^{15}Nitrogen transfer from legumes to neighbouring plants in a multi-species grassland

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Abstract

This study investigates the N transfer from legumes to neighbouring plants, grasses, legumes and herbs in a temperate grassland. In a field experiment white clover (*Trifolium repens*), red clover (*Trifolium pratense*) and lucerne (*Medicago sativa*) were leaf-labelled with ^{15}N enriched urea. The ^{15}N tracer was measured in above-ground plant tissue of eight neighbouring plants in two subsequent harvests in 2008. The three legumes donated ^{15}N to all neighbouring plants, of which grasses, white and red clover were strong receivers. Results show that N transfer increases with N application and from the 1st to the 2nd cut.

Introduction

Legumes play a crucial role in the nitrogen (N) input to organic and low-input agricultural systems. In grass-clover mixtures, N transfer from clover to grass plays an important role. This study investigated I) the importance of N transfer from three legumes, white clover, red clover and lucerne, to neighbouring plants (white clover, red clover, lucerne, grasses (*Lolium perenne* and *XFestulium*), birdsfoot trefoil (*Lotus corniculatus*), plantain (*Plantago lanceolata*), chicory (*Cichorium intybus*), salad burnet (*Poterium sanguisorba*) and caraway (*Carum carvi*)) in a multi-species mixture and II) the effect of cattle slurry application on the N transfer.

Material and methods

A nine-species grassland was established in crop rotation for organic dairy cows grown at the

Research Farm Foulumgaard, Aarhus University, Denmark. PVC cylinders (40 cm high and 29.7 cm in diameter) were installed in the field and used as experimental plots. Half of the plots were treated twice (in the spring and after the 1st cut 2008) with cattle slurry (in total 200 kg N/ha). Four times in the growing seasons, two weeks before each harvest, leaves of white clover, red clover and lucerne were labelled with ^{15}N urea, (99.5 atom %). Above-ground plant tissue was cut four times in 2008 (1st and 2nd cut are presented here), separated into different plant species and analyzed for total N and ^{15}N enrichment. ^{15}N enrichments were corrected for background ^{15}N levels from untreated plant species next to the treated plots and ^{15}N transfer from one legume species to neighbouring plants were calculated based on Ledgards equation (1985) and modified accordingly to a multi-species system.

Results

All legumes donated ^{15}N to neighbouring plant species in the multi-species mixture, which is presented as proportion of ^{15}N in receiver plants coming from the donor (Fig 1.). White clover was a generous donor in the 1st cut (3.2 % of N in all receiver plants coming from white clover in the 1st cut; 0.3 % in the 2nd cut) while red clover was most generous in the 2nd cut (2.5 % in the 1st cut; 6.8 % in the 2nd cut) and lucerne was an intermediate donor in both cuts (2.4 % in the 1st cut; 4.1% in the 2nd cut). The grasses contained the highest proportion of ^{15}N transferred from the three legumes in most of the measurements. Interestingly, the two legumes white clover and red clover received a substantial amount of nitrogen from neighbouring legumes whereas lucerne was a weak competitor for N in both cuts (Fig 1.). Also, plantain and chicory received in both cuts and both N treatments substantial proportions of ^{15}N from the donors. The percentage of ^{15}N transferred increased from the 1st to the 2nd cut for red clover and lucerne as donor and decreased for white clover as donor. Nitrogen application in the form of dairy cattle slurry generally gave an increase in % of ^{15}N transferred. To take the proportions of dry matter of each plant species into account the amount of ^{15}N in the receiver plants coming from the donors was calculated (Fig 2.). The distribution of transferred N between the different plant species was generally similar to the proportions shown in figure 1. However, the amount of N transfer from legumes to herb species was very low in most cases, besides that chicory received around 400 mg ^{15}N in 200N plots on the 2nd cut (Fig 2). Furthermore, grasses in 0N plots on the 2nd cut received lower amounts of N from red clover and lucerne, which can be attributed to the low % of grass dry matter in 0N plots on the 2nd cut (data not shown).

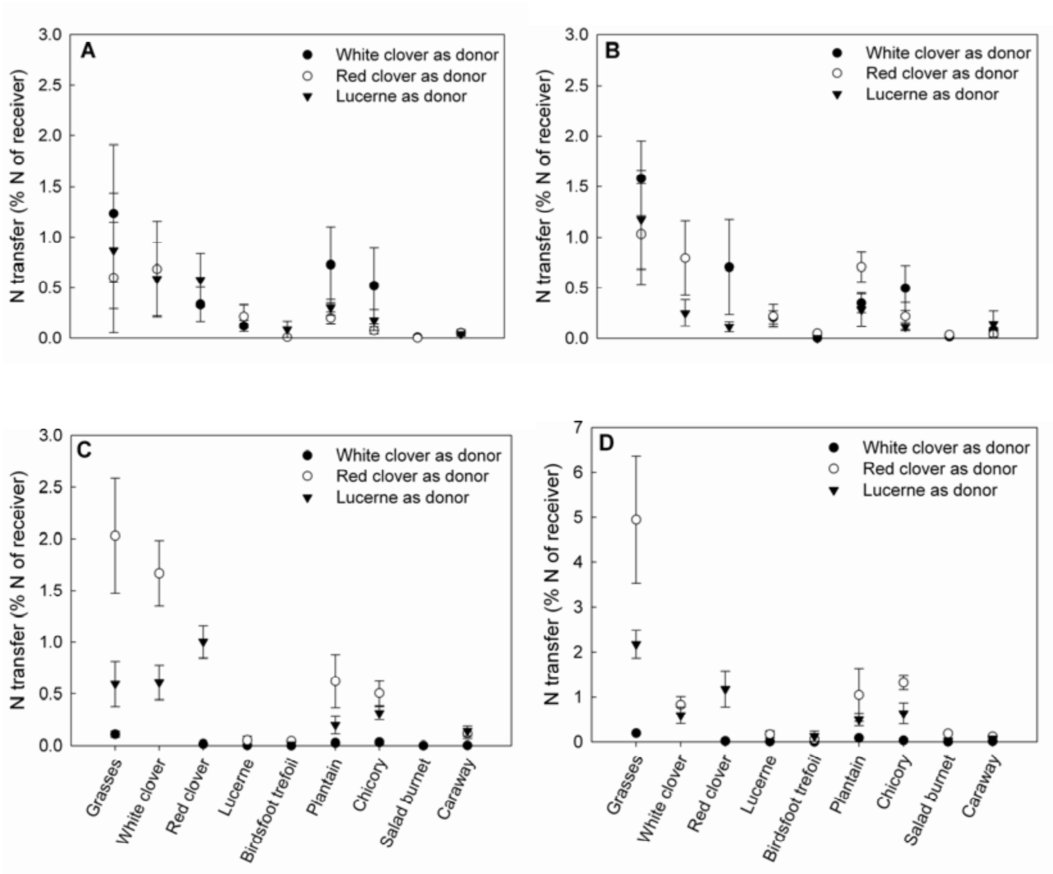

Fig 1. Percentage of ^{15}N transferred from white clover, red clover and lucerne to neighbouring plant species in cylinders with no (A, C) and with (B, D) slurry application on the 1st (A, B) and 2nd cut (C, D) in 2008. Values are means ± S.E. (n=1 to 8). Note different scale for figure D.

Discussion

This study shows that white clover, red clover and lucerne pass on N to neighbouring plant species in different scales. Generally, the N transfer was low, but in agreement to our results Høgh-Jensen et al. (2006) showed an increase of N transfer with the growing season, and thus, higher percentages of N transfer are expected for the 3rd and 4th cut. Grasses, white clover and red clover were the main receivers of N from the donor legumes. Interestingly, the N transfer to lucerne was very low, which suggests that lucerne was not able to compete with the other species for soil N, whereas both white and red clover competed well or had reuptake systems to compensate for N losses due to 'leaky' roots. Upscaling the amount of N transfer to a hectare area ranged from a very small amount of 0.0001 kg N/ha (Salad burnet received

N from white clover) to a substantial amount of 173 kg N/ha (Grasses received N from red clover). Furthermore, the application of dairy cattle slurry resulted in an increase of N transfer from legumes to neighbouring plants. Paynel et al. (2008) suggest an increase of root dry weight in the N receiver plant species' in plots with high N application, which results in an increased access to soil N resources, including N components from donor legumes.

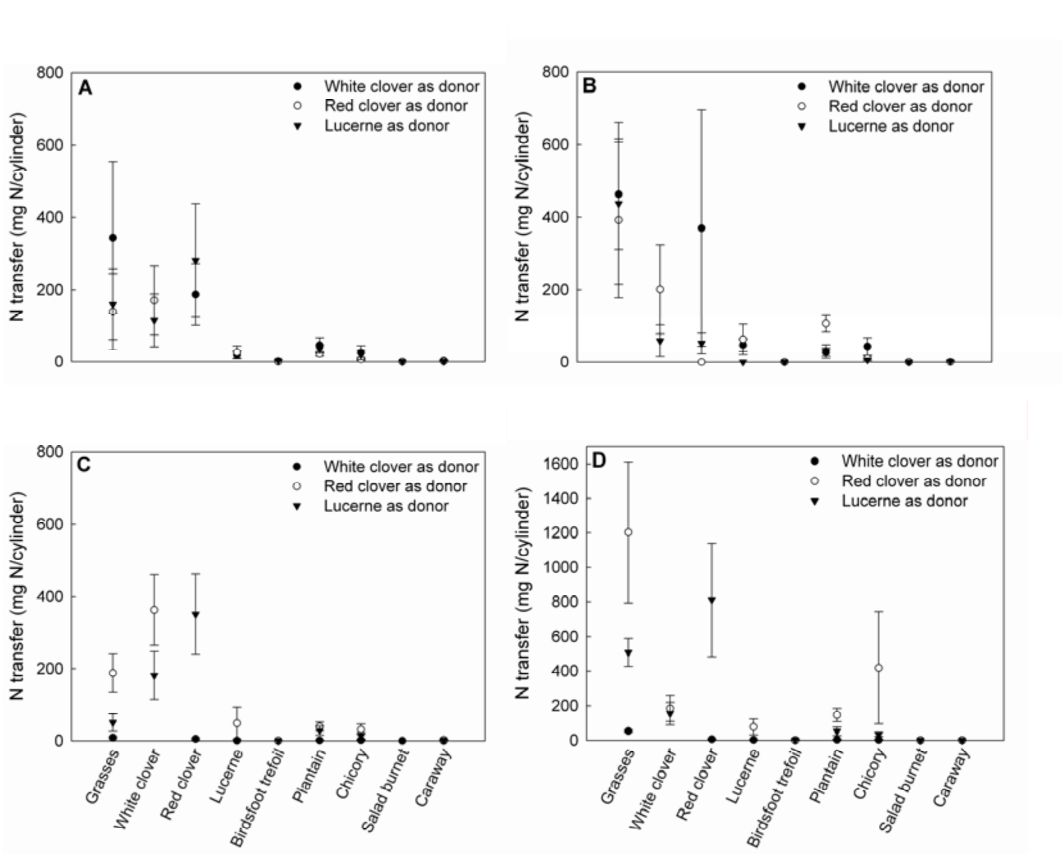

Fig 2. Amount of ^{15}N transferred from white clover, red clover and lucerne to neighbouring plant species in cylinders with no (A, C) and with (B, D) slurry application and on the 1st (A, B) and 2nd cut (C, D) in 2008. Values are means ± S.E. (n=1 to 8). Note different scale for figure D.

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