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Nitrogen contribution from above and belowground biomass of forages to the subsequent potato crop

Jennifer Whittaker[1], Judith Nyiraneza[1], David Burton[2], Bernie Zebarth[3]

[1] Charlottetown Research and Development Centre, AAFC, [2] Dalhousie University, [3] Fredericton Research and Development Centre, AAFC

Introduction

Soil N supply capacity can be enhanced by growing a legume that through biological N fixation increases N inputs or by growing a grass that have residual soil N scavenging ability. The N contribution of the above and belowground biomass (consisting of soil and roots) of different forages to the following crop still need elucidation. This study used ^{15}N isotopic fertilizer in microplot cylinders to assess the fate of different labeled forage residue N from the above and belowground biomass to subsequent potato crops.

Objectives

- Use 98 % enriched ^{15}N fertilizer applied to soil in microplots to trace N cycling in a grass (timothy, T), a legume (red clover, RC) or a mixture of both (M) and into subsequent potato crop by crop residue exchange technique (Figure 1).
- Assess the effects of forage and residue selection (above or belowground) on biomass accumulation, N uptake, and ^{15}N partitioning in subsequent potato crop and soil.

Methodology

- 2013: Hollow cylinders (microplots) installed in field, forage crops established inside microplots.
- 2014 Spring: Equivalent of 20, 40 and 60 kg N ha^{-1} of unlabeled ($^{14}NO_3{}^{14}NH_4$) or labeled 98 % enriched $^{15}NO_3{}^{15}NH_4$ fertilizer added in RC, M and T respectively in designated cylinders.
- 2014 Fall: Crop Residue Exchange (Figure 1) occurred on 21 November 2014 to produce a total of 3 forage and 4 residue treatments with 4 reps (Fig 1).
- 2015 Spring: One potato plant was planted in each microplot.
- 2015 Fall: Potatoes were removed from field before vine senescence and total plant biomass and N uptake was measured. ^{15}N recovery was measured in potatoes and in soil after potato harvest.

Crop Residue Exchange

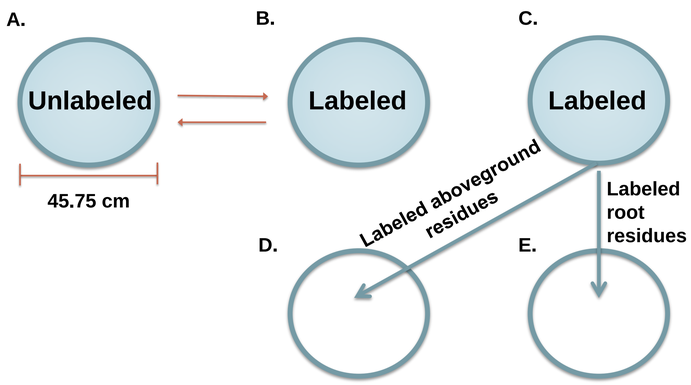

Figure 1. Residue treatments after residue exchange for one forage treatment. A: AG – Labeled aboveground residues (whole forages); B: BG – Labeled roots and soil (whole forages); C: (Not a treatment) Forages grown for AG_{only} and BG_{root}; D: AG_{only} - Labeled aboveground residues only; E: BG_{root} - Labeled recovered roots only. Shaded areas indicate microplots with forages in 2014 before residue exchange.

Results

Table 1. Total ^{15}N recovery in collected forage biomass and soil on each collection date in 2014. Soil samples were taken before crop residue exchange.

Treatment	Aboveground Biomass		Root Biomass	Soil 0-15 cm	Soil 15-30 cm
	First cut	Second cut			
			% ^{15}N		
RC	29.4^{b§}	2.20^{b}	9.57	45.9^{a}	17.4^{a}
M	38.9^{b}	4.15^{a}	8.27	33.0^{b}	9.69^{b}
T	48.1^{a}	1.98^{b}	11.0	16.3^{c}	6.68^{b}
Significance	*	*	NS	****	***

§ values followed by different letters in the same treatment are statistically different. **** $p < 0.0001$; *** $p < 0.001$; *$p < 0.01$; * $p < 0.05$; NS, not significant

Table 2a. Analysis of Variance (ANOVA) for potato dry matter accumulation and total N uptake in 2015 from forage and residue treatments.

Treatment	Whole Potato Dry Matter (tuber, root, vine)	Total N Uptake
ANOVA	g m^{-2}	
Forage (F)	****	****
Residue (R)	NS	****
F x R	***	****

Table 2b. Slicing the interaction between forage and residue treatment.

	Whole Potato Dry Matter				Total N Uptake			
Treatment	AG	BG	AG_{only}	BG_{root}	AG	BG	AG_{only}	BG_{root}
	g m^{-2}							
RC	632^{a§}	696^{a}	554^{a}	597^{a}	9.17^{a}	10.5^{a}	7.19^{a}	4.89
M	678^{a}	617^{a}	473^{a}	474^{b}	11.1^{a}	10.6^{a}	6.37^{a}	4.04
T	175^{b}	221^{b}	261^{b}	393^{b}	2.49^{b}	2.83^{b}	3.42^{b}	3.11

§ values followed by different letters in the same column are statistically different.

Table 3. Recovery of residual ^{15}N from residues in forage and residue treatments within potato plant parts. Recovery of remaining ^{15}N in soil after potato harvest in 2015.

Treatment	Level	Tuber	Vine	Root	Whole Plant	Soil 0–15 cm	Soil 15–30 cm
				% ^{15}N			
Forage (F)	RC	1.82^{a}	1.56^{a}	0.10^{a}	3.48^{a}	13.5^{a}	3.58
	M	1.72^{a}	1.57^{a}	0.09^{a}	3.38^{a}	8.82^{b}	4.74
	T	0.49^{b}	0.45^{b}	0.04^{b}	0.99^{b}	2.24^{c}	5.61
Residue (R)	AG	1.10	1.15^{ab}	0.06	2.31	5.16^{b}	1.49^{b}
	BG	1.33	1.48^{a}	0.09	2.90	20.0^{a}	14.8^{a}
	AG_{only}	1.70	1.18^{ab}	0.07	2.95	6.09^{b}	1.84^{b}
	BG_{root}	1.25	0.96^{b}	0.08	2.29	1.45^{b}	0.47^{b}
ANOVA							
F		****	****	***	****	*	NS
R		NS	*	NS	NS	*	**
F x R		NS	NS	*	NS	NS	NS

§ values followed by different letters in the same treatment are statistically different. **** $p < 0.0001$; *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; NS, not significant

Results

- Comparable aboveground dry matter was obtained from RC and M treatments but was 46 and 51 % lower in T treatment than in RC and M respectively (Data not reported) . Root biomass comprised 33 – 50 % of total forage biomass collected. In RC and M, the root N uptake comprised 18 to 28 % of the total forage N uptake respectively and 41 % in T (Data not reported).
- Recovery of ^{15}N fertilizer in forage crops ranged from 32 % to 50 % (RC < M <T) in aboveground biomass. There was no observed forage effect in ^{15}N recovery in roots. Total ^{15}N recovery in roots represented approximately 18 - 24 % of total plant ^{15}N recovery (Table 1).
- In all treatments except for BG_{root}, RC and M treatments had significantly higher whole potato dry matter and N accumulation than T. Total N uptake was proportional to the amount of residues incorporated from RC and M treatments ($BG_{root} \approx AG_{only} < BG \approx AG$); the reverse trend was observed for T (Table 2b).
- Mean whole potato plant ^{15}N recovery from labeled residue ranged from 0.99 – 3.48 %. Recovery was highest in RC and M treatments compared to T treatment and recovery from all residue treatments were comparable (Table 3).
- In 2015, the majority of residual ^{15}N remained in the soil 0-30 cm and was highest in BG.

Conclusion

- Potato dry matter and N uptake values were comparable among R and M treatments and were higher than T treatment probably due to N assimilation and subsequent unavailability from timothy.
- Only a small fraction (< 5 %) of ^{15}N from labeled forage residues were transferred to the subsequent whole potato crop. Above and belowground biomasses (recoverable roots) contributed equally to ^{15}N recovery in potato plant parts. Low residual ^{15}N recovery may be the result of N leaching losses that mainly occur over-winter in Atlantic Canada.
- Despite potential avenue for N losses, the ^{15}N from labeled residues found in the soil after potato harvest was higher in BG treatment than other residue treatments reflecting multiple ^{15}N sources coming from residual ^{15}N soil, from fine and coarse labeled roots.

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