Effect of Organic Nitrogen Levels on N Fixation in Pea-Barley Mixture

H. W. Lee
Korea National Open University, South Korea

J. D. Kim
Cheonan Yonam College, South Korea

C. H. Kim
Kongju National University, South Korea

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HW Lee [A], JD Kim [B] and CH Kim [C]

[A] Department of Agricultural Science. Korea National Open University, Seoul 110-791, Republic of Korea
[B] Cheonan Yonam College, Sunghwan, Cheonan-Si 330-709, Republic of Korea
[C] Department of Plant Resources, Kongju National University, Chongnam Ye-san Daehak-ro 54, Republic of Korea
Contact email: hyowon@knou.ac.kr

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Introduction

One limitation in organic farming is short supply of forage. Organic fertilizer including cattle manure is overproduced in Korea but farmers are reluctant to use these kinds of resources because of heavy weight and handling cost. Legumes are of crucial importance for the N supply of grassland farming. They convert atmospheric dinitrogen (N_2) to plant available N through symbiosis. Information on N_2 fixation and transfer is lacking in Asian countries with a lot of results coming from EU and America. The objective of this report was to estimate potential N fixation and determine related benefits from intercropping pea with barley at different organic fertilizer levels. We also wished to measure the efficacy of N2 fixation by 15N dilution and the difference method using barley as reference crop.

Materials and Methods

Pure stands of pea (*Pisum sativum* L. cv. Chungmi) and barley (*Hordeum vulgare* L. cv. Albori) and a mixture of the two were sown on 15th of March in 2009. Seed rate was 40 kg/ha of barley and 70 kg/ha of pea. The experiments were arranged in a complete block design with 3 replications. Treatments were three levels organic fertilizer N, 40, 80 and 120 kg/ha. P and K were applied in a chemical fertilizer. When the crops were at the early stage of plant growth, a subplot of 600cm^2 was fertilized with a solution of $^{15}NH_4SO_4$ at 99.7 atom% excess at a rate to corresponding to 7 kg/ha. Crops were harvested at maturity from each plot and separated into pea and barley. Total N content and ^{15}N values of the sample were analyzed using a continuous flow stable isotope ratio mass spectrometer. Nitrogen fixation of pea was determined with a procedure described by Peoples *et al.* (1989) and Chalk (1996).

Results and Discussion

Table 1 shows the estimate of N fixation and transfer by ^{15}N dilution. The percent of total N derived from atmosphere (%Ndfa) at maturity ranged from 0.89 to 4.45, indicating a very low value. There were significant differences between treatments with 40kg organic N lower than other N levels. Sakai *et al.* (2011) reported intercropping with lupin and cowpea transferred 18 and 17% of N, and transfer N from pea to oat was 10.7 to10.3 kg/ha. The greatest fixation was from the 80 kg organic N plots. Using the applied difference method, the transfer rate and transfer amount were highest in the 120 kg N treatment (Table 2). N transfer rate was from 23.1 to 47.5% and the amount ranged from 44.1 to 91.7 kg/ha. Haby *et al.* (2006), reported %Ndfa was 42 and the transfer N yield was less than 18kg/ha/yr. Anderson *et al.* (2004) reported that the greatest relative amount of N_2 fixed at maturity was measured for the pea grown in association with rape under condition of low N fertilization. Because the ^{15}N dilution method is based on concentration (of ^{15}N) in the N uptake and not on the total N amount as in the difference method, there was difference between two methods in terms of N fixation and transfer amount. (Geijersstam *et al.* 2006).

Table 1. Estimate of N fixation and transfer to barley at different levels of organic N fertilization by 15N dilution method.

Treatments (N/ha)	N fixation rate (%)	Total N (kg/ha)	Fixed amount (kg/ha)	Transfer amount (kg/ha)
Organic N 40 kg	0.89a	192	1.71	0
Organic N 80kg	4.43b	233	10.32	0
Organic N 120kg	4.65b	195	9.08	0

^{15}N-dillution method. Pnon-leg(<=atm) = 1 - (Enon-leg(m)/Enon-leg(p) Pleg(<=atm) = 1 - (Eleg(m)/Enon-leg(p)

Table 2. Estimate of N transfer from pea to barley at different levels of organic N fertilization by difference method

Treatment (N/ha)	N transfer rate (%)	Total N (kg/ha)	Transfer amount (kg/ha)
Organic N 40 kg	23.1a	192	44.1
Organic N 80 kg	23.2a	232	56.9
Organic N 120 kg	47.5b	195	91.7

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))

Conclusion

Our findings indicate that there was large difference between ^{15}N dilution and difference method for determination of N fixation from atmosphere. N transfer to barley was 0.89 to 4.65% in ^{15}N dilution and 23.1 to 47.5% in difference method when organic N fertilization levels were different. We also confirm that estimates of N_2 fixation were varied with measurement method, maturity, soil, plant and so on.

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