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^{15}Nitrogen uptake from shallow- versus deep-rooted plants in multi-species and monoculture grassland

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Introduction

A number of studies examined grassland diversity in terms of nitrogen (N) supply from legumes. Less examined is plant diversity in perennial grassland based on different rooting depths. Multi-species grasslands with plants differing in the rooting system could increase the N use efficiency of the whole plant community by complementary nutrient uptake.

We hypothesized….

1) that interspecific competition increases the N uptake in multi-species mixtures compared to monocultures, and…

2) that the N uptake from deep soil layers could increase by growing deep-rooted species (chicory and lucerne) in mixture with shallow-rooted species (perennial ryegrass and white clover).

Method

From September 2007 to October 2009 we grew five grassland plant communities in four replicate plots at the Research Farm of the University of Copenhagen in Denmark.

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On the 8th of June 2009, 25 days after the first cut, we placed ammonium-sulphate, enriched with the heavy nitrogen isotope ^{15}N (99.5 atom %), at 40, 80 and 120 cm depth (156.25mg ^{15}N/m^2).

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Ten days after, we measured ^{15}N enrichments in the above-ground plant biomass, which we corrected for background ^{15}N levels from untreated plant communities next to the treated plots and normalized for the respective above-ground plant biomass to finally receive the amount of ^{15}N taken up (mg^{15}N uptake/m^2).

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Regression analysis was used to analyze how ^{15}N uptake was influenced by depth in different plant communities and single plant species grown in monoculture or a 4-species mixtures.

Monoculture: Perennial ryegrass [*Lolium perenne*]

Monoculture: Lucerne, alfalfa [*Medicago sativa*]

Monoculture: Chicory [*Chicorium intybus*]

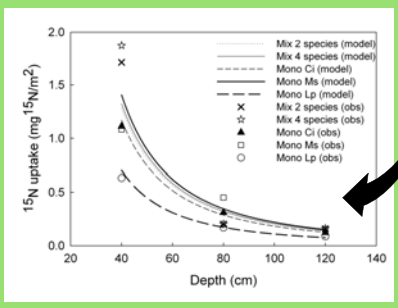
Mixture: perennial ryegrass, white clover [*Trifolium repens*]

Mixture: perennial ryegrass, white clover, lucerne and chicory

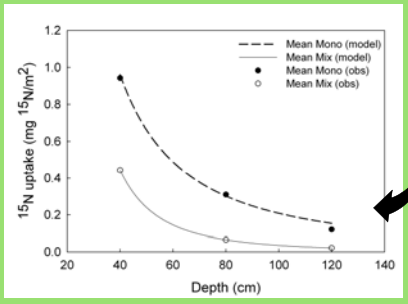
Results

All plant communities showed the same relative decline in ^{15}N uptake by increasing soil depths ($p=0.353$), except monoculture *L. perenne* showed lower ^{15}N uptake than the rest.

The observed means of ^{15}N uptake in the 4-species and 2-species plant community appeared to be higher in 40 cm depth than in the monocultures, but the difference was not significant ($p>0.05$).



The N uptake decreased relatively stronger when plant species were grown in a 4-species mixtures compared with monocultures ($p<0.0001$).



Discussion and conclusions

❖ When competing in the mixture, the deep-rooted lucerne can have invested in atmospheric N fixation instead of foraging N in deep soil layers.

❖ N uptake from deep soil layers can also change throughout the growing season and thus additional studies at different periods in the growing season can give a more detailed picture.

❖ Soil water content, measured during the experiment, was very low and could have inhibited the N uptake.

At a single period of 10 days…

1) there was no increase in N uptake by increasing depth when plant species were grown in a competitive multi-species mixture, and…

2) it was not possible to show an increase in N uptake from deep soil layers when growing deep-rooted species in mixture with shallow-rooted species.