ADJUSTING N RECOMMENDATIONS BASED ON A PREVIOUSLY GROWN CROP

D.W. Franzen, J.F. Giles, A.J. Hapka, R.J. Reitmeier, N.C. Cattanach, and A.C. Cattanach

Introduction

Nitrogen recommendations in North Dakota are based on a yield goal multiplied from some empirically derived factor in a linear formula. There are a three adjustments to the N recommendations that result form these formulas (Franzen and Cihacek, 1996). They are the soil test nitrate-N to some depth, a sampling date adjustment if the sampling was conducted in the fall prior to September 15, and a previous crop credit. Two of these three adjustments are based on some knowledge regarding mineralization of N from residue and from organic matter. The sampling date adjustment is 0.5 lb N/day for each day a field is sampled prior to September 15. The rate recommended for adjustment is based on work on successive sampling following spring wheat harvests. The date of September 15 is a date after which it is assumed that little mineralization usually occurs later in the fall. The previous crop credits currently published in North Dakota are shown in Table 1. Most of the crops are perennial and annual legumes, with the annual legumes grown for grain. One of the crops, sugarbeets, is a departure from the normal list of previous crops normally adjusted for by many states. Including sugar beets on this list is perhaps the first time that a non-legume has been on such a list. However, recent research suggests that more non-legume crops should also be included.

Table 1. Previous crop credit adjustments to N recommendations, North Dakota.

Previous crop	Crop to be grown Short season crops (wheat, barley, oat, canola, etc.)	Long season crops (corn, sunflower, potato, sugarbeet, etc.
Soybean	0.5 lb N/bu	1.0 lb N/bu
Edible bean	10 lb N/acre	20 lb N/acre
Pea and lentil	1.25 lb N/bu	1.25 lb N/bu
Harvested sweet clover	10 lb N/acre	20 lb N/acre
Harvested alfalfa		
> 5 plants/sq. foot	75 lb N/acre	150 lb N/acre
3-4 plants/sq. foot	50 lb N/acre	100 lb N/acre
1-3 plants/sq. foot	25 lb N/acre	50 lb N/acre
< 1 plant/sq. foot	0 lb N/acre	0 lb N/acre
Harvested red clover	35 lb N/acre	70 lb N/acre
Sugarbeet		
Yellow leaves	0 lb N/acre	0 lb N/acre
Yellow/Green leaves	15-20 lb N/acre	15-20 lb N/acre
Dark green leaves	60-70 lb N/acre	60-70 lb N/acre

Presented at the North Central Extension-Industry Soil Fertility Conference, Nov. 14-15, 2001, West Des Moines, IA. A state report from North Dakota.

Literature Review

It is common for N recommendations to include an adjustment for previous crop, most often for legumes (Franzen and Cihacek, 1996; Atkinson, 2000; Tisdale et al., 1985). In a review by Bundy (1998), numerous studies were cited showing evidence for the soybean previous crop N credit. Three possible sources of the credit were given:

1. Greater immobilization by corn residues than soybean residues (Green and Blackmer, 1995).
2. Decomposition of the residues themselves.
3. Increased enhancement of soil microorganism activity resulting in an increase in available soil N the first year following soybeans and a reduction the second year (presumably due to exhaustion of more readily decomposed organic materials in year one. (Vanotti and Bundy, 1995)

Green and Blackmer found that rates of immobilization of N for ground soybean residue mixed in an incubation study was similar to ground corn residues, having a C/N ratio similar to the soybean residue. Because the two residue immobilization rates were similar, it was concluded that the difference between N availability of corn and soybeans is due primarily from the greater amount of corn residues returned to the soil, compared to the amount of soybean residues. Schoessow et al. (1996) removed soybean residues in plots going to corn at one site and imposed a series of N treatments. The plots with residue showed an N response, while the plots with soybean residues removed did not show a response to N. This study appears to support the findings of Green and Blackmer (1995).

Vanotti and Bundy (1995), using data from a 15-year experiment in a rotation using a Corn-Soybean-Corn-Oats-Alfalfa (CSCOM) and a Corn-Corn-Oats-Alfalfa-Alfalfa (CCOMM) rotation, showed that there was a significant increase in yield of corn following soybeans in the CSCOM rotation, compared to the corn following corn in the CCOMM rotation. Conversely, the oats and soil nitrate-N levels were lower the second year following soybeans in the CSCOM rotation, compared to the oats in the CCOMM rotation. This supports the conclusion that soybeans may contribute N to the following crop due to increased soil organic matter mineralization compared to corn residues, but that the soil may become depleted of readily decomposed organic matter and result in a decreased soil N availability the second year following soybeans.

There is evidence that other growing non-legume broadleaf crops may require an adjustment to N rates for subsequent crops. Using labeled N through a sugarbeet crop and into wheat, application of N was optimized with 60 lb N/acre with sugarbeet residues added compared to 120 lb N/acre with no sugarbeet residues (Abshahi et al., 1984). Following this work, Moraghan and Smith (1996) applied sugarbeet tops similar to a green manure application. Two types of sugarbeet top applications were made prior to a spring wheat crop. One type contained low sugarbeet N content (1.48 %N), and the other high sugarbeet N content (3.48% N). These residues were applied at rates of 60 lb N/acre and 240 lb N/acre respectively. The high sugarbeet N residues contributed N similar to the yield response of a treatment of 120-160 lb N/acre urea application, illustrating that sugarbeet tops could be considered a potential source of N for subsequent crops. Based on this work, the recommendations for adjustments based on yellow tops, yellow-green tops and green sugarbeet tops were made. Three additional studies since 1994 have suggested that other broadleaf, non-legume crops should be considered as previous crop N credits.

Methods

The first study was a site-specific project near Mandan, ND. Sunflowers were grown in a rotation with spring wheat and winter wheat from 1995 to 1998 (winter wheat-sunflower-spring wheat). Soil samples were taken to two feet in depth at the end of each season and the fields are fertilized for 45 bushel wheat and 2000 lb sunflowers based on dense regular grid soil sampling, with samples taken at 110-150 foot intervals. Protein samples of the wheat crops were determined in georeferenced areas within each field at harvest. In 1998, components of sunflowers were harvested from 20 feet of row, dried, weighed for dry matter yield and analyzed for total N and C. The components of sunflowers consisted of seed, heads, stalks and leaves.

The second study was a whole-field rotational study near St. Thomas ND. Four fields were sampled to six feet for NO_3-N in a 150 foot grid through a three-year rotation consisting of potato-sugarbeet and spring wheat. Sugarbeet tops and potato tops were harvested, chopped, weighed, dried and ground for total N analysis and dry matter yield.

The third study consisted of a buried bags of residue from six crops; canola, corn, sugarbeet, potato, sunflower and spring wheat at Fargo and St. Thomas, ND. The spring of residue harvest, areas of each crop were fertilized with an 0, 50 and 100 lb more N than the farmer had applied before or at seeding. At harvest, the crops were cut at the soil level, the grain was removed, and the residue was chopped using a silage chopper, dried, weighed and placed into fine-mesh fiberglass bags (Hanover wire cloth 04148, 1 foot X 1 foot). 24 g of dry residue was placed in each bag, the bags were sealed and buried 3 inches deep, with each bag 24 inches from the nearest bag. The bags were buried in early November, 1999 in a randomized complete split block design. Treatments consisted of multiple bags of each residue. The residues were removed from the soil beginning May 15, with subsequent samplings at May 29, June 19 and July 2, 2000. Bags were removed every two weeks. The residue was washed, dried, weighed, ground and analyzed for C and N using a carbon analyzer and micro-kjeldahl.

Results

Mandan

Where sunflower yield was not limited by water or disease, ending soil N levels are low (Figure 1). A hail storm at harvest in 1996 resulted in a large loss of grain from the spring wheat (estimated at between 15-20 bu/acre). This grain may have contributed to the positive difference in initial minus ending N and also the high residual N found following winter wheat harvest in 1997. If the residual NO_3-N from the winter wheat in 1997 is ignored due to this aberration, the difference between initial N levels and ending N levels is -13 lb/acre for spring wheat following sunflowers, - 49 for winter wheat following spring wheat and -50 for sunflowers following winter wheat (Table 2). This suggests that there was some immobilization of N following spring wheat and winter wheat, but the immobilization was not as high following sunflower, or that additional N was released from the decomposition of sunflower, amounting to an average of about 36 lb N/acre. The NO_3-N levels found after the crop subsequent to sunflowers (spring wheat) was unusually high, with ending NO_3-N levels of 45 lb/acre compared to 18 lb/acre for winter wheat following spring wheat and 17 lb/acre for sunflower following winter wheat (Table 3), suggesting that an additional 27 lb N/acre had to come from somewhere to account for the rotational differences between sunflower and the small grain crops..

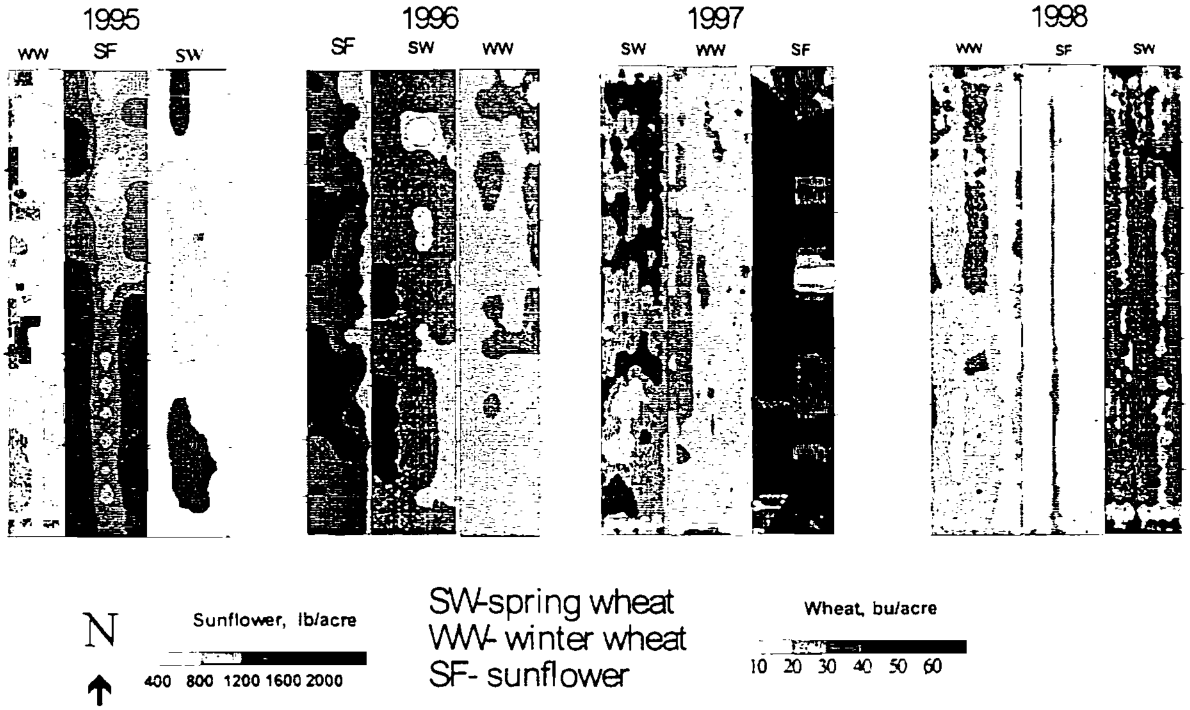

Figure 1. Mandan NO_3-N levels. Sunflower follows winter wheat, winter wheat follows spring wheat. Spring wheat follows sunflower. The ending NO_3-N levels following sunflower are always low compared to the levels following winter wheat or spring wheat. The ending NO_3-N levels the year following spring wheat are always higher than would be anticipated.

Table 2. Checkbook balance of N inputs and ending year NO_3-N levels in each of the three fields at Mandan following a winter wheat-sunflower-spring wheat rotation.

	West field	Center field	East field
95-96	ww-sf	sf-sw	sw-ww
Initial N*	21 r + 70 f = 91	17 r + 80 f = 97	19 r + 80 = 99
Grain N at harvest	38	50	47
Ending Soil N	16	23	15
Ending N** - Initial N	54 - 91 = - 37	73-97 = -24	62 - 99 = -37
96-97	sf-sw	sw-ww	ww-sf
Initial N	16 r + 95 f = 111	23 r + 80 f = 103	15 r + 80 f = 95
Grain N at harvest	53	34	36
Ending Soil N	67	80	12
Ending N - Initial N	120-111 = 9	114-103 = 11	48-95 = -47
97-98	sw-ww	ww-sf	sf-sw
Initial N	67r + 46 f = 113	80 r + 20 f = 100	12 r + 110 = 122
Grain N at harvest	30	10	43
Ending Soil N	22	24	45
Ending N - Initial N	52-113 = -61	34 - 100 = -66	98 - 122 = -24

*Initial N is the sum of residual NO_3-N (r) the fall before seeding and the fertilizer N (f) applied.
**Ending N is the sum of total in the harvested grain and the residual NO_3-N following harvest.
ww-sf denotes sunflower following winter wheat
sf-sw denotes spring wheat following sunflower
sw-ww denotes winter wheat following spring wheat

Table 3. Summary of differences between initial soil N levels and N accounted for at harvest from grain N content and soil NO_3-N, Mandan, ND.

Crop sequence/year		Accounted for ending N minus inputs. Lb N/acre	Residual NO_3-N
ww-sf	95-96	-37	23
	96-97	-47	67
	97-98	-66	45
Average		-50	45
sf-sw	95-96	-24	16
	96-97	+9	12
	97-98	-24	24
Average		-13	17
sw-ww	95-96	-38	15
	96-97	+11*	80*
	97-98	-61	22
Average		-29	39 (18.5 if 96-97 is omitted)

* Hail fell at harvest in the spring wheat field in the fall of 1996, resulting in grain loss and possible contributions of grain N to the subsequent winter wheat crop in 96-97.

St. Thomas

Soil testing following sugarbeet harvest found levels of NO_3-N were less than 30 lb/acre to 6 feet in sampling depth (Table 4). Sampling following potato harvest found an average of 49-81 lb NO_3-N/acre at the 4 to 6 foot depth, with some areas having as much as 300 lb/acre NO_3-N at the 4-6 foot depth (Reitmeier et al., 1999). Following the work of Moraghan and Smith (1996), the large amounts of N present in the sugarbeet tops were applied as a credit to the subsequent spring wheat crop. Since the estimated C/N ratio of the potato tops was even smaller than the sugarbeet tops, credits were determined, assuming two-thirds of the N would be released to the soil as available N, from the potato tops to the sugarbeets. Credits were given for deep soil N and potato tops for the two sugarbeet fields in the following year, with the resulting recommendation that no fertilizer N be applied. Average yield the following year was 21 ton/acre, with 17% sugar content. Subsequent application of sugarbeet top credits to wheat and potato top credits for adjusting sugarbeet N recommendations were successful through the rotation in maintaining yield and quality of wheat and sugarbeet crops (Franzen et al., 1999; Franzen et al., 2000).

Table 4. Soil test NO_3-N following sugarbeet and potato harvest and sugarbeet/potato total N content in the first year of the St. Thomas study.

Field	Soil N following sugarbeet			Soil N following potato			Sugar beet Top N	Potato top N
	---------- Depth of sampling, feet ----------							
	0-2	2-4	4-6	0-2	2-4	4-6		
	---------- lb NO_3-N/acre ----------						------ lb N/acre ---	
Sec. 34	5	8	8	78	71	81	165	41
Sec. 29	15	12	12	91	55	49	194	48

Buried bag study

All residues lost most of the dry matter weight which was lost during the 8 month experiment between burial and the 5/15 sampling date (Table 5). Sugarbeet and potato residues disappeared most quickly, with none of the sugarbeet residues remaining in the bag at the third sampling date at Fargo. St. Thomas was somewhat drier through the growing season than Fargo, so disappearance was not as rapid or complete. To determine the relative effects of residue disappearance and the release of N into the soil, initial N concentrations were used along with the typical weight of residue from an acre of each crop (Table 6). The amount of cumulative N released from the residues for each crop at each sampling date is summarized in Figures 2 and 3.

Sugarbeet, potato and sunflower residues all show a rapid degradation and rapid decrease in the amount of N they contain compared to wheat, canola and corn. There is also reason to suspect that the residues degrade in some stage of components rather than to analyze the entire residue sample as being similar. In sunflower (unpublished data), leaves contain a higher N content than the head or the stalk, with the stalk containing the lowest concentration of N. In potato, the fleshy part of the leaf is the first to degrade, with the thicker, more fibrous petioles and vines being the last to degrade.

Sugarbeet leaves contain little fiber and tend to degrade very rapidly, particularly in the field, where the very act of harvest results in chopped and buried residue.

Summary

Evidence is mounting that the source of soybean previous crop credits is not the benevolence of the soybean in returning N into the soil through roots or release of N from residues, but through increased stimulation of N mineralization from organic matter. However, in some broadleaf crops, there appear to be mechanisms, perhaps similar to the soybean credit, or perhaps very different, whereby a previous crop credit may be justifiable. The three crops that appear to justify such a credit are sugarbeet, potato and sunflower. Based on a buried bag study, the amounts of N to credit may be approximately 20 lb/acre following potato with top dry matter content of 1200 lb/acre and approximately 30 lb/acre following sunflower with a top dry matter content of 4000 lb/acre.

Table 5. Dry matter remaining and N content of crop residues buried in November.

Crop	Date	Fargo		St. Thomas	
		% dry matter remaining	% N	% dry matter remaining	%N
Sugarbeet	5/15	10.8	1.6	21.4	1.66
	5/29	9.9	1.2	13.6	1.41
	6/19	0	-	13.1	1.40
	7/3	0	-	7.6	1.40
Potato	5/15	25.0	1.63	29.4	1.56
	5/29	30.8	1.51	25.0	1.74
	6/19	21.6	1.51	23.2	1.52
	7/3	20.8	1.51	23.6	1.52
Canola	5/15	35.0	1.04	47.2	0.71
	5/29	33.2	0.83	41.1	0.79
	6/19	28.4	0.83	39.2	0.66
	7/3	27.2	0.83	39.0	0.66
Wheat	5/15	36.5	0.62	33.6	0.61
	5/29	39.0	0.84	53.1	0.66
	6/19	33.4	0.83	45.3	0.62
	7/3	22.2	0.84	44.6	0.62
Sunflower	5/15	25.9	1.01	35.5	1.09
	5/29	22.8	1.29	37.8	1.07
	6/19	15.5	1.18	27.2	0.83
	7/3	16.4	1.18	30.0	0.83
Corn	5/15	45.2	0.54	49.4	0.87
	5/29	35.8	0.56	55.6	0.59
	6/19	29.7	0.56	42.0	0.66
	7/3	30.8	0.56	41.6	0.66

Table 6. Buried bag study, initial November content and 5/15 results at Fargo, ND.

Crop	Initial Residue	Initial N content	Remaining Residue	Remaining N content
	- - - - - - - - - - - - - - - -	lb/acre	- - - - - - - - - - - - - - - -	
Soybean	4000	82	728	19
Potato	1230	33	308	8
Canola	3000	29	1308	10
Wheat	3000	24	1354	9
Sunflower	4000	59	828	9
Corn	6000	30	3420	16

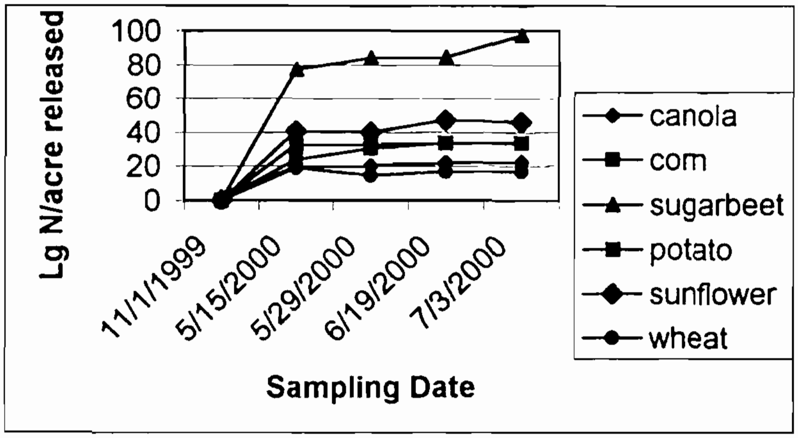

Figure 2. N released from residue bags from initial burial 11/1/1999 through 7/3/2001, St. Thomas, ND.

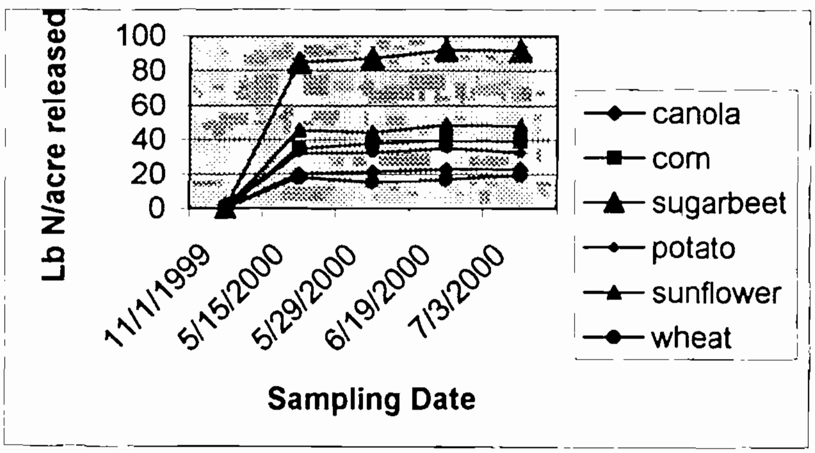

Figure 3. N released from buried bags, Fargo, ND between 11/1/99 and 7/3/00.

References

Abshahi, A., F.J. Hills, and F.E. Broadbent. 1984. Nitrogen utilization by wheat from residual sugarbeet fertilizer and soil incorporated sugarbeet tops. Agron. J. 76:954-958.

Atkinson, J. ed. 2000. Illinois Agronomy Handbook. College of Agricultural, Consumer and Environmental Sciences, Univ. of Illinois, Urbana, IL.

Bundy, L.G. 1998. Soybean nitrogen contributions and rotation effects. p. 27-36. *In* Proceedings of the 28th North Central Extension-Industry Soil Fertility Conference, Nov. 11-12, 1998, St. Louis, MO. Potash & Phosphate Institute, Brookings, SD.

Franzen, D.W. and L.J. Cihacek. 1996. North Dakota fertilizer recommendation tables and equations. NDSU Extension Circular SF-882, NDSU, Fargo, ND.

Franzen, D.W., L. Reitmeier, J.F. Giles, and A.C. Cattanach. 1999. Aerial photography and satellite imagery to detect deep soil nitrogen levels in potato and sugarbeet. p. 281-290. *In* P.C. Robert, ed., Precision Agriculture, Proceedings of the 4th International Conference, 19-22 July, 1998, St. Paul, MN, ASA-CSSA-SSSA, Madison, WI.

Franzen, D.W., A.J. Landgraff, J.F. Giles, N.R. Cattanach, and L.J. Reitmeier. 2000. Nitrogen availability and movement within wheat fields following sugarbeets. p. 117-126. *In* 1999 Sugarbeet Research and Extension Reports. Sugarbeet Research and Education Board of Minnesota and North Dakota, Fargo, ND.

Green, C.J. and A.M. Blackmer. 1995. Residue decomposition effects on nitrogen availability to corn following corn or soybean. Soil Sci. Soc. Am. J. 59:1065-1070.

Moraghan, J.T. and L.J. Smith. 1996. Nitrogen in sugarbeet tops and the growth of a subsequent wheat crop. Agron. J. 88:521-526.

Reitmeier, L.J., D.W. Franzen, J.F. Giles, A.C. Cattanach, and N.R. Cattanach. 1999. Nitrogen management in a wheat/potato/sugarbeet crop rotation. p. 125-134. *In* 1998 Sugarbeet Research and Extension Reports. Sugarbeet Research and Education Board of Minnesota and North Dakota. Fargo, ND.

Schoessow, K.A., K.C. Kilian, and L.G. Bundy. 1996. Site-specific prediction of soybean nitrogen contributions. p. 27-40. *In* Proceedings of the North Central Extension-Industry Soil Fertility Conference, St. Louis, MO, Nov. 20-21, 1996. Potash & Phosphate Institute, Brookings, SD.

Tisdale, S.L., W.L. Nelson, and J.D. Beaton. 1985. Soil Fertility and Fertilizers, 4th Edition. p. 566. Macmillan Publishing Co. NY.

Vanotti, M.B. and L.G. Bundy. 1995. Soybean effects on soil nitrogen availability in crop rotations. Agron. J. 87:676-680.

PROCEEDINGS OF THE

THIRTY-FIRST
NORTH CENTRAL
EXTENSION-INDUSTRY
SOIL FERTILITY CONFERENCE

Volume 17

November 14-15, 2001
Holiday Inn University Park
Des Moines, IA

Program Chair:
Keith Reid
Ontario Ministry of Ag, Food & Rural Affairs
581 Huron Street
Stratford, Ontario N5A 5T8
519/271-9269

Published by:
Potash & Phosphate Institute
772 – 22nd Avenue South
Brookings, SD 57006
605/692-6280