Korean J. Soil Sci. Fert. **39**(4), 209-213(2006)

Article

Influence of Rice-Soybean Rotation on Soil Chemical Properties and Crop Growth in Silt Loam Soil

Deog-Bae Lee[1,*], Chang-Hyu Yang[2], Chul-Hyun Ryu[2], Kyeong-Bo Lee[2] and Byeong-Su Kim[2]

[1] *National Institute of Agricultural Science and Technology, RDA, ROK*
[2] *Honam Agricultural Research Institute, NICS, RDA, ROK*

This study was carried out to investigate the changes in soil chemical properties and yields of crops by rice-soybean rotation cropping system at silt loam soil. There were 4 rotation cropping systems; continuous rice cultivation, annual, biennial and triennial rotation of soybean and rice.
There were little change in pH, organic matter, Ca^{2+} and K^{+} contents with decrease in available phosphate content in the continuous rice cropping. The cropping system of soybean-rice caused to increase in available P_2O_5, K^{+} and Ca^{2+} in the soil after harvest. Content of NH_4-N in the soil also increased after the rotation of soybean than the continuous rice cropping in the soil during the rice growth period. These chemical change in the soil caused to increase rice growth in number of the panicles and the spikelet per square meter.
The yield of rice was increased by the rotation with soybean, and was gradually increased in the triennial rotation of soybean and rice. But the yield of soybean was decreased in continuous cultivation for two or three years in the paddy field. It was recommended for annual rotation to prevent the yield of soybean from decrease.

Key words: Paddy field, Rice, Rotation, Soybean

Introduction

Rotation cultivation of paddy-upland crops having different uptake and consumption of nutrient affect to solve nutrient unbalance by continuous cropping and to sustain soil fertility (Iwata et al, 1997). When upland crop and horticultural crops were cultivated to the paddy field, it can increased flexibility of food supply and multiple usage of agricultural land.

As the Korean Peninsula is located in Asian monsoon belt, the annual precipitation is about 1,500mm in the southern part of Korea and there was a great variation in precipitation depending on local areas as well as seasons; Two thirds of annual mean precipitation was concentrated on June to September. Korean paddy farming resulted in this weather condition. The paddy fields, which are mainly arable lands, are mostly located in the plains or valleys in the form of levees or terraces. Honam plain area is located in southern west part of Korean peninsula, is the major plain for rice production. The soil was developed by fluvio-marine alluvial deposition and has poor drainage degree with silt loam texture and high ground water level. On the other hand, Korean rice consumption was decreased from 136.4 kg in 1970 to 82.0kg per capita in 2004 (www.maf.go.kr) and yield of milled rice was greatly increased 3,370kg in 1971 to 5,040kg per hectar in 2004 (http://www.naqs.go.kr). Therefore it is another problem for Korean government to solve the unbalance of supply and demand of rice. With this aspect, it is requiring for the development of alternative crop production on paddy land. On the while, much soybean is imported from abroad for the multiple purposes by low productivity and little cultural area. Therefore, Korean government has driven the production of soybean in the paddy land.

This study was carried out to investigate the influence of paddy-upland rotation on the soil physico-chemical properties, and crop productivity in the constructed soils with artifitial drainage system.

Materials and Methods

The experimental field was located at paddy field of Honam Agricultural Research Institute, Rural

Received : July 9. 2006 Accepted : July 30. 2006
*Corresponding author: Phone : +82312900299,
Fax: +82312900296, E-mail : leedb419@rda.go.kr

Development Administration. The experimental site was installed sand-gravel drainage trench with 2m interval, 60cm width, and 30cm height at 1m soil depth in 1982. Vinyl walls were also installed to block horizontal water movement. Soil chemical properties were shown in Table 1.

Treatments are continuous rice cultivation, annual rotation of soybean and rice, rotation of biennial soybean and rice and rotation of triennial soybean and rice.

Rice plant, Daecheongbyeo, was transplanted on May 25 with 30 cm row and 13 cm planting space. Applied amounts of fertilizer were N 110kg ha^{-1}, P_2O_5 70kg ha^{-1}, and K_2O 80kg ha^{-1}. Nitrogen were applied separately 50% at basal, 20% at tillering stage, 20% at panicle formation, and 10% at heading stage. Potassium was applied 70% at basal and 30% at panicle formation stage. All phosphate was applied before transplanting.

Soybean, Paldal variety were sow on May 15 with 50 cm row and 15 cm planting space. Basal fertilization was nitrogen 40kg ha^{-1}, phosphate 70kg ha^{-1}, and potassium 60kg ha^{-1}.

Rice straw and soybean stem were removed from the field after harvest.

Soil pH were measured by electrode, soil organic matter Tyurin method, total nitrogen kjedahl method, available phosphate Lancaster method, and exchangeable cations extraction by 1N-CH_3COONH_4 (pH7.0). Extracted cations were analyzed by atomic absorption spectrophotometer.

For measuring mineralized nitrogen, air dried soil 10g were put into the distilled water 25 mL, and incubated at 25℃ and 30℃ for 15 days under sealing condition. The mineralized nitrogen (Ammonium) was measured by micro-diffusion method using Conway-unit.

Results and Discussion

pH The changes of pH was in the range of 6.0-6.9 at paddy-upland rotation (Table 2). Kutsuna et al. (1983) reported that upland crop cultivation at the paddy-upland rotation caused to soil acidification because of base leaching by rainfall and irrigation. But pH value among the treatments had no difference from first to fifth year.

Organic matter content The content of organic matter was little difference in the continuous rice cultivation, but the content was decreased gradually by the rotation cultivation of rice and soybean (Figure 1). This trend was clear in the continuous cultivation of soybean for two and three years. This result is coincidental to the result of Kojima (1985) and Kitada (1992); soil organic matter was gradually decreased, possibly due to mineralization of organic matter in upland crop cultivation in the paddy.

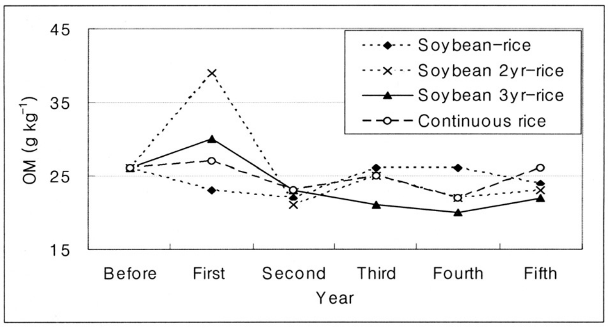

Fig. 1. Change of organic matter content in the soil after crop harvest.

Table 1. Chemical properties of surface soil before experiment

pH (1:5)	OM (mg kg^{-1})	T-N (mg kg^{-1})	A.v P_2O_5 (mg kg^{-1})	Ex. cat(cmol$^+$ kg^{-1})			
				Ca	Mg	K	Na
6.5	26	1700	131	5.4	2.7	0.38	0.3

Table 2. Change of pH in the soil after crop harvest

Cropping	First	Second	Third	Fourth	Fifth
	------------------ 1:5 ------------------				
Soybean-Rice	6.5	6.9	6.2	6.5	6.3
Soybean 2 yrs-Rice	6.1	6.0	6.1	6.5	6.4
Soybean 3 yrs-Rice	6.5	6.5	6.0	6.2	6.5
Continuous Rice	6.3	6.3	6.1	6.5	6.3

Content of available phosphate In rice cultivation, soil available phosphate content had no difference between before the experiment and after five years continuous rice cultivation, even though the content was increased drastically in the first year. On the while, the content was increased with rotation cropping of soybean in the paddy soil (Figure 2). Considering the same amount of phosphate applied in rice and soybean cultivation, this result related to the availability of phosphate in the paddy and upland condition; phosphates are released in anaerobic condition and fixed in aerobic condition. Kitada et al. (1992) also reported availability of phosphate was decreased in upland condition by fixation to Fe and Al.

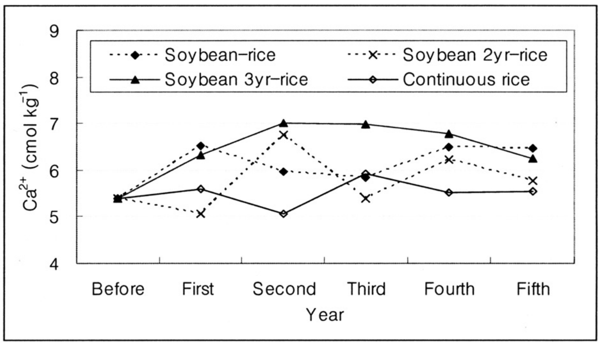

Fig. 3. Change of exchangeable Ca^{2+} content in the soil after crop harvest.

condition had positive effect on the balance of mobilization and uptake of the nutrients in soil.

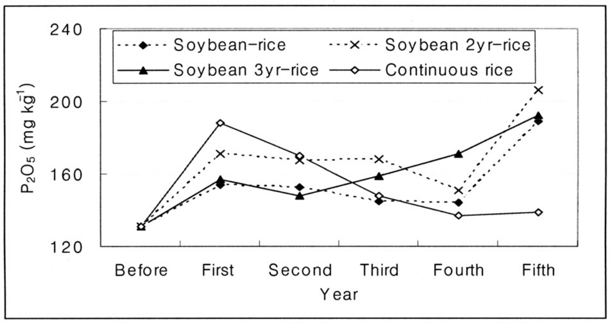

Fig. 2. Change of available phosphate content in the soil after crop harvest.

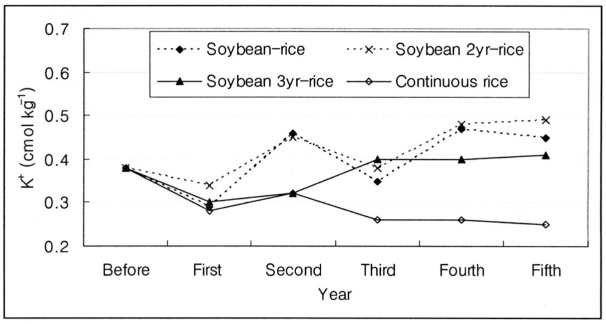

Fig. 4. Change of exchangeable K^+ content in the soil after crop harvest.

Content of exchangeable Ca^{2+} and K^+ Concentration of Ca^{2+} was lower in continuous rice cultivation than rotation culture of soybean. Increment of Ca^{2+} after soybean cultivation was clearer in biennial and triennial rotation of soybean. In addition to this, the increased Ca^{2+} after soybean cultivation was decreased by rotation of rice cultivation (Figure 3).

Exchangeable K^+ contents was increased by the rotation cultivation of soybean and rice, but the content was kept stable in the continuously cultivation of rice (Figure 4). This stable content of Ca^{2+} and K^+ in the continuous rice cultivation implied that submerged

Content of ammonium nitrogen Contents of ammonium nitrogen were high in the order of annual rotation of soybean and rice, biennial rotation of soybean and continuous rice cultivation (Table 3). According to the Watanabe (1985) and Kokano (1987), releasing amount of inorganic nitrogen in rotational paddy field were influenced by the soil texture, organic matter content, period of rotation and cropping system. And mineralized nitrogen was high in upland culture than the continuous rice culture.

Table 3. Change of ammonium nitrogen content in the soil at major growth stages of rice plant

Growth stage / Cropping	Tillering	Panicle formation	Heading	Harvest
	---------- mg kg^{-1} ----------			
Soybean-Rice	25	59	28	20
Soybean 2 yrs-Rice	43	30	24	18
Continuous Rice	21	18	21	15

Yield of rice and soybean Table 4 shows yield and yield component of rice in different cropping system. The number of panicles and grains per m^2 was increased by rotation of soybean may be related to high contents of NH_4-N in the soil. This increasing panicles and grains caused to positive effect on rice yield and this effect was increased gradually by biennial and triennial rotation of soybean.

On the while, Kaneda et al (1986) also reported that rice yield was increased in rotation culture by high root activity, and active nitrogen absorption.

Annual change of soybean yield Table 5 showed the yearly change of soybean yield by cropping system in the paddy field. Soybean yield was decreased gradually in biennial and triennial continuous cultivation of soybean. Therefore, it is recommendable for annual rotation of soybean and rice to get high soybean yield.

Park et al (1993) also reported that soybean yield was decreased greatly in 4 years continuous cultivation in sand loam and 3 years in silt loam paddy. Motomatsu (1990) also reported that soybean yield was decreased by 10% in two-year continuous cultivation and 20% in the three-year continuous cultivation. It was resulted from reduction of soil nitrogen content, root activity and increment of disease and pest injury in the continuous cropping.

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Table 4. Yield and yield components of rice by cropping system

Yield component / Cropping	No. of panicles per m^2	No. of spikelet per m^2 (×1,000)	Ripening ratio (%)	1,000 Grain weight (g)	Polished rice (kg ha^{-1})
Soybean-Rice	474	33.2	82.6	21.4	5300
Soybean 2 yrs-Rice	402	37.4	84.2	22.6	5360
Soybean 3 yrs-Rice	487	35.0	81.0	21.7	5410
Continuous Rice	433	30.6	88.4	22.3	5220

Table 5. Yearly change of soybean yield by cropping system

Year / Cropping	First	Second	Third	Fourth	Fifth	Average
	kg ha^{-1}					
Soybean-Rice	3850	-	4450	-	3450	3920
Soybean 2 yrs-Rice	4070	3860	-	2800	2910	3410
Soybean 3 yrs-Rice	4520	4050	3560	-	2740	3720

미사양토에서 벼-콩 윤작재배가 토양화학성과 작물생육에 미치는 영향

이덕배[1,*] · 양창휴[2] · 류철현[2] · 이경보[2] · 김병수[2]

[1]농업과학기술원 농업환경부, [2]작물과학원 호남농업연구소

본 연구는 미사양토인 호남평야지 논토양에서 벼와 콩의 윤작재배에 의한 토양화학성 변화와 작물생육에 미치는 영향을 구명하였다.
벼 연작, 콩-벼 1년 윤작, 콩 2년-벼 1년 윤작, 콩 3년-벼 1년 윤작의 처리를 두었다.
논 토양에서 벼를 연작 후 토양 중 pH, 토양 유기물, Ca^{2+}와 K^{+}함량은 별 변화가 없었으나 유효 인산함량은 점차 감소하였다. 한편 벼와 콩의 윤작으로 토양 중 유기물 함량은 감소하고, 유효인산과 Ca^{2+}와 K^{+}함량은 증가하였으며, 벼 생육기간 중 토양 중 암모니아태 질소함량도 높아졌다. 이러한 토양 중 양분함량의 변화로 인해 벼의 ㎡당 수수와 수당립수가 많아져서, 쌀 수량은 1-4%증가하였다.
콩은 연작 연수가 길어질수록 수량이 낮아지는 경향이어서, 콩 논 재배 시에는 벼와 매년 윤작하는 것이 수량 저하를 방지하였다.