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Vetch Effects for the Low-input No-till Direct-Seeding Rice-Vetch Cropping System

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ABSTRACT

A field experiment was carried out to observe the weed control effects of vetch and to evaluate vetch characteristics on clay loam soil in no-till direct-sown rice-vetch cropping systems. The effects of weed control, forage productivity, and N content of vetch plants were investigated.

With the progress of plant growth, density of Chinese milk vetch (*Astragalus sinicus* L.) gradually decreased, but densities of foxtail and other weeds decreased steeply due to the depression by the over-shaded vetch canopy in a no-till direct-sown rice-vetch cropping paddy field. The vetch density in tillage systems was lower than in no-tillage cropping systems. Lower vetch density occurred with an increase in foxtail density and other weeds. Weed control effect increased by the progress of vetch growth, which indicated that the vetch canopy over-shaded the weeds. Vetch straw was degraded rapidly submerqence after with water at the time of wet sowing of rice.

Early harvesting of vetch seed resulted in lower seed germination. To acquire enough seedlings without re-sowing, the harvesting of seed should be delayed at least 28 days after the flowering stage in order to ensure the vetch population is sustainable in a no-till direct-sown rice-vetch cropping system.

In order to improve the survival of vetch plants, vetch seeds should germinate from the heading stage to before the full-ripening stage of rice plants. To enhance the percent of over-wintering survival, vetch seeds should germinate no later than the end of October in southern Korea.

The dry weight of vetch plants increased with the progress of vetch growth until the flowering stage but N content decreased for 30 days from before the flowering stage (2.9%) until the ripening stage (1.8%).

We concluded that Chinese milk vetch could have an effect on weed control before the flowering stage, sustainability without re-sowing of seed annually, and effective green manure for rice pre-crop in no-till direct-sown rice-vetch relay cropping systems.

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Rice farming in Korea needs a labor saving and high productivity cultural system to reduce farming costs and to protect the environment. The no-till direct-sowing system has been adopted as the most efficient cost-reducing system (Cho and Choe, 1999. Cho et al., 1999). Additionally, vetch would be an essential crop to reduce the use of fertilizers and agro-chemicals (Cho et al. 1999). Chinese milk vetch seed is currently imported for the green paddy revolution in the winter season. Japan also imported vetch seed from China for the green manure crop, 120t in 1986, 190t in 1987, 320t in 1988 (Yasue, 1991). 30-40 kg/ha of Chinese milk vetch seed, is needed for establishing vetch seedlings (Choe, 1998)

Chinese milk vetch is more advantageous than hairly vetch and narrow leaf vetch for the sustainable no-till direct-sowing rice-vetch relay cropping system without re-sowing of vetch seed, which originated from the earlier ripening stage (Choe, 1998). Furthermore, it controls weed population by the progress of growth and it avoids damage by disease and pests by increasing the natural enemy population (Choe, 1998).

Slightly lower vetch population showed more nitrogen fixation by showing deeper rooting and larger nodule size (Choe et al., 1998). Chinese milk vetch fix 150-190 N kg/ha per year based on 20-40t/ha of green forage (Yasue, 1991). Chinese milk vetch cultivation reduced the N fertilization rate in till-transplanted rice cultivation (Jeong et al, 1996 and Ishikawa, 1963). Additionally, Chinese milk vetch could improve the physico-chemical properties of soil and the yield productivity of rice (Jeong et al, 1995). One facter to be considered is that Chinese milk vetch has hard seed which reduces the germination rate (Kim et al. 1992). With the above research results, the development of an environmently healthy rice cultivation method considered to reduce the labor and save cost has received interest.

The objectives of this research were to (1) evaluate the effects of vetch on weed control in no-till direct-sowing rice-vetch cropping systems, (2)examine the capability of sustainable rice-vetch relay cropping systems without re-sowing of vetch, and (3) decide the N supplying capacity and the organic matter productivity of Chinese milk vetch by the progress of growth.

MATERIALS AND METHODS

A field experiment was carried out to observe the effect of Chinese milk vetch (*Astragalus sinicus* L.: vetch) as the manure and cover crops on N supply and dry weight change of vetch straw. Additionally, seed germination and over-wintering characteristics were evaluated in a pot experiment.

A no-till direct-sown rice-vetch system had been conducted in a paddy field for 3 years from October 1994 to November 1997.

The vetch germinated in early September after water was drained at the ripening stage of rice in the paddy field. Over-wintered vetch plants grew gradually until the middle of April, and then grew rapidly to reach the flowering stage. Thirty days after flowering, the paddy field was submerged to degrade the vetch straw. Vetch plant height and plant density were measured as the growth progressed. Sample size was $0.1m^2$ of above-ground vetch plant. Dry weight was calculated after drying in a dry-oven at 75℃ for 48 hours. Characteristics of growth and N content of narrow leaf vetch (*Vicia Angutinefolia* L.) grown upland for 3 years without any artificial treatment, growing well in good-aeration and well water penetration soil, was compared to Chinese milk vetch in the paddy field. This was based on the same principle described by Nelson and Sommers (1982) on dry combustion using Perkin-Elmer 240. The soil pH was measured using a glass electrode pH meter (soil : water = 1 : 5). Nitrogen content (%) was analyzed with Kjeldahl method by using of Kjeltec-2000 for Digestion and Kjeltec-2000 for distilling. Exchangeable cations were extracted by 1.0N NH_4OAC (IITA, 1979), and the P, K, Ca, and Mg were measured by Inductively Coupled plasma Atomic Emmission Spectrometry, Shi-mazu (ICP 2000). The C/N ratio were simultaneously determined by using the dry combustion method on Sumigraph CHN analyzer (Sumigraph NC-90A).

Thirty vetch plant pods were harvested to determine the ripening stage and then were used for a germination test. Harvesting dates were May 10, 15, 17, 19, 21, and 23. After harvesting of pods, they were dried indoors for 4 weeks. After drying, pods were peeled out and 100 seeds were put on filter paper No.1 in a petridish(ø : 9cm) and then the petridish was covered. Water was supplied every two days with a micro-pipet. The petridish was located in a seed germinator maintained at 25℃. Germination rate was counted at intervals of 5 days for 30 days after sowing.

The pot experiment was conducted at the in experimental farm of Gyeongsang National University to observe seed germination and over-wintering. Pot size was 1/2,000a of plastic pot, which was filled with clay loam soil. A hole was made in all pots at the same level of the soil surface for water drainage. Vetch seed was sown on August 30, September 15, 25, and November 15 in the pot experiment. Fifty healthy, fully ripened seeds were over-sown on the soil surface in all pots. The germination ratio was counted 15 days after seed sowing. The over-wintering ratio was counted on March 1.

RESULTS AND DISCUSSION

Characteristics of Chinese milk vetch in paddy

Field experiment to observe weed control (Fig. 1) was carried out on clay loam soils (Table 1.) in no-till direct-sown rice-vetch cropping system. The effects of weed control, forage productivity, and plant N change were investigated.

In the paddy, all investigated nutrients were lower than the conventional cultivation paddy field which originated from the no chemical and organic fer-

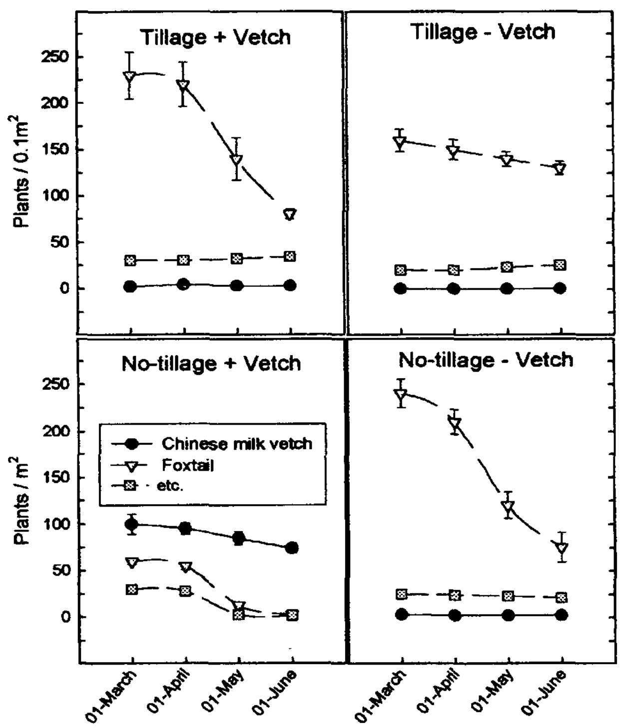

Fig. 1. Changes of plant densities affected by the tillage methods and the existence of Chinese milk vetch after over-wintering. Vertical bar indicates mean±SE.

Table 1. Chemical properties of the soil used in the experiments.

Site	Cropping	Tillage	pH	EC	Av. P_2O_5	Ca	K	Mg	OM
			(1 : 5)		(mg/kg)	(cmol+/kg)			(g/kg)
Sacheon (Sandy clay soil)	Before vetch cropping	No-till	5.7	0.21	55	8.9	0.82	1.91	17
		Till	5.8	0.22	70	7.4	0.79	1.73	16
	After vetch cropping	No-till	5.6	0.22	50	8.9	0.82	1.91	18
		Till	5.8	0.21	63	7.4	0.79	1.73	17

Table 2. Chemical composition of straws after ripening grown under paddy for Chinese milk vetch and upland for narrow leaf vetch.

Organic matter sources	Nitrogen (%)	C/N ratio	P (%)	K	S
				(cmol+/kg)	
Chinese milk vetch	2.12	15	0.30	1.47	0.38
Narrow leaf vetch	1.93	16	0.28	1.45	0.21

tilizer rice cultivation for 3 years and then Chinese milk vetch cropping fallow condition maintained for 2 years. The milk vetch contained more nutrients, N, P, K, and S, than the narrow leaf vetch after ripening (Table 2). But N content was higher in the narrow leaf vetch until the initial ripening stage (Fig. 3).

With the progress of plant growth, density of Chinese milk vetch (*Astragalus sinicus* L.) gradually decreased, but densities of foxtail and other weeds decreased steeply due to depression by the over-shaded vetch canopy in no-till direct-sown rice-vetch paddy field (Fig. 1). The vetch density in the tillage system was lower than in the no-tillage cropping system, which originated from the burying of vetch seed in the deep-soil layer. Lower vetch density occurred with the increase in the density of foxtail and other weeds (Fig. 1). The weed control effect increased with the increase in vetch plant height, which indicated that the vetch canopy over-shaded the weeds.

Germination characteristics of vetch seed

Harvesting time of vetch seed has normally affectted the germination percentage. The earlier harvesting of vetch seed has produced poor seed germination. To acquire more than 30% (critical percent to maintain vetch population without annual sowing) seed germination, harvesting of seed should be delayed at least 28 days after flowering (Fig. 2). Therefore, the vetch pod should be harvested and water submerged 28 days after flowering in order to ensure that the vetch population is sustainable in no-till direct-sown rice-vetch cropping systems.

Vetch seed production was 50~70 kg/ha, fully ripened seed only. Vetch seeds can germinate between March and October. In order to improve the survival of vetch plants, vetch seeds should germinate after the heading stage of rice. To enhance the over-wintering survival percentage, vetch seeds should germinate no later than the end of September in the southern part of Korea (Table 3).

Changes in growth characteristics and nitrogen content of vetch straw

The plant height of vetch was shorter than that of narrow leaf vetch throughout the growth period. The population of seedling numbers decreased by the progress of growth from 2,400 plants/m^2 at the initial growth stage to 1,600 plants/m^2 at the maximum flowering stage. Dry weight of vetch plant increased with vetch growth until flowering stage. In contrast to dry weight, nitrogen content (%) decreased for 30 days before flowering stage (2.9%) until the ripening stage (1.8%) (Fig. 3). The N content of vetch plant remarkedly decreased from the flowering stage to harvesting time.

Table 3. Effect of sowing dates on vetch germination rate and over wintering in pot experiment.

Sowing date	Germination (%)	Over-wintering(%)
30 Aug.	95 a[1]	65 a
15 Sept.	92 a	58 a
25 Sept.	83 b	23 c
15 Nov.	53 c	3 d

[1] Same letter means not significantly different at DMRT (0.05>P).

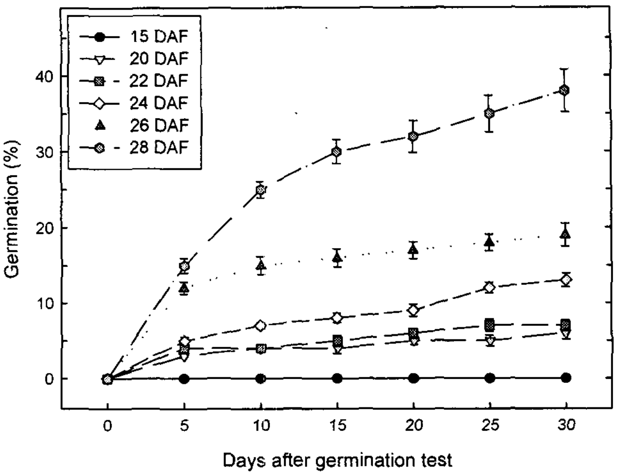

Fig. 2. Changes of seed germination rate of Chinese milk vetch(*Astragalus sinicus* L.) with different harvesting date of pod. Vertical bar indicates mean±SE.
DAF : Days after flowering stage of vetch plant.

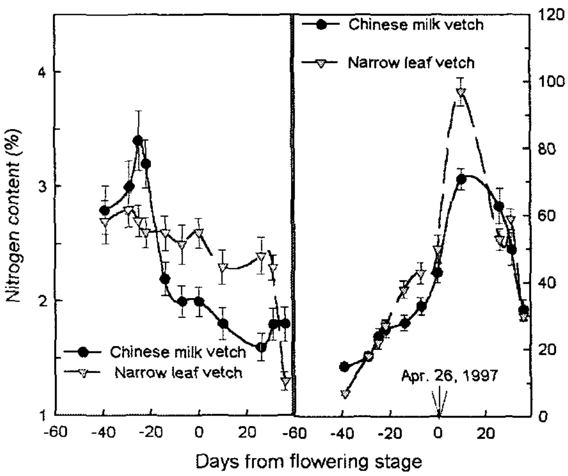

Fig. 3. Changes of plant dry weight and nitrogen content in naturally grown Chinese milk vetch in paddy and narrow leaf vetch in upland.
Vertical bar indicates mean±SE.

CONCLUSION

1. The natural seed-set date of Chinese milk vetch in no-till direct-sown rice-vetch relaying cropping systems was determined to be 28 days after flowering, but it was highly dependent on temperature. This date shall be interpreted with climate parameters, sum of average temperatures and the sum of sunshine hours during the period. Flowering of Chinese milk vetch started in mid April and reached full flowering in early May. Thus, rice seed should be sown after May 20 in order to obtain a natural vetch population without repeated sowing in the coming autumn.

2. Vetch seed sowing should be done before September 15 to get a higher over-wintering ratio to acquire enough seedlings.

3. N supply capacity was decreased due to plant growth from the initial flowering stage 155 kg/ha, as 7 organic matter t/ha, to the full ripening stage 54 kg/ha, as organic matter 3 t/ha. But the decreased organic matter was originated from the defoliation of leaves on the soil surface as the ripening progressed.

Eventually, no-fertilized no-till direct-sown rice-vetch relay cropping system could be possible in southern Korea.

4. Chinese milk vetch effectively suppressed weeds in the Spring, however, its effect decreased after the flowering stage of the vetch plant.

REFERENCES

Cho, Y. S. and Z. R. Choe. 1999. Effects of straw mulching and nitrogen fertilization on the growth of direct seeded rice in no-tillage rice/vetch cropping system. Korean J. Crop. Sci. 44(2): 97-101.

Cho, Y. S., B. Z. Lee., and Z. R. Choe. 1999. Nitrogen mineralization of cereal straws and vetch in paddy soil by test tube analysis. Korean J. Crop Sci. 44(2): 102-105.

Choe, Z. R., 1998. Development of labor-reduced high-quality rice production systems through no-till direct-sowing method. The final research report. Submitted the ministry of Agriculture and Forestry. p 65-69.

Hidaka. K., T. Mineta., and S. Takahashi., 1996. Experiment of low input sustainable rice cultivation with legumes living mulch and no-tillage under a condition of no usage of pesticide and fertilizer. ACSA, 362-363.

Ishikawa, M. 1963. Studies in the enhancement of fertilizer effect of Chinese milk vetch as green manure to paddy rice. Rep. Toyama Agr. Exp. Sta. 5: 1-140.

Jeong, J. H., Choi S. Y, Shin B. W and So J. D. 1996. Effect of milk vetch (*Astragalus sinicus* L.) cultivation on reduction of nitrogen fertilizer application rate in paddy soil. RDA. J. Agr. Sci. 38(2) : 299-303.

Jeong, J. H., So J. D. Rhee G. S and Kim H. J. 1995. Soil improvement and rice yield productivity by milkvetch (*Astragalus sinicus* L.) in paddy field. RDA. J. Agri. Sci. 37(1): 255-258.

Kim C. S. S. Y, Lee, J. W, Cho, and R. S. Kang. 1992. Research about Chinese milk vetch germination. Chungnam National Univ. Agri. research. 19(1): 1-8.

Nelson, D. W. and L. E. Sommers. 1982. Effect of sewage sludge on the decomposition of corn grain and fraction obtained by dry-milling Zea mays, additions to soil, uptake. Can. J. Plant Sci. v. 62(2): 335-344.

Yasue T. and U. Tsutiya. 1982. Chinese milk vetch and its history of cultivation. Kyoiku Shupan, Gifu. 52-107.

Yasue. T. 1991. The change of cultivation and utilization of Chinese milk vetch (*Astragalus sinicus* L.), and the effect of fertilizer and soil fertility on paddy field as a green manure. Jpn. J. Crop Sci. 60(40): 583-592.