Effects of legume mixture on nitrogen fixation and transfer to grasses in spring paddy field

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Key words: Biological nitrogen fixation, N transfer, ^{15}N dilution method

Abstract

Nitrogen fixation by legumes can be valuable sources for organic farming. This study was to investigate the effect of different legume mixtures on nitrogen fixation and transfer to grasses on spring paddy field. Three different mixtures were used (rye+hairy vetch, Italian ryegrass+crimson clover, oat+pea) in a randomized complete block design with three replications and sowed in pots with different sowing rate (5:5 rye:hairy vetch,7:3=Italian:crimson, 6:4=oat:pea) on early March. $(^{15}NH_4)_2SO_4$ solution at. 99.8 atom%^{15}N was applied to the each pot at the rate of 2kg N ha^{-1} on 16th April. Forage were harvested at ground level in heading stage and separated into legume and grass. Total N content and ^{15}N value were determined using a continuous flow stable isotope ratio mass spectrometry. DM yield of rye+vetch, Italian+crimson and oat+pea were 6,607, 3,213 and 4,312kg/ha, respectively. Proportion of N from fixation was 0.73(rye+vetch), 0.42(Italian+crimson) and 0.93(oat+pea). The percentages of N transfer from legume to grass were from 61% to 24% in different method by treatments and –35% to 21% in isotope dilution method.

Introduction

One of the advantages with grasses and legume mixture is that legume can fix atmospheric nitrogen and the process is essential for organic farmers who try to make good use of natural organic resources as possible as they can. The roughages from mixed forage can supply balanced nutrition of protein and energy for ruminants.

Legume is important because they have residual effects on the succeeding crops so that the plant contributes N economy in agricultural crop production system. The inclusion of leguminous crops into rice crop system may contribute towards improving the prospects of their long term sustainability because they are able to fix N_2 from air (Chalk, 1998). Rye is winter crops grown in mid part of South Korea and the mixture of

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legume with forage cereal become popular these days because farmer begin to recognize the role of legumes in organic farming. There are some reports on legume in N dynamic as dry season crops immediately following single or double lowland rice. To maximize forge yield in oat-hairy vetch mixture, authors recommended that the plant had to seed in the fall and harvest in the spring in South Korea (Kim, etc, 2002). The findings of N_2 fixation and N transfer from legumes to forage cereals on paddy soil is limiting in Korea. This research was to measure N_2 fixation in legumes mixed with cereals and estimate the amount of transferred N to grasses by ^{15}N dilution and different method.

Materials and methods

The studies reported here were conducted in pot trial from Jan, to June in 2006. There were three different treatment; hairy vetch+rye, crimson clover+Italianrye grass, oat+pea mixture. The experimental design was complete randomized with three replications plus only barley pots as reference crops. The pot was 45×43x30cm and sowed 4 rows $(^{15}NH_4)_2SO_4$ solution at 99.7 atom% excess was applied to pots at the rate of 2kg/ha on February 1st. All pot was well irrigated to maintain paddy moisture condition. Condition crop was harvested from central two rows in the pot at ground level and separated into grass and clover fraction. A sub sample of the plant was taken for analysis of 15N concentration by a continuous flow stable isotope ratio mass-spectrophotometer. Biological nitrogen fixation by legume was estimated by people et al (1989) method, using grasses as the control. The transfer of biologically fixed N with difference method and 15N dilution was by chalk (1996).

Results

DM yield were 7,217kg/ha in rye+vetch, 3,314kg/ha in Italian ryegrass and 4,466kg/ha in oat+pea mixture<Table 1>.The N production was 208kg in vetch+rye,54kg in crimson clover+Italianrye grass and 53kg/ha in pea+oat treatment. N production was greatly influenced by DM production in the mixture because rye+ vetch combination was higher than that of two treatments <Table 2>. The proportion of N derived from atmospheric nitrogen with different treatments were 0.73,0.42 and 0.93 respectively. The highest biological nitrogen fixation was from pea+oat while lowest on crimson clover+Italian rye grass mixture. Estimates of N transfer from legumes to grasses were presented in <Table 2>. Transfer rate from legumes to grasses was different with measurement; higher rate in N difference method than in isotopic method.

Italian+crimson and oat + pea plots showed minus value, indicating no N transfer from legumes. Different method revealed higher transfer amount than ^{15}N dilution method.

Tab. 1: Effects of legume+ grass mixture on DM yield and total N production.

Treatment	Grasses			Legume				
	DM Yield (kg/ha)	N (%)	N production (kg/ha)	DM yield (kg/ha)	N (%)	N production (kg/ha)	DM yield (kg/ha)	TN (kg/ha)
Rye+vetch	6,607.1	2.839	186.2	610.1	3.528	21.8	7,217.2	208.0
Ital.+Crimson	3,213.5	1.666	53.1	101.1	1.293	1.2	3,314.4	54.3
Oat+pea	4,321.9	1.123	48.7	144.3	3.510	5.0	4,466.2	53.7

Tab. 2: Proportion of N from N_2 and estimate of N transfer from legumes to forage grasses by different and ^{15}N dilution method.

Treatment	Method	* Prop.N from N_2	Botanical composition (G:L)	TN	Transfer rate (%)
Rye+Vetch	Difference	0.73	92:8	208.0	61
	^{15}N dilution				21
Itali.+Crimson	Difference	0.42	97:3	54.3	24
	^{15}N dilution				–32
Oat+pea	Difference	0.93	97:3	53.7	36
	^{15}N dilution			-35	-18.8

(atoms%15 N excess soil delived N)

The N-difference method

Nleg(=>non-leg) = Nnon-leg(m) - Nnon-leg(p)·R(1)

Pnon-leg(<=leg) = Nleg(=>non-leg)/Nnon-leg(m)

= 1 - (Nnon-leg(p)·R/Nnon-leg(m))

^{15}N-dillution method

Pnon-leg(<=atm) = 1 - (Enon-leg(m)/Enon-leg(p)

Pleg(<=atm) = 1 - (Eleg(m)/Enon-leg(p)

Discussion

7,217kg DM/ha in rye+ vetch mixture was lower yield than Kim's report (2002) partly because of pot trial and spring seeding. DM yield of the remainder treatment was also lower than other researcher's results (kim etc,2010). Even though the yield was not satisfied it can be good sources of natural compost for organic rice cultivation. Proportion of derivation from atmospheric nitrogen was variable. Chen (1998) reported 0.95 to 0.85.On the other hand, Lailaw(1998) showed 0.95 to 0.78 with nitrogen application. Transfer from legumes to grasses was highest in vetch+rye mixture while other two treatments showed minus transfer. It seemed that low composition of legume in the mixture was the main reason for minus transfer. Poor stand of legumes don't guarantee beneficial effect of legume in mixed stand(grass:legume=92:8 in rye+vetch treatment).Generally 50% of legume composition is recommended for N contribution.

Conclusion

DM, biological nitrogen fixation from atmospheric nitrogen, transfer from legumes to grasses were investigated.DM was ranged from 7,217kg to 3,314kg/ha and N derivation proportion from atmospheric nitrogen was 0.73 in vetch+rye pots, 0.42 in crimson+Italian ryegrass and 0.93 in pea+oat combination. N transfer from legumes to grasses varied with treatments, highest at rye+vetch pots with 61% and lowest at Italian +crimson mixture with minus 31%.Transfer rate revealed that difference method was higher than that of in isotope method .

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