(Korean J. Crop Sci.) 44(1) : 1~3(1999)

Growth of Rice Plant and Chemical Properties of Soil as Affected by Nitrogen Fertilization Level in Milk Vetch (*Astragalus sinicus* L.) Cultivation in Paddy Field

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ABSTRACT

This study was carried out to determine the effects on rice growth, yields and soil improvement under the different nitrogen levels in machine-transplanted rice after plowing at the fruiting stage of milk vetch. The fresh weight of milk vetch at plowing time was 20.95 ton/ha. In dry weight, T-N and C/N were 1.58%, 21.8%, respectively. Organic matter, total nitrogen and exchangeable calcium of soil after the experiment in the plot of milk vetch were higher than those before the experiment. Leaf area and dry weight of rice plants at heading date increased as nitrogen level increased. The number of panicle and spikelets per m² were not different except for the 110 kg/ha nitrogen level plot with milk vetch. Brown rice yield ranged from 5.45 to 6.08 ton/ha, increasing with increased nitrogen level. So the yield increased by 1% at 77 kg/ha nitrogen level, 7% at 110 kg/ha nitrogen level plot with milk vetch compared with conventional level (rice straw 5.4 ton/ha and nitrogen 110 kg/ha).

Key words : rice, milk vetch, nitrogen level, yield, soil chemical property.

Yield productivity per unit area could have been increased as not only chemical fertilizer but also organic matter had been applied because soil fertility was not maintained when it depended on only chemical fertilizer. Reported organic matters were rice straw, milk vetch, azola and white clover et al. Among them, milk vetch overwintered leguminous plant is cultivated and is native to the southern region of Korea. Milk vetch produced fresh herb of 20~40 ton/ha in the paddy field (Seong & Park, 1991). Choi et al. (1975) reported that the biomass of the milk vetch plant increased when phosphorus and potassium fertilizers were applied to milk vetch cultivated paddy fields at 20 kg per ha. It has been reported that soil improvement (Jeong et al., 1995; Hong et al., 1997) and reduction of nitrogen fertilizer rate (Jeong et al., 1996) occurred by using milk vetch in paddy soil. Full-blooming milk vetch showed high nitrogen fertilizer efficiency and fast nitrogen release in the soil. On the other hand, according to the growth after full-blooming, the contents of nitrogen in milk vetch decreased but crude fiber and lignin increased (Yasue, 1991). Therefore, fruiting milk vetch could be steadily decomposed in soil like completely decomposed manure. Paddy soil could be managed for rice cultivation without seeding milk vetch in the fall.

The objective of this study was to determine the effect on rice growth and soil improvement under different nitrogen levels in machine-transplanted rice after plowing at fruiting stage of milk vetch.

MATERIALS AND METHODS

The field experiment was conducted at Chonnam Agricultural Research and Extension Services, Naju, in 1997. We used Dongjinbyeo, a japonica rice cultivar. Soil series was Deogpyeong silt clay. This field has been managed rice cultivation for three years after introduction of milk vetch. The experiment was laid out in randomized complete block design with three replications. The treatment consisted of three nitrogen levels (55, 77, and 110 kg/ha) in plots of milk vetch and conventional plots (rice straw 5.4 ton and N 110 kg/ha). Table 1 indicates that plant height and fresh weight of milk vetch were 51.3 cm and 20.95 ton/ha, respectively immediately prior to plowing time. In dry weight, T-N, T-C, and C/N were 1.58%, 34.4%, and 21.8, respectively. So it was inferred that soil nitrogen content obtained from milk vetch plants was about 67kg/ha.

The milk vetch cultivated paddy field was plowed 39 days after blooming. The conventional plot (whole rice straw produced the previous year) was plowed in the spring. 30-day-old seedlings were transplanted on June 8 by machine transplanter. Phosphorus and potassium were applied at 70 and 80 kg/ha, respectively. Nitrogen application was split with 50% as basal, 30% at 2 weeks after transplanting and 20% at panicle initiation stage. Phosphorus was applied with the whole quantity as basal and potassium application was split with 70% as basal and 30% at the panicle initiation stage. Contents of T-N and NH_4-N were analyzed by the Kjeldahl method and the other chemical compositions were analyzed and measured by conventional methods at the soil laboratory. At maturity, the grain yield and its components were estimated

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Received 29 Sep. 1998.

Table 1. The biomass and content of inorganic elements of milk vetch plant at plowing time.

Plant height (cm)	Fresh weight (ton /ha)	Dry weight (ton /ha)	T-N (%)	T-C (%)	P_2O_5 (%)	K_2O (%)	C /N
51.3	20.95	4.23	1.58	34.4	0.35	2.55	21.8

from a sample of 5 m^2 in each plot.

RESULTS AND DISCUSSION

Jeong et al. (1996) reported that the amount of NH_4-N released in soil was the highest at 14 days after milk vetch treatment, and the contents of total nitrogen and organic matter in the soil were increased by milk vetch treatment. Lee et al. (1986) also reported that the amount of NH_4-N released in the soil was higher in the plot applicated with compost and straw than non-application. NH_4-N content in the soil was the highest at 15 days after transplanting (Table 2). NH_4-N content in the soil of the plot with applied nitrogen at 77 kg/ha and treated milk vetch was as good as the conventional level from 15 days after transplanting to 45 days after heading. The contents of total nitrogen, organic matter and exchangeable calcium of soil after the experiment in the plot of milk vetch were higher than those before the experiment (Table 3). But the contents of available phosphate in the soil in the plot of milk vetch was lower than that of the conventional level because the milk vetch cultivated paddy field had been managed without chemical fertilizer. This result indicated that the milk vetch plant steadily decomposed in the soil like rice straw, and the organic matter content in soil was increased by the milk vetch treatment.

Leaf area index (LAI) of rice was not significantly different with nitrogen level from 15 days to 49 days after transplanting (Table 4). But they increased as nitrogen level increased at heading date. Shoot dry weight of rice increased steadily from crop establishment to maturity and responded positively to increased nitrogen level. Shoot dry weight of the rice plants at heading date ranged from 982 to 1,105 g/m^2, they increased significantly as nitrogen level increased.

It was observed that the grain yield and its components of rice were affected by nitrogen levels (Table 5). The number of panicle and spikelets per m^2 were not different except for the 110 kg/ha nitrogen level plot with milk

Table 2. Changes in NH_4-N contents of soil as affected by nitrogen levels at machine- transplanted rice.

Nitrogen level (kg /ha)	NH_4-N (mg /kg)				
	15DAT†	35DAT	49DAT‡	Heading	45DAH§
55	31.8c	19.9c	18.8c	9.2b	2.0c
77	34.7b	22.3b	21.7b	12.5a	2.5b
110	39.8a	26.7a	26.2a	12.8a	2.7a
Conventional¶	35.3b	21.5b	21.3bc	12.1a	2.3b
F-value	25.55**	45.90**	15.69**	16.49**	25.68**

† DAT : Days after transplanting.
‡ Panicle formation stage.
§ DAH : Days after heading.
¶ Conventional was rice straw 5.4 ton /ha and nitrogen 110 kg /ha.
** Duncan's multiple range test at 1% level.

Table 3. Chemical properties of soil before and after experiment.

Division	Nitrogen level (kg /ha)	T-N (g /kg)	O.M. (g /kg)	Av. P_2O_5 (mg /kg)	Ex. cation ($cmol^+$ /kg)		
					K	Ca	Mg
Before experiment		1.5	20.4	48	0.28	4.1	1.5
	55	1.5	20.9	41	0.28	4.5	1.6
After experiment	77	1.7	21.8	37	0.27	4.4	1.8
	110	2.0	23.4	32	0.26	4.4	1.7
Before experiment		1.3	18.5	82	0.24	3.9	1.9
After experiment	conventional†	1.6	21.5	61	0.33	4.0	2.0

† Conventional was rice straw 5.4 ton /ha and nitrogen 110 kg /ha.

Table 4. Changes in leaf area index and shoot dry weight of rice as affected by nitrogen levels.

Nitrogen level (kg/ha)	Leaf area index				Shoot dry weight (g/m²)				
	15DAT†	35DAT	49DAT‡	Heading	15DAT	35DAT	49DAT	Heading	45DAH§
55	0.16	2.49	4.61	6.17c	27b	145b	479b	982c	1,336d
77	0.17	2.57	4.82	6.72b	34a	158b	512ab	1,071ab	1,447b
110	0.18	2.62	5.01	7.15a	35a	174a	539a	1,105a	1,608a
Conventional¶	0.18	2.56	4.69	6.66b	34a	151b	470b	1,024bc	1,393c
F-value	4.11ns	0.32ns	3.42ns	16.67**	5.28*	8.13**	6.81*	11.62**	111.75**

† DAT : Days after transplanting.
‡ Panicle formation stage.
§ DAH : Days after heading.
¶ Conventional was rice straw 5.4 ton/ha and nitrogen 110 kg/ha.
*, ** Duncan's multiple range test at 5, 1% level ; ns : Not significant.

Table 5. Grain yield and its components of rice as affected by nitrogen levels at machine- transplanted rice.

Nitrogen level (kg/ha)	Heading date	No. of panicle per m²	No. of spikelet /panicle	No. of spikelet /m²	Ripened grain (%)	1,000 grain wt. (g)	Brown rice yield (ton/ha)	Field† lodging (0~9)
55	Aug. 18	347b	74.8	25,981b	96.5	24.1	5.45c	0
77	Aug. 19	362b	76.1	27,539b	95.9	23.7	5.72b	0
110	Aug. 19	390a	78.2	30,518a	94.4	23.4	6.08a	1
Conventional‡	Aug. 19	357b	76.4	27,267b	96.4	24.0	5.66b	0
F-value		17.81**	1.01ns	13.50**	3.95ns	2.71ns	24.10**	

† The values were observed at 40 days after heading.
‡ Conventional was rice straw 5.4 ton/ha and nitrogen 110 kg/ha.
** Duncan's multiple range test at 1% level ; ns : Not significant.

vetch. Brown rice yields ranged from 5.45 to 6.08 ton/ha, indicating the yield increased as nitrogen level increased. No lodging was observed except for the 110 kg/ha nitrogen level plot with milk vetch in which a little bending lodging occurred. The yield was increased by 1% at the 77 kg/ha nitrogen level, and 7% at the 110 kg/ha nitrogen level plot with milk vetch compared with the conventional level.

Jeong et al. (1995) reported that rice yields of the fertilized plot with milk vetch (24 ton/ha) treatment, in which the degrees of field lodging and blast disease were 7 and 4, respectively, was decreased by 19% compared to the conventional (rice straw 5 ton/ha and N-P-K=110-70-80 kg/ha). This result indicated that rice yield varied with treatment time and method of milk vetch. Conclusively, rice cultivation following the cultivation of milk vetch which was plowed at the fruiting stage improved the soil as well as increased the rice yield.

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