# Germplasm Effects on Subsoil Nitrate Uptake by Alfalfa

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## Introduction

Excessive N applications as commercial fertilizer, animal manure, and organic waste products have been implicated in contamination of surface water, ground water, and the atmosphere. Field studies routinely show that soil inorganic N concentrations and nitrate leaching losses are smaller under deeply rooted perennial crops, like alfalfa (*Medicago sativa* L.), than under annual crops, like corn (*Zea mays* L.).

Nitrogen removed in alfalfa herbage consists not only of N from the inorganic soil N supply, but also atmospheric $N_2$ fixed by *Rhizobium meliloti* in root nodules and N remobilized internally from crowns and roots. In an earlier study we discovered that ineffective, non-$N_2$-fixing alfalfa was more efficient in subsoil nitrate removal than its $N_2$-fixing parent. Nutrient uptake often is related to root system architecture, and recent development of alfalfas that have divergent root architecture traits provides a means to test this in alfalfa. In addition, nitrate is reduced in both the roots and leaves of alfalfa, so the multileaf trait found in many commercial cultivars may provide an advantage for nitrate assimilation.

Our objectives were to: 1) reevaluate the efficacy of ineffective alfalfa at absorbing subsoil nitrate; and 2) compare removal of subsoil nitrate in herbage of several $N_2$-fixing alfalfa cultivars differing in their root system architecture and leaf morphology.

## Materials and Methods

The experiment was conducted at the University of Minnesota Sand Plain Research Farm, Becker, MN, on a Hubbard loamy sand soil (sandy, mixed Udorothentic Haploboroll), which is underlain by gravel at 95-110 cm. Soaker hoses were buried in parallel about 30 cm apart and 50 cm deep in April 1994 before fertilizing and liming the topsoil according to University of Minnesota recommendations.

The experimental design was a strip plot with seven replicates (2.0 X 1.8 m plots). The horizontal strip was subsoil nitrate concentration [~0.3 m*M* $NO_2$-N (well water) or 20 m*M* $NO_3$-N], both of which were applied beginning 20 August 1994 through the subirrigation system at least weekly or after > 2.5 cm rainfall was received. The perpendicular strip was alfalfa germplasm, which included Agate, Ineffective Agate (a nodulated, but non-$N_2$-fixing near isoline of Agate), WL 322 HQ (a moderately dormant cultivar selected for high forage quality), Multi-7 (a selection with more than three leaflets per leaf), and four germplasms selected for varying root system architecture (low vs. high fibrousness in combination with tap vs. branch rootedness). These germplasms were seeded 12 June 1994, after inoculation with *Rhizobium meliloti.*

Alfalfa herbage was harvested on 19 August and 19 October 1994 and 16 June, 21 July, and 10 October 1995. The tracer, $^{15}N$, was added in the nitrate form during five subirrigations from 22 June until 18 July at 0.4491 atom % $^{15}N$. Herbage was analyzed for N and $^{15}N$ concentration by Dumas combustion followed by mass spectrometry. Nitrate uptake from the labeled subsoil nitrate supply and from symbiotic $N_2$ fixation was calculated using standard isotope techniques. Data were subjected to ANOVA.

## Results and Discussion

Subsoil nitrate increased Ineffective Agate yield by 132%, but Ineffective Agate did not attain the yield of the $N_2$-fixing germplasms. Subsoil nitrate increased the yield of the $N_2$-fixing germplasms by 5% and there were marginal yield differences among the $N_2$-fixing germplasms ($P < 0.05$).

Subsoil nitrate increased total herbage N yield by 16%, but no differences among germplasms were found. Based on results from the summer regrowth period, where $^{15}N$ was applied, Ineffective Agate removed 41% more subsoil nitrate than the $N_2$-fixing germplasms. No differences in subsoil nitrate uptake were found among the $N_2$-fixing alfalfa germplasms and exposure to subsoil nitrate decreased $N_2$ fixation by 32% for each germplasm. However, we consider the results comparing effective germplasms to be too preliminary to draw firm conclusions at this time.

**Summary**

Results of this research confirm our earlier findings that ineffective alfalfa is superior to standard alfalfa for removing subsoil nitrate, despite typically lower yields with the ineffective line. Forage protein levels of ineffective alfalfa supplied with N often are nearly as high as in effective germplasms, making ineffective alfalfa a more valuable forage crop than a grass. As nitrate supply is depleted, the ineffective types will become chlorotic, thereby signaling when the site is remediated. Thus, ineffective alfalfa may be preferred for remediation of nitrate-contaminated sites. Commercial release of two ineffective alfalfas is scheduled for 1997.