Improving Predictability of Alfalfa N Credits to Corn

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Crops following alfalfa usually benefit from reduced or eliminated nitrogen (N) requirement from fertilizer or manure, increased yield potential compared to following other crops, and reduced pest pressure. Through a symbiotic relationship with soil bacteria, alfalfa gathers atmospheric N for its growth and production. During its lifetime, alfalfa sheds and regenerates fine roots, adding N to the soil, as do dropped leaves and harvest and stand losses. The N content of alfalfa herbage and roots can be up to 200 lbs N/acre. When alfalfa is terminated, the N in residue, along with increased soil N and other soil quality improvements occuring during production, typically supply large N quantities to 1+ years of subsequent crops. This increased N often is nearly or completely sufficient for first and sometimes second successive corn crops. The size of the reduction in additional N for first-year corn compared to continuous corn (corn following 2+ years of corn) is commonly known as the 'alfalfa N credit.'

Alfalfa N Credit Guidelines for Corn

Guidelines in Minnesota and several other Midwest states indicate N credits of 150, 75, and 50 lbs N/acre should be used for first-year corn following good, fair, and poor alfalfa, respectively. For second-year corn following alfalfa, guidelines indicate N credits of 75, 50, and 0 lbs N/acre should be used following good, fair, and poor alfalfa, respectively. To gain confidence in alfalfa N credits, consider using an 'N-rich' strip (strip with a high N rate applied) in fields where alfalfa N credits are adopted. If significant differences in plant color or tissue tests occur, a sidedressed N application may be warranted. If sidedressed N is applied, consider leaving a zero-N strip and compare yields with a yield monitor or weigh wagon to determine whether sidedressed N increased yield. Color of the crop, and even symptoms of N deficiency in old leaves, are not evidence the applied N fertilizer will be cost efficient.

First-Year Corn Following Alfalfa N Rate Guideline Validation

In 2009-2012, on-farm research trials were conducted to determine economic optimum N fertilizer rates for first-year corn and to confirm alfalfa N credits for modern, high-yielding corn hybrids. Results of 31 trials showed alfalfa N credits are reliable and often are larger than current guidelines suggest. Only 3 of 31 fields required N fertilizer to increase corn grain yield where responsive fields had good alfalfa stands at termination, while some other non-responsive fields had average stands. These results led to preliminary conclusions: a) first-year corn rarely responds to N fertilizer (90% of fields did not need additional N), b) response to N is poorly related to final alfalfa stand density, and c) research needs to identify when first-year corn requires N fertilizer.

First-Year Corn Following Alfalfa Field-Specific N Rate Guidelines

To identify when corn following alfalfa requires N fertilizer and how much N is needed on responsive fields, on-farm trial results were combined with data from other trials available in the literature and other researchers. With the resulting 259 first-year corn trials, combinations of soil textural class, age of alfalfa at termination, alfalfa termination timing, and weather conditions between alfalfa termination and corn planting were found to affect the frequency and level of N response in corn (Table 1). These factors were used in predictive equations to estimate when corn will respond to N and what the economic optimum N rate will be. We found first-year corn rarely responds to N except on:

- sandy soils;
- fine-textured soils when there are prolonged wet early-season conditions;
- medium-textured soils when following 1-year-old direct-seeded alfalfa;
- medium-textured soils when following 2-year-old alfalfa (including the establishment year) seeded with a small grain companion crop;
- medium-textured soils when following spring-terminated alfalfa.

Predictive equations are being validated with Minnesota on-farm trials. Use current guidelines based on alfalfa stand density until more site-specific guidelines can be developed. Soil tests, such as the pre-sidedress soil nitrate test (PSNT), have low accuracy in first-year corn, as only 60% of 114 trials in Minnesota and the literature were correctly predicted as being responsive or nonresponsive to N fertilizer.

Table 1: Summary of grain yield response to N fertilizer in 259 trials of first-year corn following alfalfa.

Soil Texture[a]	Alfalfa Seeding Method[b]	Alfalfa Age[c]	Alfalfa Termination	Sites Responsive to N Fertilizer	Total Sites	Range in EONR[d]
		Years		%		lbs N/ac
Coarse	D or C	1-3	Fall or spring	96	11	90-210
Medium	D	1	Fall	56	16	50-200
Medium	C	2	Fall	35	54	50-240
Medium	D	2	Fall	8	25	50-150
Medium	D or C	3+	Fall	5	86	80-155
Medium	D or C	3+	Spring	17	48	40-160
Fine	D or C	1-7	Fall or spring	53	19	20-150

[a]Coarse = loamy sand; medium = loam, sandy loam, silt loam, fine sandy loam; fine = clay loam, silty clay loam. [b]D = direct-seeded without a companion crop, C = seeded with a small grain companion crop. [c]Alfalfa age at termination including the seeding year. [d]Range in economically optimum N rate (EONR) for the N cost ÷ corn grain price ratio of 0.10 in fields that needed additional N.

Second-Year Corn Following Alfalfa N Rate Guideline Validation

On-farm research trials were conducted in Iowa from 1989-1991 and in Minnesota from 2011-2012 to determine economic optimum N fertilizer rates for second-year corn following alfalfa and to confirm alfalfa N credits. Results from these 28 trials showed: a) no N fertilizer was needed to maximize grain yield on 14 fields, b) optimum N rate was less than 80 lbs N/acre on 5 fields, c) optimum N rate was less than 120 lbs N/acre on 6 fields, and d) remaining 3 fields needed 175 lbs N/acre. What was most striking about the results was that N fertilizer did not increase yield on one-half of the fields. As with first-year corn, alfalfa stand density did not relate well to the size of the alfalfa N credit. Again, PSNT had low accuracy in second-year corn, as only 57% of 53 trials in Minnesota and the literature were correctly predicted as being responsive or nonresponsive to N fertilizer.

Second-Year Corn Following Alfalfa Field-Specific N Rate Guidelines

In order to identify when second-year corn following alfalfa requires N fertilizer and how much N is needed on responsive fields, the same approach as for first-year corn is being used with 200 trials of second-year corn, in collaboration with Joe Lauer (University of Wisconsin), Antonio Mallarino (Iowa State University), and Tom Morris (University of Connecticut).

Extension bulletin describing management practices for alfalfa termination and the two subsequent corn crops helping utilize the alfalfa benefits is available at: http://z.umn.edu/rotation.