1} by broadcasting before rice harvesting. The biomass and nitrogen production of hairy vetch were not significantly different between 60 kg ha^{-1} and 90 kg ha^{-1} of seeding rates. Also, rice yield was not siginicantly differnt between seeding rate 60 kg ha^{-1} of hairy vetch and conventional pratice for two years. Therefore, we suggested that seeding rate of hairy vetch should be reduced by continuous cropping and incoportion of hairy vetch under rice-based cropping system.

Introduction

The cultivation of green manure crops is necessary for organic farming to replace chemical fertilizer in Korea. Especially hairy vetch is a good green manure for rice culivation as a legume crops. This crop has excellent winter survival and high content of nitrogen. Therefore, it is possible to cultvate this in a wide region in Korean penisula. However, seeds of hairy vetch has been imported from aborad at high cost because seed production of hairy vetch was so difficult due to economic and climatic conditions of Korea. Recently the reqeust of Korean cosumer has been increasing the production of organic farming as national income has increased (Jeon at al., 2006). So it is popular due to well-being in the coutry. Korean goverment (Ministry for food, agriculture, forestry and fisheries) has planed to increase the cultivation area of hairy vetch to 36% of green manure upto 2013. The seeding rate of hairy vetch is from 60 to 90 kg ha^{-1} and 30 kg ha^{-1} in paddy and upland soil, respectively in Korea. We suggested a hypothesis if hairy vetch has been contiuosly practiced under rice based cropping system, seeding rate of hairy vetch could be reduced as improving of soil environment. The effect of hairy vetch has been not studied in long-term of paddy soil as rice was cultivated to watering condition for long period. Therefore, this study was conducted to the effect of reduced seeding rate of hairy vetch on rice grwoth and yield by different seeding rates.

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Materials and methods

The experiment was conducted to find out the ruducing of seeding rate of hairy vetch under rice based cropping system at paddy soil (fine loamy, mixed, nonacid, mesic, family of Aeric Fluventic Haplaquepts) in NICS, Korea from September 2008 to October 2010 that had previously been planted hairy vetch for two years in a rice monoculture system. Climatic data during the two growing seasons of the experimentation are given in Table 1. Hairy vetch was seeded on the 3rd October and the 25th September in 2008 and 2009 by broadcasting before rice harvesting. The seeding rate cosisted of 30, 60, 90 kg ha^{-1}. Before 14 to 16 days of transplanting of rice seedling, the above ground portion of the plant was measured and then dried in an oven at 70°C, until a constant weight as obtained to measure the dry weight. Then, the total carbon (C) and total nitrogen (N) were measured using a CNS analyzer (Leco, USA). The harvested hairy vetch was used to cover the soil and was also incorporated into the soil for rice cultivation. Rice (*O. sativa* L. cultivar Wungang) seedlings that was 25 days old were transplanted on the 4th June for 2 years using the transplanting machine at 30 x 14 cm density. The biomass of green manure, the soil chemical, physical characteristics and crop growth were investigated by standard methods of Rural Development Administration (RDA), Korea. Differences among treatments were estimated by one-way analysis of variance (ANOVA) using the SAS program (SAS institute, ver. 9.2, 2004) with Tukey's LSD. Differences were considered significant at $p< 0.05$.

Table 1. Monthly mean air temperature and total rainfall during the two growing seasons of experimentation at Suwon, Korea.

	Mean monthly temperature (℃)			Total monthly rainfall (mm)		
Month	2008/2009	2009/2010	30-year average	2008/2009	2009/2010	30-year average
Sep.	22.3	21.6	20.2	101.9	56.3	133.5
Oct.	16.0	15.7	13.4	35.6	64.5	52.3
Nov.	7.4	6.9	6.1	18.5	68.2	51.0
Dec.	0.9	-0.7	-0.4	17.4	18.7	24.1
Jan.	-2.6	-4.4	-3.2	7.9	26.9	23.5
Feb.	2.4	1.4	-1.0	26.8	56.7	24.0
Mar.	6.1	4.6	4.5	59.5	78.7	47.0
Apr.	12.0	9.6	11.2	45.0	58.6	76.0
May	18.3	17.1	16.7	102.4	100.7	94.8
Jun.	22.1	23.1	21.4	118.8	116.1	133.2
Jul.	24.2	26.0	24.8	766.0	206.8	302.7
Aug.	25.7	26.9	25.2	207.1	372.8	305.8
Sep.	-	22.2	20.2	-	375.9	133.5

Results and Discussion

The biomass of hairy vetch plays a role using green manure under rice based cropping system. During two years of this experiment, fresh weight, dry weight and nitrogen production were evaluated before 14 to 16 days of rice seedling transplanting

(Table 2). During hairy vetch growing season, fresh weight, dry weight and N production were not significantly different between 60 and 90 kg ha^{-1} of seeding rate. It was estimated that hairy vetch was previously cultivated for two years. The cropping of hairy vetch was changed to soil environment such as chemical (Hatcher and Melander, 2003), physical (Jeon et al., 2008) and microbiological (Buyer et al., 2010) properties. Especially legumes such as hairy vetch are able to fix atmospheric nitrogen by microorganism (Clark et al., 2007; Schulz et al., 1999). It was indicated that hairy vetch root turnover and exudation during growing season had a positive effect on soil microbial activity (Buyer et al., 2010). However, the biomass of 30 kg ha^{-1} seeding rate was significantly lower than 60 and 90 kg ha^{-1}. The first year's biomass of hairy vetch was higher than second year's due to weather condition such as low temperature and much rainfall of growing season compared to the average year (Table 1).

Table 2. Biomass and N - uptake on of hairy vetch by different seeding rates.

Seeding rate (kg/ha)	2008/2009			2009/2010		
	Fresh weight (ton ha^{-1})	Dry Weight (ton ha^{-1})	N - Uptake (kg ha^{-1})	Fresh weight (ton ha^{-1})	Dry Weight (ton ha^{-1})	N - Uptake (kg ha^{-1})
30	14.6b	2.28b	67b	15.4b	1.60b	55b
60	26.6a	3.36a	118a	23.7a	2.35a	74a
90	26.9a	3.39a	116 a	27.3a	2.56a	93a

Rice yield and field lodging were conducted to investigate different seeding rate of hairy vetch as effective green manure (Table 3). In the first year, rice yield was not different between 60 kg ha^{-1} of seeding rate and conventional practice although 90 kg ha^{-1} increased yield compared to conventional practice. In the second season, 60 and 90 kg ha^{-1} of seeding rate did not show significant difference to conventional practice. Field lodging was occurred to this year because of typhoon. The 90 kg ha^{-1} of seeding rate showed serious lodging compared to conventional practice.

Table 3. Yield and field lodging of rice by different seeding rates of hairy vetch.

Seeding rate (kg/ha)	2008/2009		2009/2010	
	Rice yield (kg/ha)	Field lodging (0~9)	Rice yield (kg/ha)	Field lodging (0~9)
30	4751c	0	3949b	2
60	5000b	1	4537a	3
90	5352a	1	4578a	5
Conventional practice[1)]	5171ab	0	4325a	1

[1)] Applied to chemical fertilizers (N-P_2O_5-K_2O=90-45-57 kg ha^{-1}) and herbicide.

Green manure or cover crops can improve soil physical properties such as water infiltration and storage, and soil nutrients (Clark, 2007). Bulk density, porosity and carbon content of soil were investigated (Table 4) after rice harvesting. The bulk density and porosity of soil were improved at hairy vetch used plot compared to conventional plot. Carbon content was similar to bulk density and porosity.

Table 4. Bulk density, porosity and carbon content of soil after rice harvesting in 2010

Seeding rate (kg/ha)	Soil depth (0-10 cm)			Soil depth (10-20 cm)		
	Bulk density (Mg m^{-3})	Porosity (%)	Carbon content (%)	Bulk density (Mg m^{-3})	Porosity (%)	Carbon content (%)
30	1.02b	61.6a	1.70a	1.23b	53.7a	1.58a
60	1.07b	58.5a	1.82a	1.20b	54.8a	1.66a
90	1.15b	56.7a	1.84a	1.19b	55.0a	1.74a
Conventional practice	1.37a	48.5b	1.39b	1.34a	49.6b	1.54b

Conclusions

The cultivation of green manure is very important in organic farming. Hairy vetch usage replaces chemical fertilizer application under rice based cropping system. Field experiments were conducted to evaluate the effects of different seeding methods on the biomass and N production of hairy vetch and rice yield. The seeding rate of hairy vetch could be reduced to improving of soil physical and chemical properties in this system by continuous cropping.

References

Buyer, J.S., Teasdale, J.R., Roberts, D.P., Zasada, I.A., Maul, J.E. 2010. Factors affecting soil microbial community structure in tomato cropping systems. Soil Biology & Biochemistry 42; 831-841.

Clark, A. 2007. Managing cover crops profitably (third edition). Sustainable agriculture network. MD, USA.

Jeon, W.T., Yang, W.H., Roh, S.W., Kim, M.T. 2006. Influence of controlled-release fertilizer levels on rice growth, weed control and nitrogen efficiency in paddy mulching transplanting. Korean J. Soil Sci. Fert. 39(9): 345-350.

Jeon, W,T,, Kim, M.T., Seong, K,Y., Oh, I,S. 2008. Changes of soil properties and temperature by green manure under rice-based cropping system. Korean J. Crop Sci. 53(4): 413-416.

Hatcher, P.E., Melander, B, 2003. Combining physical, culture and biological methods: prospects for integrated non-chemical weed management strategies. Weed Res. 43: 303-322.

Rosecrance, R.C., McCarty, G.W., Shelton, D.R., Teasdale ,J.R. 2000. Denitrification and N mineralization from hairy vetch (*Vicia Villosa* Roth) and rye (*Secale cereal* L.) cover crop monocultures and biculture. Plant and Soil 227:283-290.

Schulz, S., Keatinge, J.D.H., Wells, G.J. 1999. Productivity and residual effects of legumes in rice-based cropping systems in a warm – temperate environment Ⅰ. Legume biomass production and N fixation. Field Crops Research 61: 23-35.