

# Control of fall nitrate leaching from early harvested potatoes on Prince Edward Island

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Milburn, P., MacLeod, J.A. and Sanderson, B. 1997. Control of fall nitrate leaching from early harvested potatoes on Prince Edward Island. *Can. Agric. Eng.* 39:263-271. The ability of a catch crop (winter wheat) and a lightly incorporated straw mulch to reduce NO<sub>3</sub>-N leaching following harvest of early potatoes (variety Superior) on Prince Edward Island (PEI) was evaluated over two cycles of a potato-cereal rotation, from spring 1989 to spring 1993. The extent of nitrate leaching from each treatment was indicated by the mean annual (spring to spring) flow-weighted NO<sub>3</sub>-N concentration (NO<sub>3</sub>-N<sub>f</sub>) of tile drainage water. Mean annual values for the winter wheat and barley crops in the rotation ranged from 2.9 to 7.7 mg/L. For the first potato crop, both fall treatments significantly reduced NO<sub>3</sub>-N<sub>f</sub> values, from 12.8 mg/L in the control to 10.7 mg/L for the straw incorporated and to 8.8 mg/L for the winter wheat crop. For the second potato crop, only the straw-incorporated treatment was significantly lower than the control, 27.5 compared to 18.0 mg/L. The relatively short time available for plant biomass accumulation following fall planting in PEI appears to limit the ability of winter wheat to consistently reduce post-harvest NO<sub>3</sub>-N leaching. Soil profile NO<sub>3</sub>-N content measured by coring in late fall and early spring after potatoes were grown did not show any significant differences among treatments. **Key words:** nitrate, leaching, potatoes, tile drainage, catch crops, immobilization.

La capacité d'une culture dérobée (blé d'automne) et d'un paillis légèrement incorporé à réduire le lessivage du NO<sub>3</sub>-N après la récolte des pommes de terre hâtives (variété Supérieure) sur l'Île-du-Prince Édouard, a été évaluée sur deux cycles d'une rotation pomme de terre-blé, du printemps 1989 au printemps 1993. On a déterminé l'étendu du lessivage de chacun des traitements à partir de la concentration moyenne annuelle de NO<sub>3</sub>-N, pondérée selon le débit (NO<sub>3</sub>-N<sub>f</sub>) d'eau qui coule des drains. Les valeurs des moyennes annuelles pour les cultures de blé d'automne et d'orge allaient de 2.9 à 7.7 mg/L. Après la première récolte de pommes de terre, les deux traitements pratiqués à l'automne ont réduit de manière significative les valeurs de NO<sub>3</sub>-N<sub>f</sub>, de 12.8 mg/L dans le témoin à 10.7 mg/L pour le paillis incorporé et 8.8 mg/L pour la culture de blé d'automne. Après la deuxième récolte de pommes de terre, seule la concentration du traitement avec le paillis incorporé était significativement plus faible que celle du contrôle, 27.5 comparé à 18 mg/L. À l'Île-du-Prince Édouard, la période d'accumulation de la biomasse par la plante suite au semis d'automne est trop courte et limite la capacité du blé d'automne à réduire de façon régulière le lessivage du NO<sub>3</sub>-N après la récolte. Les teneurs en NO<sub>3</sub>-N d'échantillons de sols prélevés tard à l'automne et tôt au printemps, après des cultures de pommes de terre, ne montrent pas de différences significatives entre les traitements. **Mots-clés:** nitrates, lessivage, pommes de terre, drainage souterrain, cultures dérobées, immobilisation.

## INTRODUCTION

The potato industry is an important contributor to the PEI economy. The area of PEI farmland planted annually to

potatoes increased from 23 500 ha in 1980 to 34 000 ha in 1993. The annual farm gate value of the PEI potato crop was \$99 M in 1993, that is 42% of total provincial farm cash receipts (Province of PEI 1994). Prince Edward Island potato production constitutes 29% of Canada's total annual production and 45% of Canada's total exports of seed and table potatoes in 1990 were produced in PEI (Agriculture Canada 1992).

The soil-climate attributes of PEI that favour widespread production of potatoes are also conducive to NO<sub>3</sub>-N leaching and this may lead to subsequent contamination of groundwater. Leaching of NO<sub>3</sub>-N from the root zone occurs when soil NO<sub>3</sub>-N levels exceed the demands of the crop and precipitation exceeds evapotranspiration (Kowalenko 1987; Scharf and Alley 1988). Hence, leaching usually increases with increasing precipitation (Scharf and Alley 1988) and frequency of irrigation (Hergert 1986) and is generally greatest during the non-cropping portion of the year (Cameron and Wild 1984; Milburn and Richards 1994).

Approximately 50% of the PEI land area is devoted to agricultural activities. Potato and grain production are practised on approximately 35% of the agricultural land (Government of Canada 1987). The soils are generally coarse-textured (MacDougall et al. 1988); accumulated precipitation exceeds potential evapotranspiration by approximately 400 mm/y; the growing season is relatively short, 130 to 150 frost-free days; and potatoes with their shallow root system are produced using relatively high fertilizer N recommendations (130 to 150 kg N•a<sup>-1</sup>•y<sup>-1</sup>) (Asiedu et al. 1987; Dzikowski et al. 1984).

Because potato production in temperate climates can cause NO<sub>3</sub> contamination of groundwater (Milburn et al. 1990; Hill 1982; Richards et al. 1990) and because PEI depends completely on groundwater for domestic drinking water sources, it is desirable and prudent that alternative potato production techniques be tested for their ability to minimize NO<sub>3</sub> leaching while maintaining economic yields. The objective of this study was to evaluate, at field scale under PEI soil and climate conditions, the potential of two crop management treatments to limit post-harvest NO<sub>3</sub> leaching associated with the production of early harvested potatoes. The function of each treatment was to remove NO<sub>3</sub> remaining in the root zone following potato harvest, thus minimizing the amount of soil NO<sub>3</sub> available for leaching during the subsequent fall, winter, and spring periods.

Treatments tested were: (1) a control, where the field was

chisel plowed following potato harvest and left idle until operations began the next spring; (2) incorporating cereal straw into the soil following potato harvest to stimulate the process of N “immobilization”; and (3) planting a fall “catch crop”, winter wheat, to assimilate residual NO<sub>3</sub>.

## BACKGROUND

### Immobilization

Immobilization is a microbially-mediated temporary transfer of plant-available forms of N (e.g. NO<sub>3</sub>) to the non-leachable, non-plant-available, organic N form. Immobilization is stimulated by adding organic residues of low N content (<1.2-1.5% N) or high carbon to nitrogen ratio (C/N ratio 30) to the soil (Jansson and Persson 1982; Peterson and Frye 1989). Immobilization reactions are reversible and nitrogen immobilized may be subsequently re-mineralized to a plant available form under suitable environmental conditions. Strebel et al. (1989) and Powlson (1988) suggested applications of straw as a measure to decrease nitrate leaching. The C/N ratio of wheat straw is approximately 100 (Cochran et al. 1980; Smith and Douglas 1971). In our experiment, we anticipated that most of the NO<sub>3</sub> immobilized in the fall, due to the addition of straw, would be re-mineralized during the next growing season when a growing crop was present.

### Catch crops

Several small grains and grasses may serve as catch crops. The desirable characteristic of a catch crop is that it be a good nitrate scavenger; that is, it germinates quickly and develops an aggressive rooting system and readily accumulates biomass during periods of cool temperatures (Ditsch and Alley 1991). Oilseed radish was evaluated in western Europe for its superior ability to withdraw NO<sub>3</sub> from the soil (Sorenson 1992); however, it currently has no economic end use in eastern Canada. Winter grains that are fall planted, remain dormant through the winter and become biologically active early the next spring are also known as good catch crops. Because there was already considerable experience with production of winter wheat in PEI, it was selected for the catch crop treatment.

The principal unknown in the experiment was the extent to which these treatments would effect changes in soil NO<sub>3</sub> levels, given the short season remaining after potato harvest for regrowth or other biological processes. In parts of Europe, for example, catch crops such as winter wheat or winter rye may have up to three months for growth following fall seeding; whereas, in PEI this time frame is reduced to four to six weeks (Dzikowski et al. 1984). Conversely, if either of the treatments show merit, both are agriculturally and practically feasible and could be effectively implemented by producers.

**Table I. Cropping sequence and treatments imposed in nitrate leaching experiment**

Year	Treatment 1 (conventional)	Treatment 2 (winter wheat)	Treatment 3 (straw incorporated)	Comments
Spring 1989	potato	potato	potato	Variety Superior planted May 19, all treatments. Nitrogen (145 kg N ha <sup>-1</sup> ) from 12 -10-20 NPK blended fertilizer banded at planting.
Fall 1989	fallow	winter wheat	straw incorporated	Potatoes harvested September 6, then chisel plowed. Winter wheat planted September 14 (treatment 2). Wheat straw (3 t/ha) applied with commercial straw shredder, followed by single pass of a disk harrow (treatment 3).
Spring 1990	barley	winter wheat	barley	Nitrogen (60 kg N ha <sup>-1</sup> ) as ammonium nitrate was broadcasted on all treatments. Barley planted May 15 on treatments 1 and 3.
Fall 1990	stubble; late tillage	stubble; late tillage	stubble; late tillage	All treatments harvested in late August followed by chisel plowing in early November; straw chopped and incorporated.
Spring 1991	potato	potato	potato	As shown for Spring 1989; planted May 16.
Fall 1991	fallow	winter wheat	straw incorporated	As shown for Fall 1989; potatoes harvested August 29-30.
Spring 1992	barley	winter wheat	barley	As shown for Spring 1990
Fall 1992	stubble; late tillage	stubble; late tillage	stubble; late tillage	As shown for Fall 1990
Spring 1993		end of experiment		Drainage sampling terminated May 15

## MATERIALS AND METHODS

### Crop Rotation

We used a two year potato-grain rotation commonly used in eastern Canada. This rotation was repeated twice in the study, with the sequence of crops and management summarized in Table I. Cultural practices for the potatoes (variety Superior), including cultivation, herbicide, fungicide, and pest control were similar to those used in commercial production (Asiedu et al. 1987). The potatoes were fertilized with a 12-10-20 N-P-K commercially blended fertilizer made up from ammonium nitrate, diammonium phosphate, and potassium chloride. The fertilizer was banded at planting to supply 145 kg N/ha. The potato crops were harvested with commercial equipment. Following harvest the total area was chisel plowed to a depth of 150 mm and the treatments imposed.

Treatment 1, the conventional or control treatment, consisted of a potato crop in year 1 (1989) followed by a spring barley crop in year 2 (1990). With this system, any residual soil N remaining after the potatoes were harvested, plus any mineralized soil N, would be subject to leaching. The rotation was repeated in 1991 (potatoes) and 1992 (barley). With treatment 2, winter wheat was planted with commercial seeding equipment immediately following potato harvest. Fertilizer was not added at time of seeding. Seedbed preparation for the winter wheat consisted of chisel plowing followed by harrowing. In treatment 3, following potato harvest and subsequent chisel plowing, wheat straw was distributed over the plots using a commercial "bale-buster". This pull-type implement macerates large round straw bales and spreads them uniformly over the soil. A rate of approximately 3 t/ha was applied, an amount equivalent to the straw produced by an average wheat crop on PEI. The straw was then lightly incorporated into the soil with a single pass of a disc harrow. In the following spring, barley was seeded on each plot where straw was applied and ammonium nitrate was applied at a rate of 60 kg N/ha.

### Site conditions; water sample collection

The 10-plot contiguous tile drainage system and associated equipment used to expedite tile drainage flow rate measurement and year round sampling of the drainage leachate was described by Milburn and MacLeod (1991) and Milburn et al. (1992). The system is located on 3.4 ha of gently sloping (1-3%), sandy loam soil common to the potato growing areas of Prince Edward Island (Fig. 1). The soil was mapped as a Charlottetown fine sandy loam (Orthic Humo-Ferric Podzol) with some Malpeque sandy loam (Gleyed Eluviated Drystic Brunisol) inclusions at the lower elevations (MacDougall et al. 1988).

Water samples were collected every 8 hours inside the heated discharge monitoring shelter (Fig. 1) with ISCO

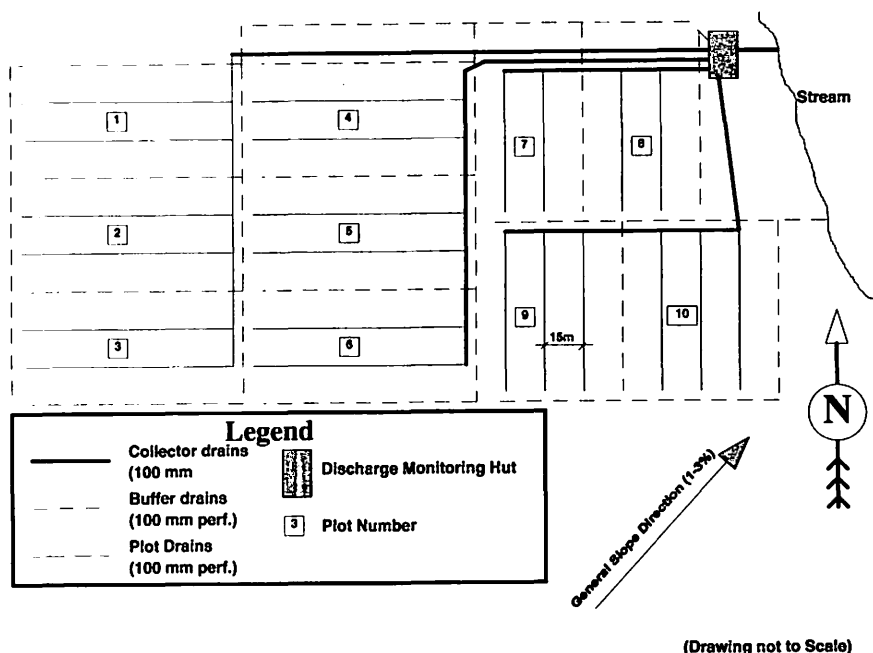


Fig. 1. Schematic of plot layout (adapted from Milburn and MacLeod 1991).

Model 2900 portable, sequential, wastewater samplers (ISCO Ltd., Omaha, NE). Drainage discharge rate was determined hourly using tipping bucket flow meters. Nitrate concentrations were determined by Technicon Industrial Method No. 782-8T using hydrazine to reduce to nitrite and the sulfanilimide color reaction (Technicon 1986). Monthly precipitation, daily maximum and minimum air temperatures, and associated 30-year normals for the nearby (10 km) Environment Canada meteorological station at the Charlottetown airport were used to estimate climate conditions at the experimental site.

The effectiveness of each treatment in reducing nitrate leaching was indicated by the flow-weighted mean annual  $\text{NO}_3\text{-N}$  concentration of the tile drainage outflow,  $\text{NO}_3\text{-N}_f$  (Milburn and Richards 1994; Milburn et al. 1990). This value was calculated by dividing the total accumulated  $\text{NO}_3\text{-N}$  loss in the tile flow for the period of interest (planting date until just prior to planting the following year) by the total cumulative tile flow for that period. Total cumulative  $\text{NO}_3\text{-N}$  loss in tile flow was calculated by multiplying average hourly  $\text{NO}_3\text{-N}$  concentrations of the tile water by hourly flow volumes and summing over time. Hourly concentration data were derived assuming a linear relation between measured (every 8 hours) concentration points. Total cumulative  $\text{NO}_3\text{-N}$  loss in the tile drainage was not assumed to equal the total annual leaching loss from the soil system because natural drainage was moderate to well over parts of the experimental area. Furthermore, some events were not measured due to equipment failure.

### Statistical design

Observations at the experimental site throughout 1988, prior to the establishment of the water quality experiment, revealed considerable variation among plots in cumulative drainage outflows. Plots at higher elevations generally yielded less

outflow than those at lower elevations (Fig. 1). This was attributable to poorly drained Malpeque soil inclusions at low elevations, resulting in less natural soil drainage in these plots and, thus, more cumulative flow in the drains compared to cumulative drain flow in the plots at higher elevation where natural drainage was greater. To isolate the effect of variable cumulative drainage outflows on  $\text{NO}_3\text{-N}_f$  from true treatment effects, the experimental site was blocked according to similar cumulative outflows. Three blocks were designated and the three treatments were randomized within each block to form a Randomized Complete Block (RCB) design. To provide an indication of variation of  $\text{NO}_3\text{-N}_f$  with time, the two-year crop rotation on which the study was based (potatoes-grain) was repeated twice. Since the experiment required only 9 plots, plot 10 was not utilized.

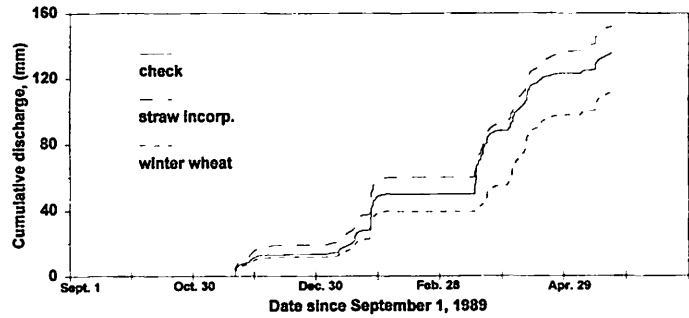
The analysis of variances was performed on the RCB design using GENSTAT software (Lane et al. 1987). Mean separation was performed using least significant differences. Differences were declared significant at ( $p>0.05$ ).

### Crop yields; N uptake by crop

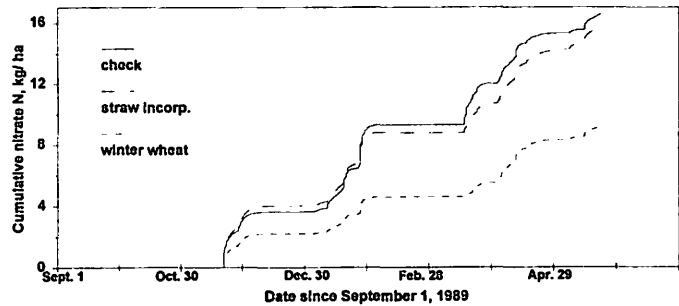
Tuber yield within each plot was determined from a 20 m hand harvested section of row in 1989 and from two 6.4 m sections in 1991. A subsample of tubers was taken to determine tuber dry matter and N content by Kjeldahl digestion and color determination (Technicon 1987). Grain yields were determined by harvesting a 1.25 m x 20 m subsample in each plot with a small plot combine. Grain samples were dried and digested for N analyses as above.

### Soil N

Soil samples for  $\text{NO}_3\text{-N}$  determination were collected using a Giddings tractor-mounted soil sampling machine fitted



a) cumulative tile drainage discharge



b) cumulative nitrate N leached in drainage discharge

Fig. 2. Mean cumulative drainage and concomitant  $\text{NO}_3\text{-N}$  leached for the 1989 potato crop; no drainage occurred between planting and November, 1989.

with a sampling probe holding a metre long, 43 mm diameter plastic tube. Samples were obtained to a depth of 900 mm. Three soil cores per experimental unit (plot) were taken in early May (as early as field would support traffic of a 45 kW

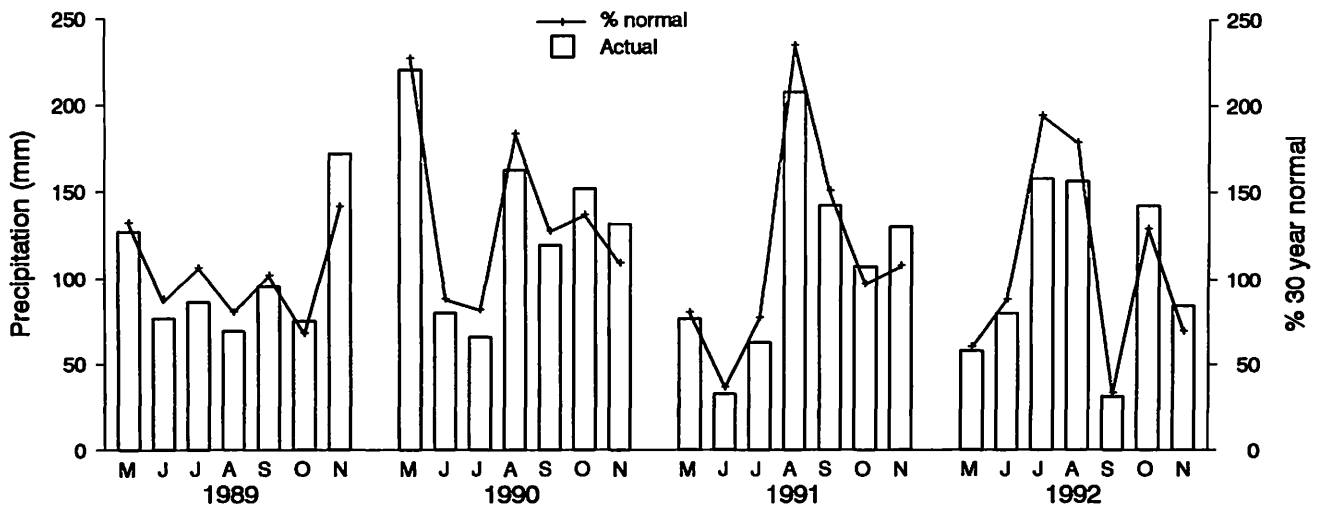


Fig. 3. May to November precipitation at the Charlottetown airport, 1989-1992 (data supplied by Environment Canada).

tractor) and again in late November (just prior to fall freeze-up) each year. Core samples were stored intact at 3°C in the sampling tubes until analysis by the method described by Sanderson and MacLeod (1994). Analyses were performed on each 100 mm increment of the soil cores and results were summed according to treatment for the depth increments 0-300, 300-600, and 600-900 mm.

## RESULTS AND DISCUSSION

All drainage over the four-year study occurred between September 1 and May 30 the next year. Precipitation measured at the Charlottetown airport for this period was 96, 112, 107, and 94% of normal for the years 1989-90, 1990-91, 1991-92, and 1992-93, respectively. An example of cumulative drainage and concomitant cumulative NO<sub>3</sub>-N leached in the tile drainage is presented in Fig. 2.

### Crop yields

Potato yields in 1989 and 1991 averaged 39.4 and 34.0 t/ha, respectively, about 25 % higher than the Provincial averages for those years of 30.7 and 28.4 t/ha (Table II; Province of PEI 1994). The lower potato yields of 1991 were mostly attributable to dry growing conditions; May, June, and July rainfalls were about 75, 30, and 60% of normal (Fig. 3). In 1989 potato tuber yields and N removal by the tubers were similar across all treatments. In 1991, there was no residual effect of the management treatments on potato yields and N removal by tubers (Table II). Tuber N content varied between 1.35 and 1.53% (data not shown), well within the general range of 1.20 to 1.90% provided by Meisinger and Randall (1991). Barley and winter wheat yields (Table III) were similarly higher than Provincial averages.

### Drainage; annual flow-weighted concentrations

There were no significant differences in cumulative drainage discharge among treatments in any year (Table IV). Fall treatments lowered the NO<sub>3</sub>-N<sub>f</sub> compared to the control in each of the two potato production years, but the effect of the winter wheat treatment in 1991 was not significant. Imposition of the fall treatments resulted in a maximum reduction of the control NO<sub>3</sub>-N<sub>f</sub> of about 30% in both potato years; by the winter wheat catch crop in 1989 and by the incorporation of straw in 1991.

The NO<sub>3</sub>-N<sub>f</sub> values for the 1990 cereal crops were not significantly different. The range of these values increased in 1992, from 2.9 to 7.7 mg/L, with values being highest for the control and lowest for the winter wheat catch crop. Reasons for the significantly lower NO<sub>3</sub>-N<sub>f</sub> value for the winter wheat

**Table II: Average potato yields and N removed by tubers**

Treatment	1989		1991	
	Yield <sup>1</sup> (t/ha)	N removed in tuber (kg/ha)	Yield <sup>1</sup> (t/ha)	N removed in tuber (kg/ha)
1. <b>Conventional</b> (chisel plowed after potato harvest; spring barley the next crop year)	39.1	104	32.8	47
2. <b>Winter wheat</b> (fall planted following potato harvest)	39.6	124	35.3	35
3. <b>Straw incorporated</b> (following potato harvest; spring barley next crop year)	39.4	128	33.9	48
Standard error of mean*	2.46 (ns)	9.3 (ns)	1.35 (ns)	3.6 (ns)

<sup>1</sup> total tuber yield

\* df = 4, n = 3

**Table III: Average yields and N uptake by cereals**

Treatment	1990		1992	
	Yield <sup>1</sup> (t/ha)	N removal <sup>1</sup> (kg/ha)	Yield <sup>1</sup> (t/ha)	N removal <sup>1</sup> (kg/ha)
1. <b>Conventional</b> (chisel plowed after potato harvest; spring barley the next crop year)	2.04	43	2.8	47
2. <b>Winter wheat</b> (fall planted following potato harvest)	2.63	55	1.67	35
3. <b>Straw incorporated</b> (following potato harvest; spring barley next crop year)	2.13	45	2.75	48
Standard error of mean*	0.33 (ns)	5.5 (ns)	0.17 (5%)	4.4 (ns)

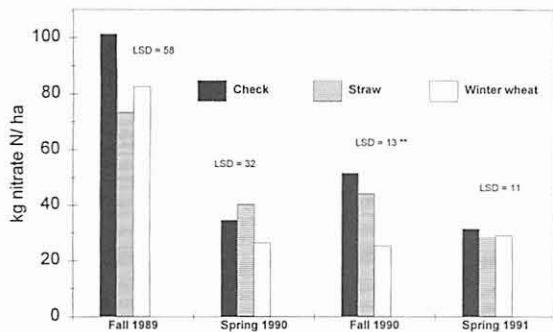
<sup>1</sup> grain portion only

\* df = 4, n = 3

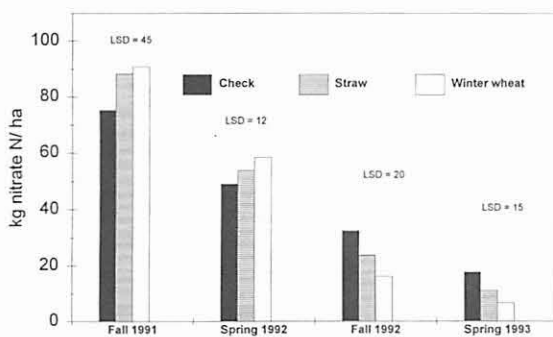
in 1992 are not apparent. Grain yield of the winter wheat was low compared to the barley crops, but the N removal by each grain crop was similar (Table III). A possible explanation is that conditions favouring immobilization were greater in the winter wheat plots compared to the barley plots following incorporation of the stubble and straw in the fall of 1992, thereby limiting the amount of NO<sub>3</sub>-N available for leaching.

### Nitrate in soil

Late fall soil sampling following potatoes grown in 1989 (Fig. 4a) and in 1991 (Fig. 4b) did not reveal significant



a) Late fall 1989 following potatoes till early spring 1991 after cereals.



b) Late fall 1991 following potatoes till early spring 1993 after cereals.

**Fig. 4. Mean soil NO<sub>3</sub>-N content (0-900 mm profile) for each of the two potato-grain rotations: a) late fall 1989 following potatoes till early spring 1991 after cereals; b) late fall 1991 following potatoes till early spring 1993 after cereals. (\* denotes significance at the 5% level.)**

treatment differences in profile NO<sub>3</sub>-N contents. Similarly, for the spring 1990 and spring 1992 samples following potatoes, differences in profile NO<sub>3</sub>-N content were not significant.

Following the cereal crops, differences in profile NO<sub>3</sub>-N were significant only in fall 1990 with the winter wheat (Fig. 4a). A similar, non-significant trend was measured in fall 1992 (Fig. 4b).

Overall, the soil sampling regime employed did not mirror the treatment results of the tile water analysis. The NO<sub>3</sub>-N<sub>f</sub> values of the tile water indicated that the fall treatments did indeed reduce NO<sub>3</sub>-N leaching following potato harvest, while soil NO<sub>3</sub>-N contents in late fall and early spring immediately following treatments indicated no treatment differences. We attribute this discrepancy to the limited replication of the soil core data (3 cores per plot) coupled with the wide variation in soil NO<sub>3</sub>-N encountered on the large plots utilized in this study. The relatively large LSD values of Fig. 4 provide evidence of this variability. Conversely, the utility of field scale tile drainage plots to integrate the effects of land management practices and varying soil conditions and to detect significant results with rather limited replication is amply demonstrated.

## Straw incorporation compared to catch crop

Since the catch crop treatment was most effective at reducing leaching losses for one potato crop, but straw incorporation was more effective for the other, it is appropriate that we try to explain the likely causes for this outcome. Several processes were potentially involved, including mineralization, nitrification, immobilization, volatilization, plant uptake, and leaching (Power and Broadbent 1989; de Willigen 1991). Hutson and Wagenet (1991), commenting on simulation models of N dynamics, observed that there are many input parameters in these models so that they can ultimately be adjusted to obtain a good match between measured and simulated results. They suggest that increasing one's understanding of the interactions between various components of the soil system is far more important than exact reproduction of measured data.

Possible sources of variation that contributed to the observed treatment results were:

- 1) The time for residual soil N uptake and fall biomass accumulation of winter wheat sown in September in Atlantic Canada is limited by the early arrival of freezing air temperatures (Dziskowski et al. 1984); available soil moisture or available soil N were unlikely to be limiting growth factors. Therefore, a reduction of the control NO<sub>3</sub>-N<sub>f</sub> value by about 4 mg/L may be all that can be expected for the winter wheat treatment under the prevailing site conditions. Studies in England and the USA have indicated the importance of an early planting for optimum performance of catch crops; a one month delay in planting date reduced N uptake by three to five times (Meisinger et al. 1991).
- 2) Compared to the fall growth of winter wheat, which is limited by freezing air temperatures, immobilization can proceed longer into the fall because soil temperatures generally lag air temperature. Sain and Broadbent (1977) reported that for a rice straw, decomposition (and attendant N immobilization) was retarded more by low temperature than by excess moisture. Since both minimum and maximum average fall air temperatures (and by inference soil temperature) were greater in 1991 compared to 1989 (Table V) and because more soil N was likely available for soil microbial processes following potato harvest in 1991 than 1989 (due to lower potato yields in 1991), conditions were generally more favourable for immobilization in fall 1991 compared to 1989.
- 3) Net immobilization occurs when the C/N ratio of incorporated material is greater than 30. Given an adequate supply of soil N, more immobilization would be expected from material with the greater C/N ratio. We did not compare the chemical composition of the straw used for each of the two independent potato crops. Stewart et al. (1966) showed that wheat straw with a low sulphur content could limit decomposition (and soil N immobilization) rates in soils low in sulfates. Therefore, differences in the composition of the straw could account for some of the variation in the effectiveness of the straw incorporated treatment observed over the two potato crops.

**Table IV: Mean annual drainage discharge and NO<sub>3</sub>-N<sub>f</sub> concentrations in drainage water**

Treatment	1989 (potato)		1990 (cereal)		1991 (potato)		1992 (cereal)	
	Drainage <sup>1</sup> (mm)	Conc. <sup>!!</sup> (mg/L)	Drainage (mm)	Conc. (mg/L)	Drainage <sup>+</sup> (mm)	Conc. (mg/L)	Drainage (mm)	Conc. (mg/L)
1. <b>Conventional</b> (chisel plowed after potato harvest; spring barley the next crop year)	135	12.8a*	169	7.2	94	27.5a	71	7.7a
2. <b>Winter wheat</b> (fall planted following potato harvest)	111	8.8c	192	5.5	75	24.0ab	113	2.9b
3. <b>Straw incorporated</b> (following potato harvest; spring barley next crop year)	152	10.7b	182	6.9	90	18.0b	83	5.8ab
Error mean square, (df)	1928, (4)	0.379, (4)	2043, (4)	1.487, (4)	567, (2)	2.134, (2)	2860, (4)	3.691, (4)
LSD	ns	1.4	ns	ns	ns	6.3	ns	4.4

<sup>1</sup> From planting (about May 15) till planting time the next spring; no drainage between May and September of each year.

<sup>!!</sup> Mean annual flow-weighted concentrations.

\* Means followed by the same letter are not significantly different at the 5% level.

+ Due to equipment malfunction, one block was dropped from the analysis; some tile flow not measured across all treatments. When the 1989 (potato crop) data were analysed with 2 replications, as in 1991, results remained the same.

**Table V: Average daily minimum and maximum air temperature in fall and spring following 1989 and 1991 potato harvests**

		Fall*			
30 y mean		1989		1991	
minimum	maximum	minimum	maximum	minimum	maximum
4.3 °C	12.0 °C	3.1 °C	12.0 °C	5.3 °C	12.7 °C
		Spring*			
		1990		1992	
1.2 °C	10.0 °C	1.1 °C	9.3 °C	0.3 °C	10.0 °C

\* Fall = September 1 to November 30; Spring = April 1 to May 30; data for Charlottetown Airport Meteorological Station supplied by Environment Canada

4) Surface-managed crop residues decompose more slowly than incorporated residues, indicating that the N immobilization potential of surface residues is lower than that of residues mixed in the soil (Cochran et al. 1980). Though the same implement and procedure was used to incorporate the straw following each potato crop, unintentional differences in the degree of incorporation between the two potato years could be affecting the amount of soil N immobilized.

### Other considerations

Straw spreading (mulching) onto bare potato fields following potato harvest is currently recommended in PEI to control soil erosion by water (Personal communication: R. Dehaan, Soil Conservation Engineer, PEI Department of Agriculture, Forestry and Fisheries, Charlottetown, PEI). Incorporation of the straw with the single pass of a disk harrow, as demonstrated in this study, can reduce NO<sub>3</sub>-N leaching while still providing erosion control. The precise effect of light straw incorporation on erosion prevention compared to surface spreading only should be determined. Straw incorporation may effectively reduce both sediment content in surface waters and NO<sub>3</sub>-N leaching to groundwater.

Since this study was initiated, it has been shown that winter rye produces more biomass during the fall under conditions common to Atlantic Canada than winter wheat (unpublished data: J. A. MacLeod, Research Scientist, Agriculture and Agri-food Canada Research Centre, Charlottetown, PEI). Therefore, the ability of catch crops other than winter wheat to reduce fall NO<sub>3</sub> leaching should be evaluated.

Testing of recently developed nitrogen simulation models (eg. Hutson and Wagenet 1994; Jansson et al. 1991) with the management scenarios employed in our study should be undertaken to assess their utility under Atlantic agro-climatic conditions. Notwithstanding the complexity and large data requirements of these models, they may at the very least qualitatively assess the effects of various management alter-

natives on NO<sub>3</sub>-N leaching. An improved focus for regional field research could be the result.

## CONCLUSIONS

The ability of a catch crop (winter wheat) and a lightly incorporated straw mulch to reduce NO<sub>3</sub> leaching following harvest of early potatoes (variety Superior) on PEI was evaluated over two cycles of a potato-cereal rotation, from spring 1989 to spring 1993. The catch crop treatment significantly reduced the mean annual flow-weighted NO<sub>3</sub>-N concentration in tile drainage discharge (NO<sub>3</sub>-N<sub>f</sub>) compared to the control (potato production without a catch crop or straw incorporation) in one of the two years, while the straw incorporation treatment significantly reduced NO<sub>3</sub>-N<sub>f</sub> in both years.

This study has demonstrated that there can be sufficient time following fall harvest of early potatoes on PEI to manipulate the soil N cycle and thereby reduce NO<sub>3</sub>-N leaching. The straw incorporation treatment reduced NO<sub>3</sub>-N<sub>f</sub> by 15 and 30% for the two potato crops. The relatively short time available for biomass accumulation following fall planting in PEI appears to limit the ability of winter wheat to consistently reduce post-harvest NO<sub>3</sub>-N leaching. Other more promising catch crops such as winter rye should be evaluated.

The control treatment (conventional potato production) produced NO<sub>3</sub>-N<sub>f</sub> values greater than 10 mg/L in both potato production years (12.8 and 27.5 mg/L). Values from the production of cereal rotation crops (winter wheat and barley) were consistently less than 10 mg/L (range 2.9 -7.7 mg/L).

Field scale tile drainage plots can be effectively employed to integrate the effects of land management practices and varying soil conditions and to detect significant differences between management schemes with rather limited replication.

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