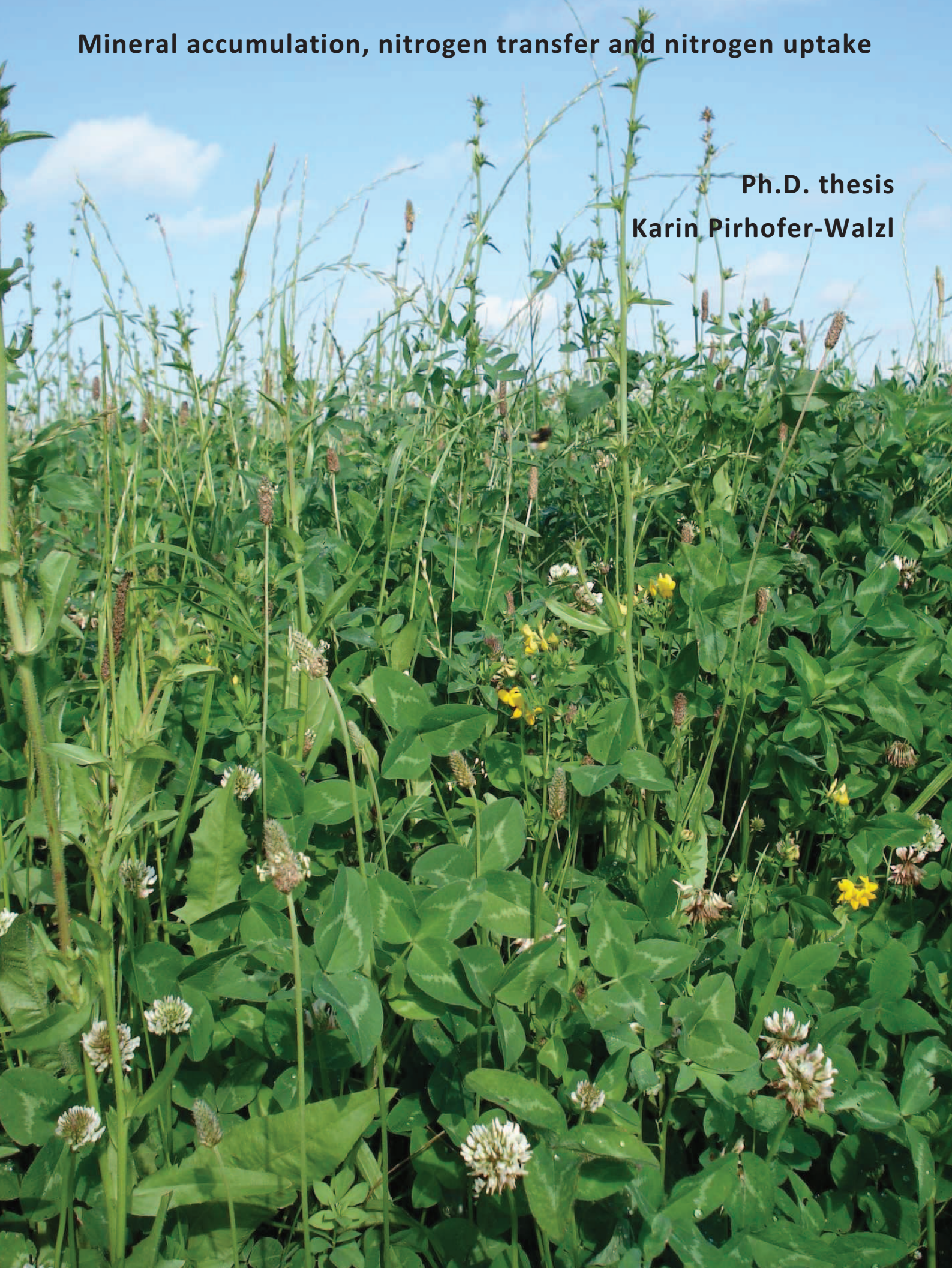


Performance of multi-species grassland mixtures

Mineral accumulation, nitrogen transfer and nitrogen uptake

Ph.D. thesis

Karin Pirhofer-Walzl





PhD thesis

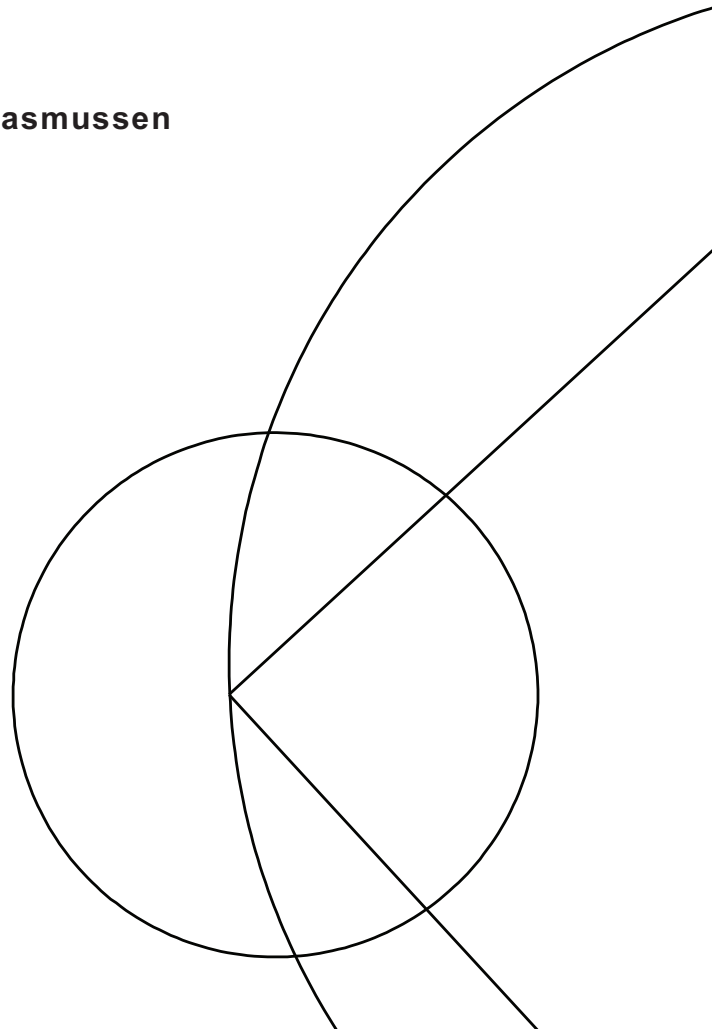
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Submitted: 15 April 2011



„Denn wenn keine Natur wäre, so wäre auch keine Herrlichkeit und Macht, viel weniger Majestät, auch kein Geist; sondern eine Stille ohne Wesen, ein ewig nichts ohne Glanz und Schein.“ (Jakob Böhme)

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English summary

This thesis is located within the framework of research on temperate agricultural grasslands. Plant diversity in temperate agricultural grasslands is impoverished today. Many conventional grasslands in Europe consist of simple grass mixtures, sometimes monocultures. Organic and increasingly conventional grasslands are sown as mixtures of grasses and legumes and from time to time as multi-species mixtures that include forage herbs. Temporary grasslands are regularly resown or incorporated in a crop rotation and produce ruminant fodder. Some studies indicate that various forage herbs have traits that may complement grass-legume mixtures; among others, increased macro- and micromineral concentration. Hence multi-species grassland mixtures, comprising grasses, legumes and herbs, may have a potential to improve common grasslands consisting of low plant diversity. The legume component of a grass-legume mixture contributes to nitrogen (N) self-sufficiency of the grassland because of its ability for symbiotic N₂ fixation, which allows reduced fertilizer application. Several studies present a positive plant diversity-productivity relationship for temporary European grasslands. Increased soil nutrient use in grasslands with higher plant diversity may be one explanation, where, for example, deep-rooted plant species enable nutrient uptake from deep soil layers.

In a state of limbo between ecological hypotheses and agricultural needs, and with the background of limited information on forage herbs and multi-species grassland mixtures, the objective of this Ph.D. study was to quantify the performance of multi-species grassland mixtures in terms of three nutrient processes: 1) mineral accumulation, 2) nitrogen transfer and 3) nitrogen uptake. Three field experiments were conducted in Denmark: two on a loamy-sandy site and one on a sandy-loamy site.

The four forage herbs – chicory (*Cichorium intybus* L.), plantain (*Plantago lanceolata* L.), salad burnet (*Sanguisorba minor* L.) and caraway (*Carum carvi* L.) – grown in a nine-species grass-legume-herb mixture showed in my first field experiment, potential in increasing the macro- and micromineral quality of ruminant fodder derived from grasslands. In a second experiment, legumes, which were confirmed to be the N-richest forage plants of the multi-species mixture, donated N to all nine neighboring plants. Grasses (*x**Festulolium* and *Lolium perenne* L.) received the largest amount of N among the receiver plants, mainly from white clover (*Trifolium repens* L.), and slurry application mainly stimulated N transfer from legumes towards grasses. The third experiment confirmed the strong N absorption characteristic of perennial ryegrass when grown in a multi-species mixture. When deep-rooted chicory and lucerne (*Medicago sativa* L.) were added to a shallow-rooted perennial ryegrass-white clover mixture, total N uptake from three vertical soil

layers of this four-species grass-legume-herb mixture did not increase. Chicory, however, took up greater proportions of N from deeper soil layers compared with the other plant species.

This study showed that multi-species grassland mixtures have the potential to improve the common simple grass or grass-legume mixtures by reducing the need for external mineral supplementation and by more efficient N use. Yet to use varying plant diversity as a management tool in an agricultural system based on grasslands, more knowledge from grass-legume-herb mixtures to animal performance is needed. Ecologists, agronomists and seed companies may work together to develop improved sustainable grasslands which to a certain extent may mimic natural grasslands.