Natural Reseeding Technology for Chinese Milk Vetch(*Astragalus sinicus* L.) in Rice Cropping System in Southern Korea

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Abstract

This study was carried out to develop a natural reseeding technology for chinese milk vetch (CMV)-rice cropping system in southern Korea. The optimum soil incorporation time of CMV plant residues, seed persistence in soil, N contribution and subsequent rice yield were determined from 2005 to 2007. Generally, insufficient seedling stand was regenerated when CMV was incorporated to the soil at 25 and 30 days after flowering(DAF), while high regeneration of greater than 400 seedlings m^{-2} was observed at 35 and 40 DAF. High reseeding of CMV incorporated at 35 DAF is related with hard seed dormancy and high seed viability. Appreciable number of CMV seeds remained in the soil three month after burial and CMV seedling regenerated from the seed bank at rice harvest time in the fall. Based on the relationship of reseeding number of CMV plants, seed hardness and seed viability after rice harvest in the fall, CMV plants should be incorporated into the soil 35DAF(May 30) or later when CMV seeds are sufficiently matured. The natural reseeding stand for the 3-year trials is stable ranging from 437 to 700 plants m^{-2} and also the biomass production is sufficient to supply nitrogen for rice growth. The use of reseeding CMV plant can increase rice yield by about 11% as compared with rice mono cropping. Natural reseeding technology has several advantages compared to the annual CMV one-time seeding such as reduction of rice production cost, enhancement of the winter survival of CMV, and 70~100% reduction of nitrogen fertilizer requirement, depending on the production of CMV biomass. The results indicate that natural reseeding technology is beneficial and could be encouraged in CMV-rice cropping system in the southern parts of Korea.

Media summary

Natural reseeding technology using CMV is beneficial and could be encouraged in CMV-rice cropping system in the southern parts of Korea.

Key words

Chinese milk vetch, reseeding, N content, rice yield, dormancy, persistence

Introduction

Chinese milk vetch is a popular winter annual green manure for sustainable production in rice fields of southern Korea because of its well adaptation to the winter environment(Kim et al. 2007; Lee et al. 2006; Na et al. 2007; Shim et al. 2004). In Korea, CMV seeds are entirely imported from China and the seeds planted annually in late September before rice is harvested because Korean farmers incorporate the CMV plants into the soil when CMV seeds are still immature. To reduce production costs, the introduction of natural reseeding technology for in rice production is necessary.

Recently, the policy on high quality rice production recommended the delay in rice transplanting time from mid or late May to early June which coincides with the maturation time of CMV seeds. Many green manures can be reseeded naturally depending on grazing termination date(Carr et al. 2005a, 2005b; Evers and Smith 2006), tillage methods(Chauhan et al. 2006) and seed persistence in soil(Rampton and Ching 1970; Mennan and Zandstra 2006). The study was carried out to determine the optimum soil incorporation time of CMV plants, seed persistence, dry matter production, influence on rice yield and its economic advantages compared to annual seeding and to develop natural reseeding technology for CMV in CMV-rice cropping system.

Methods

This investigation was conducted on silty clay loam at the experimental field of the Yeongnam Agricultural Research Institute, Milyang, Korea. Four CMV soil incorporation schedule from 25 to 40 DAF of CMV at 5-day interval were evaluated and the optimum natural reseeding date was determined based on the relationship of number of reseeding CMV plants, seed hardness, and seed viability after rice harvest in the fall. For biomass production, CMV plant was collected using 0.25㎡ quadrat at 10-day interval from seedling stage to maturity stage and the nitrogen content was analyzed with 2300 Kjeltec Analyzer Unit(Foss, Sweden)

For the seed persistence study, nylon mesh bags, each containing 100 seeds and pods were put separately in soil, one set at the soil surface(0 cm) and another at 5cm depth on June 13, 2007 prior to rice transplanting. The bags were retrieved at monthly interval until October. After each recovery*, in situ* germination, hard seed, and seed recovery were recorded and germination test was carried out with the recovered seed.

To investigate the CMV residues influence on rice growth, 25-day old rice seedlings were transplanted on June 8, 2007 and rice yield data was recorded after rice harvest.

Results

High regeneration rate of more than 400 seedlings m^{-2} was obtained when CMV plants were incorporated into soil at 35 and 40 DAF(Figure 1). During this stage of the CMV plants, the pods are matured sufficiently enough as indicated by their black color. However**,** incorporating CMV plants at 25 to 30 DAF resulted in low regeneration rates.

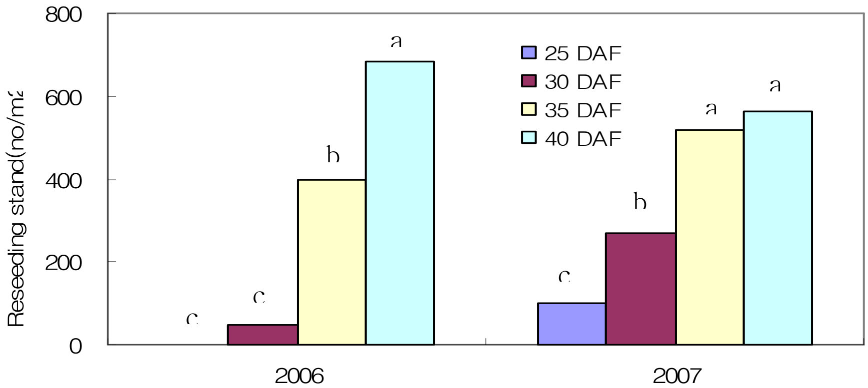

Figure 1. Natural reseeding stand of chinese milk vetch plant after rice harvest as influenced by CMV soil incorporation time into the soil.

High reseeding rates of CMV incorporated at 35 DAF or later are related with high hard seed dormancy and seed viability(Table 1). The seeds collected at 35 and 40 DAF had seed viability of 95 to 98 % and the weight of 1,000 seed ranged from 2.92 to 3.09g, indications of high maturity levels, while that of 25 to 30 DAF showed significantly low seed viability and lighter seed weight.

Table 1. Seed germination and seed viability of chinese milk vetch seed as influenced by seed collection time.

Seed collection time (DAF)	Germination (%)		Hard seed (%)		Seed viability (%)		1,000 seed weight (g)	
	2006	2007	2006	2007	2006	2007	2006	2007
25	15	6	52 c	81 b	54 c	83 b	1.94 c	2.25 c
30	12	7	82 b	92 a	85 b	97 a	2.59 b	2.74 b
35	8	3	92 a	95 a	95 a	98 a	2.92 a	3.06 a
40	7	4	93 a	95 a	98 a	98 a	3.09 a	3.08 a

In each column, means having a common letter are not significantly different at 5% level by DMRT

Freshly harvested CMV seeds were strongly dormant due to hard seed coat but the dormancy was gradually broken as the seeds stayed long in the soil. The percentage of hard seed was high with 95% in June but it decreased to 12 to 22% in seed and 31 to 33% in seeds with pod after three months of being buried. The seed viability loss was faster in the seeds than in seeds with pods regardless of depth of placements in the soil The seed recovery rate was only 52 to 65% in the seed while nearly100% recovery was recorded in the seeds with pods after three months of being buried in the soil in both 0 and 5cm depths in September (Figure 2**).** The recovered seed germination rate was 25 to 35% in seeds and 55 to 61% in pod storage. This indicates that dormant CMV seeds buried in the soil during land preparation become nondormant after rice cropping period and appreciable number of remaining seeds are regenerated in the months of September or October when the rice field was drained for rice harvest in the fall. These results confirmed that CMV plant could regenerate naturally from the seed bank during previous cover crop periods.

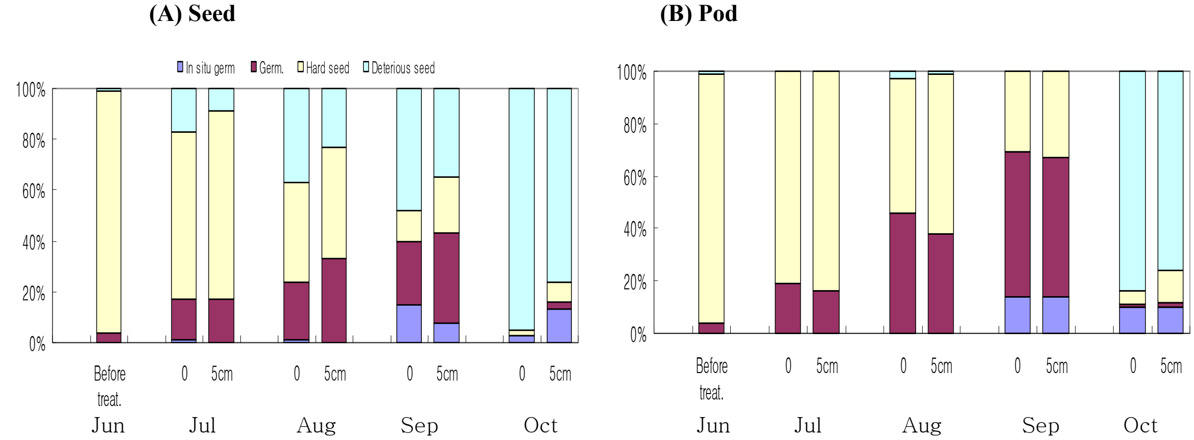

Figure 2. Change in percentage of hard seed, germination and seed persistence in chinese milk vetch seed buried in the rice field as seed(A) and pod(B) at 0 and 5cm soil depth.

High CMV reseeding stand ranging from 437 to 700 plants m^{-2} were recorded during the 3-year trails when soil incorporation was made on May 30(Table 2). The CMV cover crop provided 101 to 158 kg N ha^{-1} and the greater CMV N content in 2007 was associated with greater dry matter accumulation.

Table 2. Seedling stand, biomass production and N yield in natural reseeding CMV-rice cropping systems.

Year	Seedling stand (plant/㎡)	Dry matter (Mg/ha)	N content (kg/ha)
2005	437	3.47	101
2006	565	4.38	130
2007	700	4.97	158

The use of CMV cover crop alone increased rice yield about 11% as compared with rice mono cropping although this increase was not statistically significant(Table 3). The increase in rice yield was contributed by increased panicle spiketlet number m^{-2} and heavier grain weight in CMV-rice cropping system. This indicates that the CMV residues are sufficient to supply N nutrient in rice production without the application of additional chemical fertilizer.

Table 3. Rice growth and milled rice yield in natural reseeding CMV-rice cropping systems.

CMV production (Mg/ha)	N Fertilizer (kg/ha)	Spiketlet (no/㎡)	Ripened grain (%)	1,000 brown rice weight (g)	Milled rice (kg/ha)
2.61	0	27,602 a	85.1 a	23.3 b	4,740 a
4.97	0	31,184 a	80.8 b	24.1 a	5,140 a
Chemical Fertilizer	90	30,869 a	83.4 ab	23.0 b	4,880 a

In each column, means having a common letter are not significantly different at 5% level by DMRT

The practice of natural reseeding technology showed several advantages compared to the annual CMV seeding. These include saving of seed cost, reduction of rice production cost, enhancement of the winter survival of CMV, and 70~100% reduction of nitrogen fertilizer requirement depending on the production of CMV biomass. The result indicated that natural reseeding technology is beneficial and could be encouraged in CMV-rice cropping system in the southern parts of Korea.

Conclusion

In southern Korea, soil incorporation of CMV plants at 35 DAF(May 30) or later can successfully reseed naturally with only one-time CMV seeding and will result to comparable rice yield without additional chemical fertilizer application.

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